CONTENTS

TABLES

FIGURES

6 CRITICALITY

The Versa-Pac Shipping Container is described in Section 1.2, *Package Description*. The package exists in two distinct but similar versions consisting of outer 55-gallon and 110-gallon drums.

The VP-55 consists of a 16 gauge body, bottom and cover. The drum uses a 12 gauge bolted closure ring, standard carbon steel lugs, 5/8" diameter, ASTM (American Society for Testing Materials) A307 bolts and nuts, and a closed-cell EPDM (ethylene propylene diene monomer) gasket. The overall outer dimensions of the VP-55 are 23-$^{1}/_{16}$" OD x 34-¾" in height to the top of the drum bolt ring. The drum cover is reinforced by an eighth-inch thick 22-$^{3}/_{8}$" OD x 18-$^{3}/_{8}$" ID plate, and four ½" bolts are provided to lend additional strength to the drum closure ring.

The VP-110 utilizes a 16 gauge body, bottom and cover. The drum uses a 12 gauge bolted closure ring, standard carbon steel lugs, 5/8" diameter ASTM A307 bolts and nuts, and a closed-cell EPDM gasket. The overall outer dimensions for the 110 gallon package are 30-$^{7}/_{16}$" OD x 42-¾" in height to the top of the drum bolt ring. The drum cover is reinforced by an eighth-inch thick 29-¾" OD x 27-¼" ID plate and eight ½" bolts are provided to lend additional strength to the drum closure ring.

Both drums are further strengthened with vertical stiffeners fabricated from 1-¼" carbon steel square tubing, two inner liners of rolled 16 gauge carbon steel insulated by ceramic fiber blanket encase the vertical tubing, and a ¼" carbon steel reinforcing plate on the bottom. Reinforcing angles and solid bars within the liners provides additional strength.

The package's interior is completely insulated with layered ceramic fiber blanket around the containment area with rigid polyurethane foam disks on the top and bottom. The ceramic fiber blanket and polyurethane foam provide shock and thermal protection to the containment area.

The containment and exterior structure including their respective closures provide two barriers to prevent the payload dispersion and water inleakage. An illustration of the packaging is provided in Figure 1-1.

The criticality analysis demonstrates that the payload material may be pre-packaged in hydrogenous or non-hydrogenous containers within the payload vessel. Hydrogenous pre-packaging materials consist of polyethylene, polypropylene, or PVC (polyvinyl chloride). PTFE (Polytetrafluoroethylene) or Teflon® pre-packaging material are also allowed. Metallic pre-packaging materials consisting of aluminum, stainless and carbon steel are further allowed provided their total weight is controlled to within the payload allotment of the package. In addition, only materials listed in Table 1-4 are presently qualified for use within the Versa-Pac shipping container; all other materials must meet the 600°F minimum auto-ignition temperature describe in Section 1.2.2. The user is required to establish that the auto-ignition temperature is a minimum of 600°F using an established method, such as the method prescribed by ASTM D2883-95 (2009) [1].

A summary of the results for the most reactive HAC configuration for the criticality evaluation is provided in Table 6-1. The most reactive HAC configuration was determined to consist of an arrangement of inhomogeneous spheres placed within the containment area of the package to achieve maximum interaction from contiguous packages in a triangular array.

6.1 Description of the Criticality Design

6.1.1 Design Features

The Versa-Pac Shipping Container does not use any neutron moderators or absorbers. However, minimum thicknesses of continuous sheet and plate carbon steel (e.g., containment liner, inner/outer liner, drum lid, body and bottom, including top and bottom reinforcing plates) are modeled in the analysis. Discrete carbon steel consisting of the vertical stiffeners, flanges, angles, and bars are not modeled. Also not modeled are the flange ring interfaces with the flange. These are modeled assuming a continuous thickness of the flange material

Criticality control of the Versa-Pac Shipping Container relies on control of the payload vessel diameter, the vessel-to-vessel spacing provided by the drum, and number of packagings that may be shipped together. In addition, the payload is limited by mass according to U-235 enrichment, as shown in Table 6-1A. Justification for the limits at 5, 10, and 20 wt% U-235 is provided in Appendix 6.10.3: Enrichment Loading Table.

Table 6-1A Uranium Mass Limits for Enrichment Levels

U-235 Wt-%	Mass U-235 (g)	Mass U (g)
100	350	350
20	410	2,050
10	470	4,700
5	580	11,600

Criticality control does not rely on moderation-control. The analysis assumes optimum moderation with polyethylene. The polyethylene is evaluated at a density of 0.98 g/cc, which conservatively bounds the use of pre-packaging materials containing carbon (including graphite and paraffin) and hydrogen. The higher density polyethylene bounds other moderating materials with a Hydrogen density less than or equal to 0.141 g/cc. Refer to Table 6-4 for a comparison of the moderating materials considered in this analysis.

Thus, the physical packaging design features that are important to criticality safety are the payload vessel diameter, the drum outer diameter, and the payload vessel body, body welds, blind flange and seals. Administrative control of the payload mass and shipment array must also be implemented.

6.1.2 Summary Table of Criticality Evaluation

Table 6-1 provides a summary of the results of the criticality evaluation of the Versa-Pac for the most reactive configuration. The U-235 fissile mass modeled as a sphere leads to the most reactive configuration. A detailed description of the analytical models and methodology is provided in Section 6.3. All results are less than the conservative administrative Upper Subcritical Limit of 0.95 minus the code bias and bias uncertainty.

As indicated in Section 6.3, a single model is conservatively constructed to represent the Normal Condition of Transport (NCT) and Hypothetical Accident Condition (HAC) package configurations for both the VP-55 and VP-110.

6.1.3 Criticality Safety Index (CSI)

The Criticality Safety Index (CSI) for the Versa-Pac is 1.0 and is calculated as follows. The number "N" is defined [2] as that number such that five times "N" undamaged packages (i.e., NCT) with no moderation between the packages, and two times "N" damaged packages (i.e., HAC) with interspersed moderation, would be subcritical. Further, "N" cannot be less than 0.5.

The Versa-Pac analysis uses the HAC model to represent both NCT and HAC configurations. Since the minimum array size evaluated was 272, N equals the lesser of 272/5 (54.4) or 272/2 (136). Therefore, N=54.4 and the CSI equals 50/54.4 = 0.919, which is rounded up to 1.0.

The corresponding maximum number of packages to be transported under non-exclusive use based on a CSI of 1.0 is 50.

6.2 Fissile Material Contents

All material shall be in solid form with no freestanding liquids. Density is not limited. The contents may not exceed the uranium limits shown in Table 6-1A in any non-pyrophoric form. Materials that may be shipped in the Versa-Pac include uranium oxides (U_yO_x), uranium metal (U-metal), uranyl nitrate crystals (UNX), and other uranium compounds (e.g., Uranyl Fluorides and Uranyl Carbonates) enriched up to 100 Wt% U-235. The uranium compounds may also contain carbon or graphite (e.g., UC, U_2C_3, and UC_2). UNX may be in the form of uranyl nitrate hexahydrate, trihydrate or dihydrate, and may contain any amount of moisture; however, the UNX must be in solid form with no freestanding liquid.

The payload may be in homogeneous (powder or crystalline) or inhomogeneous (pelleted or lumped) form. Table 1-5 identifies the limits for U-234 and U-236 as applied to the Versa-Pac. The A_2 values are used as stated in 10CFR71 [2] and are applied to the package since the payload is limited to normal form material.

The package is evaluated assuming optimum moderation using a bounding high-density polyethylene plastic (Density = 0.98 g/cc) and supports packaging applications containing both carbon (graphite) and hydrogen based materials. Non-fissile chemical impurities do not increase the reactivity of the system; therefore, they may be present in any quantity.

The payload material may be pre-packaged in hydrogenous or non-hydrogenous containers within the payload vessel. Hydrogenous pre-packaging materials may include polyethylene, polypropylene, and PVC. PTFE or Teflon® pre-packaging material are also allowed. Metallic pre-packaging materials such as aluminum, stainless and carbon steel are further allowed provided their total weight is controlled to within the payload allotment of the package. In addition only materials listed in Table 1-4 are presently qualified for use within the Versa-Pac shipping container; all other materials must meet the 600°F minimum auto-ignition temperature describe in Section 1.2.2. The user is required to establish that the auto-ignition temperature is a minimum of 600°F using an established method, such as the method prescribed by ASTM D2883 [1].

No payload materials are to be considered as neutron absorbers.

6.3 General Considerations

6.3.1 Model Configuration

Table 6-3 compares the package actual dimensions with the model dimensions. Figure 6-1 shows a representation of the unit model used in the criticality analysis for both NCT and HAC. The model dimensions represent a damaged VP-55. The packaging consists of a cylindrical carbon steel shell surrounded by insulation, an inner/outer steel liner, and an outer carbon steel shell. The steel payload vessel, flange, and blind flange are modeled as carbon steel with reduced minimum dimensions. The drum, inner and outer liners, and upper and lower drum plates are also modeled as carbon steel with reduced minimum dimensions. An enrichment of 100 Wt.% U-235 is used to evaluate all limiting cases.

The model conservatively represents the HAC package configuration (i.e., damaged package configuration) for the VP-55. The VP-55 was chosen over the VP-110 because the smaller package envelope is inherently more reactive in array calculations.

The model is constructed considering the worst-case damage to both the VP-55 and VP-110 package designs. As indicated in Section 2.12.3, the tested VP-110 sustained little damage from both the NCT and HAC testing, suggesting small differences in the final evaluated package array sizes. Section 2.0 also indicated that prototype testing of both package designs shows that the VP-110 sustained more damage due to the heavier weight and greater distance between vertical stiffeners. Therefore, the criticality analysis model is constructed based on the VP-55 package dimensions, due to the potential for higher package and fissile mass densities, coupled with the conservative application of actual damage sustained during testing of the VP-110 version. It therefore bounds the NCT (undamaged package configurations) for both the VP-55 and VP-110 packages and further bounds the HAC (damaged package configuration) for the VP-110 package design.

With construction of a NCT model (undamaged package design) based on the VP-55 design, the evaluated array size would be increased due to additional spacing afforded between the fissile material in adjacent packages. This would lead to a lower CSI. Thus, a smaller package design, considering worst-case damage of the two designs, to the most restrictive CSI criteria can conservatively represent the VP-55 and VP-110.

6.3.1.1 Model Conservatisms

Table 6-2 summarizes the dimensional changes to the test packages indicated as Test Articles with Serial Numbers 10550, 10551, and 10553. The pre- and post-test measured results for each package are provided in Section 2.13.2, *Century Industries Performance Test Report for the Versa-Pac*. The worst-case dimensional changes from these tests, as summarized in Table 6-2 , are: $^{1}/_{8}$" (0.125") increase in the inner containment diameter, $^{5}/_{16}$" (0.3125") decrease in the outer drum diameter, and ¼" (0.25") decrease in the outer drum height (including lid). Note that the measured dimensions do not include the outer drum lid. Also, the outer drum diameter reduction only occurs on one side of the drum mostly due to compression of the area between drum stiffeners at the impact location of the test plate.

The outer dimensions of the VP-55 packaging are 23$^{1}/_{16}$" (23.0625") OD x 34¾" (34.75") height. Neglecting the drum stiffeners and bolt ring reduces the OD to 22½" (22.50").

The model dimensions are established as follows

- The VP-55 drum OD is reduced 1.313” to 21.187” (26.9081 cm radius), which bounds the 0.3125” decrease resulting from the tests.
- The VP-55 drum height is reduced 1.10” to 33.625” (85.408 cm), which bounds the maximum reduced dimension resulting from the tests of 0.250” (1/4”).
- The containment inner diameter is modeled at both nominal (15.0”) and increased by 1/8” to 15.125”. (This corresponds to 19.05 cm radius and 19.2088 cm radius, respectively).
- The containment inner height is modeled at 27.187” (69.056 cm).

The four vertical members (square tubing), reinforcing angles, and bottom plate ring constructed from carbon steel have been conservatively neglected resulting in modeling less than 50% of the package carbon steel. All insulation products are conservatively modeled as optimum interspersed water moderation.

Packages and arrays of packages were also modeled with full density water boundary reflection.

6.3.2 Material Properties

Table 6-3 provides the materials and key dimensions used to evaluate the Versa-Pac. The density for each material used in the models is provided in Table 6-4. The default atomic number densities from the SCALE library were used for all materials and mixtures.

6.3.3 Computer Codes and Cross Section Libraries

The SCALE 4.4a code with the 44-Group Standard Cross Section Library was used to evaluate k_{eff} of the Versa-Pac Shipping Container under all conditions of transport. The code sequence BOMANI, NITAWL, and KENO VI (CSAS6) was used in all analyses.

The verification cases CSAS6 and KENOVI, as provided with the code for verification purposes, were executed prior to commencement of calculations and then upon completion of the final calculations. Other than time and date differences no additional differences were noted in a comparison of the different verification runs.

Distributed fissile mass models were reevaluated with the SCALE 6.1.3 code, and included in the benchmark evaluation documented in Section 6.10.5. Original analyses of the U(100) lumped fissile models are maintained under the SCALE 4.4a code and benchmarking documented in Section 6.10.2. The additional enrichment loadings described in Section 6.10.3 were evaluated with the SCALE 6.1.3 code and benchmark evaluation in Section 6.10.5.

6.3.4 Demonstration of Maximum Reactivity

6.3.4.1 Fuel Density and Distribution

The uranium was modeled in all cases as 350 grams of U-235 (i.e., uranium at 100 wt.% U-235 enrichment). The uranium density, reported in Table 6-4, bounds other uranium compounds including oxides, fluorides, and nitrates. The uranium is modeled in a U-poly mixture as discussed in Section 6.3.4.3. This moderated fissile material bounds the presence of uranium containing carbon or graphite.

The fissile mass was modeled three basic ways:

1) As a distributed fissile mass, filling the drum at levels ranging from 5% to 100% of the drum volume.
2) As a spherical lumped configuration, with the sphere diameter being varied to determine the effect on fissile mass density.
3) As a cylindrical lumped configuration, with both the diameter and height being varied to determine the effect on fissile mass density and interaction.

Additional calculations were made to study the sensitivity of k_{eff} with the fissile mass at 375 and 400 grams U-235. Increasing the mass increases the k_{eff} and would result in a need either to reduce the array size or the amount allowed in each package.

6.3.4.2 Heterogeneous Effects

The Versa-Pac analyses were completed using a homogeneous source material. The heterogeneous effect noted with enriched Uranium is caused by the presence of U-238, which is not present in the U(100) model configurations. The modeled homogeneous source material is representative of and bounding of the proposed payload.

The fissile material was modeled as a discrete lump, as both spheres and cylinders, to study inhomogeneous distribution effects of the fissile mass. The height-to-diameter ratio of the modeled cylinder was also varied. Spheres are typically more reactive than cylinders while cylinders are more interactive. The modeled conditions of the package will dictate the more reactive geometry. For instance, the modeled package carbon steel will have a more significant effect on the cylindrical geometry due to the higher degree of interaction between neighboring cylinders. Both geometrical configurations are specifically evaluated in the criticality analysis.

6.3.4.3 Fuel Mixture (U-Poly) Moderation

As mentioned above, the fissile uranium mass was modeled as a U-poly mixture, with polyethylene (CH_2) moderation to bound a full range of packing materials.

The polyethylene was initially modeled at a density of 0.92 g/cc, which equates to a hydrogen density of 0.132 g/cc. This bounds water moderation (density of about 0.998 g/cc), with a corresponding hydrogen density of 0.112 g/cc.

The polyethylene density was then increased to 0.98 g/cc, which equates to a hydrogen density of 0.141 g/cc or a carbon density of 0.840 g/cc. This bounds compounds that may contain more carbon and hydrogen, but have a lower hydrogen density. At this density, the polyethylene moderation would bound paraffin ($C_{25}H_{52}$), whose density is 0.90 g/cc. Paraffin has a hydrogen density of 0.134 g/cc. Optimum poly-moderation with an increased poly-density is therefore demonstrated for the package.

Finally, the polyethylene density was varied by adjusting the volume fraction to evaluate partial moderator density in the fissile mixture.

Since water-moderation is bounded by poly-moderation, any amount of water- or poly-moderation may be present in the package, and pre-packaging materials having a hydrogen density less than or equal to that of high density polyethylene (0.141 g/cc) do not need to be controlled for criticality purposes. Materials with a hydrogen density greater than 0.141 g/cc are not allowed.

In all instances, the carbon-moderated cases are bounded by the poly-moderated cases. There is no limit imposed on pre-packaging material or carbon-containing pre-packaging materials.

6.3.4.4 Interspersed Moderation

A full range of interspersed moderator (water) density volume fractions from 0.0001 to 1.0 was evaluated to determine the optimum interspersed moderator density for the packaging. Interspersed water moderation was evaluated for the thermal blanket and foam regions of the package. Water moderation was also considered in the package area that contains the vertical carbon steel stiffeners (e.g., square tubing and support angles) and further above the payload within the containment boundary. Also, interspersed water moderation was considered between packages. Due to the higher k_{eff} results for the inhomogeneous modeled configurations, additional region dependent cases are analyzed individually for the payload, payload containment insulation, inner/outer liners, top/bottom insulation, and the package exterior.

The results show that increasing the interspersed moderation in all moderator regions causes an increase in the single package multiplication factor and a reduction in the multiplication factor for arrays of packages.

6.3.4.5 Package Array Configurations

Several different package array configurations were evaluated to determine the most reactive arrangement. The package was evaluated using both square-pitched and triangular-pitched close-packed arrays. The triangular-pitched arrays provide slightly more interaction between packages and yield the higher system k_{eff}.

The homogeneous distributed fissile mass systems considered only the triangular-pitch close-packaged array. Square-pitched close-packed array calculations were not performed since the k_{eff} results for these calculations were low and the results were significantly lower than the lumped fissile mass systems.

However, the inhomogeneous lumped fissile mass systems considered both square-pitched close-packed arrays and triangular-pitched close-packed arrays. These calculations further considered the fissile mass as both spheres and cylinders. Both spheres and cylinders were considered in the array calculations due to the lower than expected differences noted in the k_{eff} results.

6.4 Single Package Evaluation

6.4.1 Configuration

The single package evaluation considered both the homogeneous distributed fissile mass and an inhomogeneous lumped fissile mass. The distributed fissile mass calculations included the package in the model. The analyses consisted of first varying the drum fill level from 5% to 100% to find the optimum level. The model at the optimum fill level was then analyzed by varying the poly-moderation density in the fuel mixture, and then by varying the interspersed moderator (water) density volume fraction inside the drum from 0.0001 to 1.0. The single package model was constructed as previously described, based on the HAC test results, so it bounds the NCT configuration.

A lumped fissile mass was evaluated without the packaging but with full water reflection. The analysis consisted of increasing the sphere radius from 6cm to 14cm to find the optimum dimension, and then varying the poly-moderator density to determine the optimum moderation.

The HAC model would in general have the higher k_{eff} results when compared to a similar NCT model due to the reduced exterior package dimensions resulting from the required performance testing. However, the lumped spherical fissile mass with full boundary reflection bounds both NCT and HAC models in all cases since it is independent of the package modeled geometry. Therefore, the single package safety can be assessed with the use of a single very conservative model.

6.4.2 Results

The single package results are summarized in Table 6-5. All results are less than the conservative administrative Upper Subcritical Limit (USL) of 0.94.

The fully poly-moderated and reflected lumped spherical fissile mass provides the most reactive arrangement, Figure 6-5.

Due to their simplicity, single package input cases are not provided in Appendix 6.10.1. However input cases can be constructed using the provided array input cases with modification of the array boundaries.

6.5 Evaluation of Package Arrays Under Normal Conditions of Transport

6.5.1 Configuration

The Normal Condition of Transport (NCT) evaluation is represented by analysis of an array of 272 Versa-Pac packages. (See Section 6.1.3). As previously stated, the Hypothetical Accident Condition (HAC) model is used to evaluate the NCT cases. The HAC array configurations are described in Section 6.6.1.

6.5.2 Results

Results of the HAC calculations are given in Section 6.6.2.

6.6 Evaluation of Package Arrays Under Hypothetical Accident Conditions

6.6.1 Configuration

Regulations [2] require that 2N damaged Versa-Pac Shipping Packages (2*54.4≈108), arranged in the most reactive array, be evaluated for Hypothetical Accident Conditions (HAC). Because the same package model is used for NCT (5N) and HAC (2N) calculations, the more limiting 5N criterion is used. Therefore, array sizes of at least 272 packages were analyzed for the HAC cases.

The evaluation analyzes for optimum interspersed moderation, optimum fissile mass moderation, and assumes close full-water reflection at the boundaries. The contents are arranged within the package in the most reactive configuration to maximize interaction.

The package bottom offers the least amount of carbon steel and provides the shortest distance to the boundary of the package. Therefore, the most reactive package orientation occurs when the fissile mass is positioned at the base of the package and every other row of packages is inverted to maximize interaction with the row above. This places the lumped fissile mass within two contiguous packages in their closest proximity. This configuration is designated as MOD0, with the drums stacked vertically and every other row inverted.

The packages are also evaluated in both square and triangular configurations with the lumped fissile mass oriented to achieve maximum interaction between contiguous drums. Larger arrays are then constructed by repeating the arrangement. Figure 6-16 and Figure 6-17 show the package arrangement with lumped fissile mass for the triangular and square array configurations, respectively. It can be seen that more packages can be placed in a triangular array. Figure 6-18 shows the MOD0 configuration for a 4-row package array.

Four additional array configurations were considered in this analysis. They are labeled MOD1, MOD2, MOD3, and MOD4, and are shown in Figure 6-19, Figure 6-20, Figure 6-21, and Figure 6-22, respectively. Like MOD0 each has four rows of packages. MOD1 has the top two rows in normal orientation and the bottom rows inverted. MOD2 has the top two rows inverted and the bottom two rows in normal orientation. MOD3 has the same row orientation as MOD1 but the spherical masses are centered on the package bottom, thereby eliminating the triangular cluster of spheres. MOD4 has the top three rows in the normal orientation with the fourth row inverted.

The density of each material in the models is provided in Table 6-4. The default atomic number densities from the SCALE library were used for all materials and mixtures. Specific package orientations are discussed below.

6.6.1.1 Homogeneous Model

Three homogeneous distributed fissile mass model array configurations are investigated. The first configuration is similar to the single package model but employs specular reflection in a triangular array to produce an infinite array of packages. For the second configuration, the U-235 fissile mass is evenly distributed in the base of two packages that are oriented in the MOD0 configuration (i.e., bottom package inverted). A finite model is constructed of this arrangement and then specular boundary reflection is applied to generate an infinite 3D array. The packages are modeled in both a square and triangular configuration. The third configuration places the distributed fissile mass in the most limiting finite array defined by the inhomogeneous lumped material analysis, which is described below. The effect of interspersed moderation and variations in the fissile mass moderation density are further investigated.

The results for homogenous material are significantly lower than that for the inhomogeneous models as discussed in Section 6.6.2.

6.6.1.2 Inhomogeneous Model

For the inhomogeneous model, the fissile mass is lumped in the base of the containment region of the package with two packages oriented in all five MOD configurations [3] [3]. A finite array model is constructed of this double-stacked arrangement with placement of additional packages (drums) in a similar arrangement with their lumped fissile mass further placed in a similar fashion. A finite array of packages is then configured with explicitly modeled full water boundary reflection. Square and triangular configurations are modeled. The effect of interspersed moderation and variations in the fissile mass poly-moderation density are further investigated.

Figure 6-18 shows the MOD0 configuration, in this case showing the spheres. A cylinder, with an H/D of 1.0, would occupy the same region.

The calculated results for the lumped spherical and cylindrical shapes are anticipated to be very close. Additional sensitivity studies are performed for the most reactive configuration. These calculations consider different cross section libraries, increased fissile mass, additional reductions in the minimum modeled carbon steel thicknesses, increased poly-moderation density, and lumped spherical mass placement within the package.

The results are discussed in Section 6.6.2.

6.6.2 Results

The maximum array size for the Versa-Pac that results in a $k_{eff} + 2\sigma$ less than 0.94 is 272. This result is based on a 12.0-cm radius inhomogeneous spherical fissile mass (i.e., 350 grams U-235 with poly-moderation at an increased density of 0.98 g/cc), with packages oriented in a triangular configuration and the fissile mass positioned to achieve optimum interaction. The MOD1 array configuration is selected as bounding, although both the MOD0 and MOD1 configurations appear to interchangeably produce higher k_{eff} results depending on the number of stacked packages.

The file VERSAPAK_HAC_FINH_12S_4X272P is the input deck corresponding to the most reactive case, in the MOD1 configuration. For this case name, FINH signifies a finite array (FIN) in a hexagonal pitch (H); 12S signifies lumped fissile mass spheres (S) with a 12-cm radius; 4 signifies the height of the array, in packages; 272 signifies the total number of packages in the array; and P signifies polyethylene moderation.

Summary results for the most reactive cases are shown in Table 6-1, and detailed results showing the comparison among the 5 MOD configurations are found in Table 6-10.

6.6.2.1 Homogeneous Model

The homogeneous, or distributed fissile mass material was modeled in finite and infinite array calculations. It was found that infinite array calculations produced a maximum $k_{eff} + 2\sigma$ that exceeded the USL. This made it necessary to perform finite array calculations, modeling the homogeneous material in the most limiting array case defined by the inhomogeneous lumped fissile mass analysis (discussed below); comparison of finite array results confirm that the homogeneous material is bounded by the inhomogeneous. The homogeneous material was analyzed in the finite array model at different percent fill levels ranging from 5% to 30%, and the optimum fill level was found to be 18%. The results of this analysis can be seen in Table 6-14. This fill percentage was used for all subsequent finite array sensitivity analyses, whose results can be found in Table 6-15.

Two input decks are provided in Section 6.9 as examples. The first, VERSAPAK_HAC_INFH_15_A, represents an infinite (INF) array of packages with their fissile mass content occupying the bottom 15 percent of the inner package. The package is modeled in a hexagonal (H) lattice arrangement with full fissile mass poly-moderation (A).

The second input deck, VERSA_HAC_FINH_18D_4X272P, represents a finite (FIN) array of 272 packages with the distributed fissile mass occupying the bottom 18 percent of the inner package in the MOD1 configuration.

6.6.2.2 Inhomogeneous Model

Spheres and cylinders are evaluated in the lumped fissile mass model for the Versa-Pac. Radii ranging from 8-cm to 14-cm are modeled, with cylinders also modeled by varying their height-to-diameter (H/D) ratios. Since the fissile mass is fixed at 350 grams U-235 at 100wt%, cylinders modeled with a higher H/D ratio will have a lower U-235 density. Thus, as cylinder height is increased to promote interaction between cylinders in adjacent packages, the single unit reactivity is reduced because fissile mass density decreases.

The drums are analyzed in both triangular and square lattice configurations. Calculations are initially performed for 2x2x2 (8), 4x4x4 (64), 6x6x4 (144), 6x6x6 (216), 8x8x6 (384), 8x8x8 (512), and 10x10x8 (800) finite arrays in the MOD0 sphere placement configuration.

Results of the lumped mass calculations indicate that the 12-cm radius sphere in the triangular configuration is the most reactive. See Table 6-8.

Cylindrical mass calculations considered only the triangular configuration since these arrays produced the higher k_{eff} results in the spherical model calculations. The 10.0-cm (H/D = 1.0) and 12-cm (H/D = 0.8) radius cylinders consistently produced higher k_{eff} results. The k_{eff} results differed by only 0.0005. However, because the 12-cm radius sphere produced a higher k_{eff} than either cylinder array, sensitivity studies described in Section 6.6.1.2 were performed with the spherical mass model. The results of the sphere vs. cylinder comparison cases are summarized in Table 6-7.

A reduction in the modeled diameter of the package had virtually no effect on the more reactive inhomogeneous (lumped fissile mass) modeled system since the reduced diameter does not otherwise limit placement of the modeled spherical mass.[3]

Two input cases are provided in Section 6.9. Cases VERSAPAK_HAC_FINS_12S_A7 and VERSAPAK_HAC_FINH_12S_A7 represent finite (FIN) arrays of packages in square (S) and hexagonal lattices (H). The fissile mass is modeled as a 12-cm radius sphere in both cases (12S) with full fissile mass poly-moderation (A). The modeled array size is 800 packages (7) in an 10x10x8 array. Corresponding cases A1 through A6, as indicated in Table 6-7, can be reproduced with modification of the array parameters. Likewise, the cylindrical fissile mass models can be duplicated by changing the modeled sphere to a cylinder with further indication of the cylindrical height.

6.6.2.2.1 Expanded Array Analysis

The lumped 12.0-cm radius spherical mass is used in an expanded array interaction analysis with sphere placement as shown in Figure 6-18 for the MOD0 configuration. Poly-moderation with a density of 0.92 g/cc is used in this analysis. The purpose of the analysis is to evaluate arrays of at least 400 packages starting with a single layer (Z=1) and continuing to a multiple stacked layer (Z=10). The method of analysis is to stack 400 packages in layers until the USL is exceeded and then reduce the number of packages in each layer and proceed with additional stacking. Stacked layers with a Z>10 were not modeled due to the decreased k_{eff} trend with the same package array size as the Z is increased from 8 to 10.

---

[3] Section 2.12.4 indicates that the inner diameter of a VP-55 package was slightly reduced by $^{1}/_{16}$" after the 30-ft slap-down test.

The calculation results are combined with the initial package array calculations as show in Figure 6-14. The initial results are indicated by “Trend 1” while the latter results are shown as “Trend 2”. The results of these calculations indicate that package arrays consisting of 400, each containing a lumped fissile mass, has a k_{eff} + 2σ of 0.94.

The results of these cases are further summarized in Table 6-8. A single input case is provided in Section 6-8, case Versa_HAC_FINH_12S_10x064, representing an 8x8x10 package array. The nomenclature is similar to that described for other array input cases. The 10x064 designation represents a modeled array with 10 packages stacked in the Z direction with a single layer of 64 packages modeled in the X-Y direction (an 8x8 array). Other cases, as indicated in Table 6-9, can be reproduced with modification of the array parameters. Likewise, the cylindrical fissile mass models can be duplicated by changing the modeled sphere to a cylinder with further indication of the cylindrical height.

6.6.2.2.2 Increased Poly-Moderation Density

The calculations performed in Section 6.6.2.2.1 were duplicated with an increased poly-moderation density from 0.92 to 0.98 g/cc. The results, shown in Figures 6-14 and 6-15, indicate that an increase in the poly-moderation density causes a reduction in the drum array size from 400 to 300 while maintaining a k_{eff} + 2σ of 0.94.

Increasing the evaluated poly-moderation density to 0.98 g/cc bounds other carbon-hydrogen based moderators (paraffin) with sufficient margin. The k_{eff} for cases with paraffin moderation are greater than cases with poly-moderation at a density of 0.92 g/cc however these same cases are all lower than cases with an increased poly-moderation density of 0.98 g/cc. Therefore, poly-moderation with a density of 0.98 g/cc is bounding for this analysis.[4]

Replacing the poly-moderation with graphite causes the array k_{eff}’s to decrease significantly. A single calculation for a 10x10x8 package array with the 12.0-cm radius lumped 350 gram U-235 fissile mass moderated with graphite reported a k_{eff} of 0.1554. Therefore, the package array reactivity is dictated exclusively by the presence of hydrogen-based moderation. This allows Uranium-Carbon/Graphite compounds such as UC, U_2C_3, and UC_2 in the context of “other uranium compounds”, as proposed in Section 6.2, since they are bound by the analysis of Uranium Metal. Also, the other uranium compounds, including UC, U_2C_3, and UC_2 may also be mixed with carbon or graphite, as both moderator materials are bound by the modeled hydrogen (high density polyethylene) moderation.

The results of these cases are summarized in Table 6-8. The single calculation with only graphite moderation is provided in Table 6-9. The input cases provided in Section 6.9 can be modified to duplicate the cases described in this section by changing the poly-moderation density from 0.92 to 0.98 and by further substitution of the poly-moderation input with graphite or paraffin at their respective material densities.

6.6.2.2.3 Interspersed Moderation

The initial array calculation model involving 800 drums with a 12-cm radius sphere with an interspersed moderation volume fraction (VF) of 0.0001 was duplicated with the interspersed

[4] The Hydrogen density associated with high density polyethylene (HDPE) is 0.141 g/cc. Moderators with a Hydrogen density exceeding 0.141 g/cc are expected to produce higher k_{eff} results.

moderation values of 0.001, 0.01, 0.1, 0.5, and 1.0. The results, provided in Table 6-9, show that increasing the interspersed moderation consistently within all regions causes the array k_{eff} to be reduced. With full interspersed moderation the k_{eff} result approaches the value of a single fully reflected sphere.

Input cases can be duplicated by changing mixture 5 in the provided input cases to the desired value.

Additional interspersed moderation calculations as a function of each modeled package region are documented in Section 6.6.2.2.9.

6.6.2.2.4 Fissile Moderation Density

The initial array calculation model involving 800 drums with a fully poly-moderated (VF=1.0) 12.0-cm radius sphere with an interspersed moderation volume fraction (VF) of 0.0001 were duplicated with reduced poly-moderation values (VF) of 0.90, 0.80, 0.70, 0.60, and 0.50. The results, provided in Table 6-9, show that decreasing the poly-moderation volume fraction causes the array k_{eff} to be reduced.

Input cases can be duplicated by changing the poly-moderation in mixture 1 in the provided input cases to the desired value.

6.6.2.2.5 Carbon Steel Reduction

The drum arrays initially modeled consisting of 8, 64, 144, 216, 384, 512, and 800 packages, as presented in Section 6.6.2.2, were duplicated by changing the Material and Volume Fraction for Carbon Steel to Water with a Volume Fraction of 0.0001. The results, provided in Table 6-9, show that eliminating the minimum modeled carbon steel causes the array k_{eff} to be increased. By comparison, the analysis involving the minimum modeled carbon steel thicknesses supported an array size of 400 drums.

A reduction of the minimum fabricated carbon steel thicknesses to values below the manufacturing tolerance causes a significant impact on the results. The original analysis essentially considered approximately 50% of the carbon steel of the package. Eliminating the minimum carbon steel in the modeled configuration decreases the array size from 400 to about 216. Further reductions may be necessary when considering a cylindrical lumped fissile mass. Therefore, the minimum modeled carbon steel thicknesses are not only required for structural integrity but also needed to ensure that the USL is not exceeded.

Input cases can be duplicated by changing the volume fraction of mixture 3 in the provided input cases to 0.50.

6.6.2.2.6 Cross Section and Neutron Histories

The initial array calculation model involving 800 drums is executed again by changing the modeled cross sections from the 44-Group Standard Cross Section Library to the 238 group. The case is executed with 600 generations and 1000 neutrons per group (600,000 neutron histories). The results differ by 0.0001 with the 44-Group generating the larger value.

To determine the sensitivity to the magnitude of the neutron histories the case is again executed with the 238-group cross sections with 600 generations and the neutrons per group increased from 1000 to 2000 (1,200,000 neutron histories). Although the $k_{eff} + 2\sigma$ for the case increases by 0.0017 the result is within 2σ of the original result. For comparison, the case using the 44-group cross sections is executed with 600 generations and 2000 neutrons per group. The raw k_{eff} for this case increases by 0.0010 however with reduction in the uncertainty the final $k_{eff} + 2\sigma$ result remains the same.

The use of different cross sections and increasing the neutron histories did not change the final result. Therefore, the cases used in the original analysis are sufficient and properly converged. There is also no observed benefit with migration of a larger group cross section library as the 44-group produces consistent results. The results are further summarized in Table 6-9.

Input cases can be duplicated by changing the cross section input, neutron generations and neutrons per group to their desired values.

6.6.2.2.7 Increased Fissile Mass

The package array cases (8, 64, 144, 216, 384, 512, and 800 packages) were evaluated with fissile mass increased to 375 and 400 grams at 100 wt.% U-235. The results, provided in Table 6-9, show that increasing the fissile mass by 25 grams requires that the array size be reduced to stay under the USL. The 350 gram U-235 model, as originally evaluated, could potentially support a 550 package array and remain below the USL. The 375 and 400 gram U-235 models require that the array size be reduced to 350 and 275 packages, respectively, to remain below the USL.

Increasing the fissile mass above 350 grams U-235 requires additional sensitivity analysis, as no calculations were performed to determine the optimum sphere diameter with more fissile material. Therefore, a fissile mass limit of 350 grams U-235 at 100wt.% enrichment is established for the Versa-Pac.

Input cases can be duplicated from those provided in Section 6.9 by changing the fissile constituent volume fraction of mixture 1 to correspond to the increased fissile mass.

6.6.2.2.8 Lumped Spherical Mass Placement Sensitivity

The mass placement configuration shown in Figure 6-18 (MOD0) was expected to produce the highest k_{eff} results because of the way the material is clustered within the array. The results of the MOD0 calculations are less than the USL for package arrays of 300 with high-density poly-moderation. To confirm that the MOD0 arrangement is the most reactive configuration, four additional array configurations were analyzed. These configurations, labeled MOD1 through MOD4, are illustrated in Figures 6-19, 6-20, 6-21, and 6-22. Table 6-10 gives detailed results for the MOD0-MOD4 configuration sensitivity study, which includes analyzing multiple array sizes and array heights from 1-12 packages. Table 6-11 summarizes the data of Table 6-10.

It can be seen from Table 6-10 that the MOD0 and MOD1 configurations give identical results for array heights ranging from 1 to 3, and close results for array heights 4-12. The MOD1 array is most reactive for the limiting array case, 272 packages in a 4-high array. The arrays are similar in that the MOD1 array has a central clustered sphere array. However, the remaining spheres are positioned in the opposite ends of the packages. The MOD1 configuration places more spheres in the vicinity of the array full water boundary reflection.

The MOD2 array is similar to the MOD1 array but without the central cluster of spheres. See Figure 6-20. In the MOD2 array the spheres are positioned at the opposite ends of the packages. In all cases, the MOD2 results are lower than the MOD1 results.

The MOD3 array is similar to the MOD1 array except that the spheres are centered in the package base and not clustered. In all cases, the MOD3 results are lower than the MOD1 results. Comparing the MOD1 and MOD3 results suggests that centralization of the main cluster within the package array (MOD1) appears to produce the most reactive case.

The MOD4 array differs from MOD1 in that the packages in the third row are oriented normally. In other words, only the bottom row of packages is inverted. Calculations for the MOD4 array are only performed for configurations with package heights of 4 and 6. The MOD4 configuration is shown in Figure 6-22. MOD1 configuration is more reactive than MOD4.

6.6.2.2.9 Interspersed Moderation with Modeled Package Region

The input decks for the MOD1 array were modified to allow different moderator volume fractions to be specified for five different package regions. The regions are:

- Payload region (Mixture 5),
- Payload insulation region (Mixture 6),
- Top/bottom insulation regions (Mixture 7),
- Inner/outer liners (Mixture 8), and
- Exterior region between packages (Mixture 9).

The MOD1 array was analyzed with the volume fractions of each region varied from 0.001, 0.01, 0.1, 0.5 and 1.0. The results of these calculations are presented in Table 6-12. The calculations indicated that the MOD1 configurations with moderator volume fractions of 0.0001, 0.001, and 0.01 produce the higher k_{eff} results. All results are below the USL.

An input case of the revised base model is provided in Section 6.9.

6.7 Fissile Material Packages for Air Transport

The Versa-Pac Shipping Container is not authorized for air transport.

6.8 Benchmark Evaluations

6.8.1 Benchmark Experiments and Applicability

Appendix 6.10.2 documents 161 critical experiments modeled using the SCALE 4.4a code (KENO VI) with the 44 Group Standard Cross Section Library. Uranium compounds used in the experiments include uranyl nitrate, uranium fluoride, uranium dioxide, uranium-aluminum alloys, and uranium metal. Moderators included water, alcohol, nitric acid, hydrofluoric acid, beryllium, aluminum and silicon oxides, water, D_2O, iron, tungsten, plastics and graphite. Reflectors included aluminum, steel, concrete, water, D_2O, titanium, tungsten, lead, iron, and graphite. Enrichments ranged from 62.4 to 97.68 wt% U-235. The H/X ratio ranged from 0 to 1,837. ALCF (eV) ranged from 3.0E-02 to 9.14E+05. The fuel density ranged from 0.014 to 18.6 gU-235/cc.

The HEU experiments were selected and categorized into four distinct groups. These groupings consisted of:

Group 1: All experiments (161) used in this validation,

Group 2: Experiments (81) with ALCF ≤ 10^{-2} eV, data sets 1-82, and

Group 3: Experiments (56) with ALCF > 10^{-2} eV and ≤ 10^{5} eV, data sets 83-138, and

Group 4: Experiments (24) with ALCF > 10^{5} eV, data sets 139-162.

The cases evaluated for the Versa-Pac Shipping Container include uranium metal, water, graphite, steel, and plastic moderation/reflection. The Versa-Pac Shipping Container cases were evaluated at an enrichment of 100 wt% ^{235}U, and the H/X ratio ranged from 0 to 1,011. The ALCF for the Versa-Pac Shipping Container cases ranged from 3.00E-02 to 9.90E-02. The fuel density ranged from 0.00160 to 0.020 gU-235/cc. Although the evaluated higher enrichment falls very slightly outside the validated range, the benchmark results for Group 2 and Group 3 are directly applicable to the Versa -Pac Shipping Container cases.

6.8.2 Bias Determination

Details of the benchmark calculations are provided in Appendix 6.10.2. In order to validate the SCALE 4.4a code for use with high-enriched uranium systems, it is necessary to determine if KENO predicts the multiplication factor in an accurate and precise manner throughout the range of fission energies of interest. To evaluate the accuracy of the code, the mean of each Group of experiments was compared to the mean of the experimental results. A t-test was performed for each Group to determine whether or not the average result of a KENO calculation (the mean calculated k_{eff} for each Group) is statistically the same as the experimental result (unity). Passing the t-test affirms that the KENO code predicts multiplication factors accurately for the Group being tested, without bias. Failure of the t-test indicates that the mean KENO k_{eff} is statistically different from the experimental mean, and that a bias exists in the data. Groups that failed the t-test were further evaluated for bias and uncertainty, and these parameters applied to provide an upper limit subcritical multiplication factor for the Group.

Each Group of KENO-calculated k_{eff} values are also graphed against key system parameters (Energy of the Average Lethargy Causing Fission (EALF), Hydrogen-to-Fissile Atom Ratio (H/^{235}U), enrichment, and fissile material density (g ^{235}U/cc)) to identify trends within the data that may indicate inaccurate cross-sections or instabilities in the code. The normality of residuals is also tested using the Anderson-Darling method. The null hypothesis of a normality test is that there is no significant departure from normality. When the probability level, ρ is greater than 0.05, it fails to reject the null hypothesis and thus the assumption holds. Histogram, skewness and kurtosis plots are also provided for each group. Jaech's [4] method for bias determination is applied, and the upper subcritical limit is calculated based upon NUREG/CR-6361 [5].

6.8.3 Benchmark Results

For the groups of interest for the Versa-Pac Shipping Container, the bounding combined bias and bias uncertainty was reported as 0.0026 (Group 3). Thus, including a conservative 5% administrative margin, the applicable upper subcritical limit for the Versa-Pac Shipping Container is 0.9466 for the calculated k_{eff} +2σ. For conservatism, a USL of 0.94 is adopted.

6.9 References

[1] American Society for Testing Materials (ASTM), "Standard Test Method for Reaction Threshold Temperature of Liquid and Solid Materials," ASTMD2883-95, 2009.

[2] Nuclear Regulatory Commission (NRC), Title 10, Part 71-Packaging and Transportation of Radioactive Material.

[3] Daher-TLI, "Versa-Pac Enrichment Loading Curve Evaluation, Rev. 0," CN-20000-040-602, 2015.

[4] John L. Jaech, "Statistical Methods in Nuclear Material Control," Exxon Nuclear Company, Richland, WA, TID-26298, 1973.

[5] Nuclear Regulatory Commission (NRC), "Criticality Benchmark Guide for Light-Water-Reactor Fuel in Transportation and Storage Packages," NUREG/CR-6361, 1997.

[6] Oak Ridge National Laboratory, "SCALE: A Comprehensive Modeling and Simulation Suite for Nuclear Safety Analysis and Design," SCALE Version 6.1.3, 2013.

[7] International Atomic Energy Agency (IAEA), "Thorium Fuel Cycle - Potential Benefits and Challenges ," IAEA TECDOC 1450, 2005.

[8] Organization for Economic Cooperation and Development - Nuclear Energy Agency (OECD-NEA), "International Handbook of Evaluated Criticality Safety Benchmark Experiments," NEA/NSC/DOC(95)03, 2014.

6.10 List of Appendices

Appendix 6.10.1: Selected SCALE 4.4a Input Cases

Appendix 6.10.2: Validation of SCALE4.4a-PC for High Enriched Uranium Systems, Montgomery Engineering and Technical Services (METS-424 Rev 1), June 2009

Appendix 6.10.3: Enrichment Loading Table

Appendix 6.10.4: Selected SCALE 6 Input Cases

Appendix 6.10.5: SCALE 6 Benchmark Evaluation

Table 6-1 Summary of Results for the Most Reactive Case

Case ID (Note 1)	Package Array Size	Material	Modeled Configuration (Note 2)	Poly-Moderation Density (g/cc)	^{235}U Mass (kg)	Interspersed Moderation (water volume fraction)/ Package Region (Note 3)	Close Water Reflection	H/X (Note 4)	EALF (eV)	k_{eff}	σ	$k_{eff} + 2\sigma$	Applicable USL
VERSAPAK_HAC_FINH_12S_4x272P	272	U-Metal, 12.0-cm Dia. Sphere	MOD1	0.98	0.350	0.0001 All	Yes	636	3.84E-02	0.9378	0.0010	0.9398	0.94
VERSAPAK_HAC_FINH_12S_4x272Pb MOD1/R5	272	U-Metal, 12.0-cm Dia. Sphere	MOD1	0.98	0.350	0.001 Region 5	Yes	636	3.84E-02	0.9374	0.0012	0.9398	0.94
VERSAPAK_HAC_FINH_12S_4x272Pb MOD1/R8	272	U-Metal, 12.0-cm Dia. Sphere	MOD1	0.98	0.350	0.001 Region 8	Yes	636	3.84E-02	0.9374	0.0012	0.9398	0.94

Notes:
1. Case ID naming convention defined in Section 6.6.2.
2. Modeled Configuration defined in Section 6.6.1.
3. Package regions 5-9 are defined in Section 6.6.2.2.8. “All” indicates that regions 5-9 are modeled at the indicated water volume fraction. “Region y” indicates that that region is modeled at the indicated water volume fraction and the others are modeled at 0.0001.
4. “X” refers to U-235 since the modeled enrichment is 100 wt.%.

Table 6-2 Versa-Pac Shipping Package - Test Package Dimensional Changes

Location	Description	Package 10550	Package 10551	Package 10552
A-C	Inner Container Inner Diameter	+ 1/8	NC	+ 1/16
A-C	Outer Container Outer Diameter	+ 1/16	NC	- 3/16
A	Drum Height	+ 1/8	+ 1/16	- 3/16
A	Wall – In/Out	+ 1/8	- 1/16	+ 1/8
A	Inside Height	NC	NC	NC
A	Top Rim – Inside Flange	+ 1/8	+ 1/8	- 3/8
B	Drum Height	+ 1/16	NC	- 1/4
B	Top Rim – Inside Flange	+ 1/16	NC	- 1/4
B	Wall – In/Out	- 1/8	NC	+ 1/8
B-D	Inner Container Inner Diameter	+ 1/16	NC	NC
B-D	Outer Container Outer Diameter	- 1/16	+ 1/8	- 5/16
C	Drum Height	NC	NC	NC
C	Wall – In/Out	+ 3/16	+ 1/16	- 11/16
C	Inside Height	NC	+ 5/16	- 1/8
C	Top Rim – Inside Flange	- 1/16	NC	- 1/4
D	Drum Height	NC	NC	NC
D	Top Rim – Inside Flange	NC	+ 1/16	- 1/16
D	Wall – In/Out	- 1/16	+ 1/16	- 7/16
D	Inner Container	+ 7/16	- 1/8	NC

NC – Denotes No Change (Dimensional) with tested orientation

Table 6-3 Versa-Pac Shipping Package Actual Versus Modeled Dimensions and Materials

Component	Actual Dimension (in)	Actual Dimension (cm)	Modeled Dimension (in)	Modeled Dimension (cm)	Actual Material	Modeled Material/Notes
Radial Direction						
Payload vessel Inner diameter	15.0	38.1	15.0 – 15.125	38.1 – 38.4175	Payload – Containment Boundary	The fissile material is initially modeled in a defined volume with the remaining interstitial volume completely filled with poly-moderation. In this case, the sum of the volume fractions of both fissile material and poly-moderation are equal to unity. Subsequent calculations reduce the poly-moderation volume fraction to demonstrate that the system is not over moderated (or not more reactive with partial poly-moderation). In the latter case, the mixture is then comprised of fissile material, poly-moderation, and void. Void is technically modeled within the mixture under conditions in which the summed fissile material and poly-moderation volume fractions are less than unity. Both homogeneous and inhomogeneous (lumped) fissile masses are modeled.
Payload vessel Wall thickness	0.1345 (10 ga)	0.3416	0.1211	0.3076	Carbon steel	Carbon steel modeled with reduced manufacturing tolerance
Insulation thickness	3.0	7.62	2.5	6.35	Insulation	Optimum interspersed moderator
Inner liner wall thickness	0.0598 (16 ga)	0.1518	0.0533	0.1354	Carbon steel	Carbon steel modeled with reduced manufacturing tolerance
Outer insulation, vertical and horizontal tubing and angles	1.25	3.175	1.25 NCT 0.25 HAC	3.175 NCT 0.6356 HAC	Carbon Steel & Insulation	Optimum interspersed moderator. Carbon steel tubing and angles are neglected for conservatism.
Outer liner wall thickness	0.0598 (16 ga)	0.1518	0.0533	0.1354	Carbon steel	Carbon steel modeled with reduced manufacturing tolerance
Drum wall thickness	0.0598 (16 ga)	0.1518	0.0533	0.1354	Carbon steel	Carbon steel modeled with reduced manufacturing tolerance
Drum outer radius	11.531 [Note 1]	29.2887	11.250 NCT [Note 2] 10.593 HAC	28.575 NCT 26.908 HAC	N/A	The outer radius of the 55 gallon package is 23". Neglicting the drum stiffeners and bolt ring reduces the outer diameter to 22-1/2". For the bounding HAC/NCT model, the 55-gallon drum is further modeled with a reduced outer diameter of 1.313" which significantly bounds the maximum reduced dimension resulting from the tests of 0.313" (5/16") as indicated in Section 2. The outer radius of the 55 gallon package HAC model is then 21.1875".
Axial Direction From Bottom of Package						
Drum bottom thickness	0.0598 (16 ga)	0.1518	0.0533	0.1354	Carbon steel	Carbon steel modeled with reduced manufacturing tolerance
Bottom reinforcing plate	0.25	0.635	0.24	0.6096	Carbon steel	Carbon steel modeled with reduced manufacturing tolerance
Bottom insulation layer thickness	2.5	6.35	2.5	6.35	Insulation	Optimum interspersed moderator
Payload vessel Bottom wall thickness	0.1345 (10 ga)	0.3416	0.1211	0.3076	Carbon steel	Carbon steel modeled with reduced manufacturing tolerance

Table 6-3 Versa-Pac Shipping Package Actual Versus Modeled Dimensions and Materials

Component	Actual Dimension		Modeled Dimension		Actual Material	Modeled Material/Notes
	(in)	(cm)	(in)	(cm)		
Payload vessel Inner height	27.0625	68.7387	27.0625 – 27.1875	68.7387 – 69.0562	Payload – Containment Boundary	Fissile material, same as payload vessel inner diameter.
Payload vessel Closure lid wall thickness	0.50	1.27	0.49	1.2446	Carbon steel	Carbon steel modeled with reduced manufacturing tolerance
Lid-to-plug gap	0.9065	2.3025	0.4265	1.0833	Gasket, Carbon steel bolts, Air	Clearance for gasket and inner fasteners. Modeled as optimum interspersed moderator
Inner plug liner	0.0598 (16 ga)	0.1518	0.0533	0.1354	Carbon steel	Carbon steel modeled with reduced manufacturing tolerance
Top insulation layer thickness	2.5	6.35	2.5	6.35	Insulation	Optimum interspersed moderator
Drum lid	0.0598 (16 ga)	0.1518	0.0533	0.1354	Carbon steel	Carbon steel modeled with reduced manufacturing tolerance
Drum outer height	34.5 [Note 3]	87.63	34.0 NCT [Note 4] 33.625 HAC	86.36 NCT 85.4075 HAC	N/A	The outer height of the 55 gallon package is 34-1/2”. Neglecting the drum bottom chime reduces the outer height to 34”. For the bounding HAC model, the 55-gallon drum is modeled with a reduced outer height of 0.875” which bounds the maximum reduced dimension resulting from the tests of 0.250” (1/4”) as indicated in Section 2. The outer height of the 55 gallon package HAC model is then 33.625”.

Notes on Table 6-3:

1. Dimension includes the drum ring stiffeners.
2. Dimension does not include the drum ring stiffeners, lid, chime, or lock ring.
3. Dimension includes the drum bottom chime.
4. Dimension does not include the drum bottom chime.

Table 6-4 Package and Material Regional Densities

Material	Maximum Material Density (g/cc) at 21°C	Material Hydrogen Density (g/cc)
UO_2	10.96	N/A
U-metal	19.05	N/A
UNX at 1,274 gU/L	2.705	N/A
H_2O	0.9982	0.1117
Carbon Steel (CS)	7.8212	N/A
Polyethylene (LDPE) – CH_2	0.92	0.1323
Polyethylene (HDPE) – CH_2	0.98	0.1409
Paraffin – $C_{25}H_{52}$	0.90	0.1338
Carbon (graphite)	2.300	N/A

Table 6-5 Single Package Results

Case ID	Drum Fill Percent	Poly-Moderation	^{235}U Mass (kg)	Interspersed Moderation (water volume fraction)	Close Water Reflection	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)	Comments
Homogeneous Fissile Material as a Function of Drum Fill Percentage										
VERSAPAK_HAC_SIN_5_A	5	100	0.350	0.0001	Yes	0.2181	0.00089	0. 2199	6.72E-02	
VERSAPAK_HAC_SIN_10_A	10	100	0.350	0.0001	Yes	0.4425	0.00098	0.4444	4.24E-02	
VERSAPAK_HAC_SIN_15_A	15	100	0.350	0.0001	Yes	0.5694	0.0010	0.5714	3.67E-02	
VERSAPAK_HAC_SIN_20_A Note 1	20	100	0.350	0.0001	Yes	0.6210	0.0010	0.6230	3.40E-02	
VERSAPAK_HAC_SIN_30_A	30	100	0.350	0.0001	Yes	0.6224	0.00099	0.6244	3.18E-02	
VERSAPAK_HAC_SIN_40_A	40	100	0.350	0.0001	Yes	0.5801	0.00086	0.5819	3.09E-02	
VERSAPAK_HAC_SIN_60_A	60	100	0.350	0.0001	Yes	0.4831	0.00088	0.4849	3.00E-02	
VERSAPAK_HAC_SIN_80_A	80	100	0.350	0.0001	Yes	0.4076	0.0007	0.4091	2.95E-02	
VERSAPAK_HAC_SIN_100_A	100	100	0.350	0.0001	Yes	0.3491	0.00077	0.3506	2.92E-02	
Homogeneous Fissile Material as a Function of Poly-Moderation Density										
VERSAPAK_HAC_SIN_20_A Note 1	20	100	0.350	0.0001	Yes	0.6210	0.0010	0.6230	3.40E-02	k_{eff} decreases with reduced poly-moderation density
VERSAPAK_HAC_SIN_20_B	20	90	0.350	0.0001	Yes	0.5861	0.0010	0.5881	3.51E-02	
VERSAPAK_HAC_SIN_20_C	20	80	0.350	0.0001	Yes	0.5440	0.0010	0.5460	3.62E-02	
VERSAPAK_HAC_SIN_20_D	20	70	0.350	0.0001	Yes	0.4901	0.0010	0.4921	3.77E-02	
VERSAPAK_HAC_SIN_20_E	20	60	0.350	0.0001	Yes	0.4228	0.00096	0.4247	4.01E-02	
VERSAPAK_HAC_SIN_20_F	20	50	0.350	0.0001	Yes	0.3451	0.00089	0.3468	4.33E-02	
Homogeneous Fissile Material as a Function of Interspersed-Moderator Density										
VERSAPAK_HAC_SIN_20_A Note 1	20	100	0.350	0.0001	Yes	0.6210	0.0010	0.6230	3.40E-02	keff increases with increased interspersed moderation density
VERSAPAK_HAC_SIN_20_Aa	20	100	0.350	0.001	Yes	0.6224	0.0010	0.6244	3.41E-02	
VERSAPAK_HAC_SIN_20_Ab	20	100	0.350	0.01	Yes	0.6234	0.0010	0.6254	3.41E-02	

Table 6-5 Single Package Results

VERSAPAK_HAC_SIN_20_Ac	20	100	0.350	0.1	Yes	0.6408	0.00098	0.6427	3.36E-02	
VERSAPAK_HAC_SIN_20_Ad	20	100	0.350	0.5	Yes	0.6907	0.0011	0.6929	3.34E-02	
VERSAPAK_HAC_SIN_20_Ae	20	100	0.350	1.0	Yes	0.7096	0.0012	0.7120	3.31E-02	Maximum Homogeneous Result
Case ID	**Drum Fill Percent**	**Poly-Moderation**	**^{235}U Mass (kg)**	**Interspersed Moderation (water volume fraction)**	**Close Water Reflection**	**k_{eff}**	**σ**	**$k_{eff} + 2\sigma$**	**EALF (eV)**	**Comments**
Single Lumped Fissile Mass										
VERSAPAK_HAC_SIN_6S_A	6	100	0.350	0.0001	Yes	0.6471	0.0012	0.6495	1.45E-01	
VERSAPAK_HAC_SIN_8S_A	8	100	0.350	0.0001	Yes	0.7927	0.0012	0.7951	6.55E-02	
VERSAPAK_HAC_SIN_10S_A	10	100	0.350	0.0001	Yes	0.8683	0.0012	0.8707	4.47E-02	
VERSAPAK_HAC_SIN_12S_A [Note 2]	12	100	0.350	0.0001	Yes	0.8814	0.0012	0.8838	3.66E-02	Maximum Lumped Result
VERSAPAK_HAC_SIN_14S_A	14	100	0.350	0.0001	Yes	0.8429	0.0011	0.8451	3.27E-02	
Single Lumped Fissile Mass as a Function of Poly-Moderation Density										
VERSAPAK_HAC_SIN_12S_A [Note 2]	12	100	0.350	0.0001	Yes	0.8814	0.0012	0.8838	3.66E-02	keff decreases with reduced poly-moderation density
VERSAPAK_HAC_SIN_12S_B	12	90	0.350	0.0001	Yes	0.8431	0.0012	0.8455	3.77E-02	
VERSAPAK_HAC_SIN_12S_C	12	80	0.350	0.0001	Yes	0.7952	0.0011	0.7974	3.90E-02	
VERSAPAK_HAC_SIN_12S_D	12	70	0.350	0.0001	Yes	0.7411	0.0011	0.7433	4.07E-02	
VERSAPAK_HAC_SIN_12S_E	12	60	0.350	0.0001	Yes	0.6800	0.0012	0.6824	4.27E-02	

Notes on Table 6-5:

1. Duplicate entry for observance of trend.
2. Duplicate entry for observance of trend.

Table 6-6 HAC Results for Homogeneous Models

Case ID	Drum Fill Percent	Poly-Moderation	^{235}U Mass (kg)	Interspersed Moderation (water volume fraction)	Close Water Reflection	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)	Comments
Infinite Triangular Package Array - Homogeneous Fissile Material as a Function of Drum Fill Percentage – Bottom Filled Package Model										
VERSAPAK_HAC_INFH_5_A	5	100	0.350	0.0001	Yes	0.9506	0.0010	0.9526	6.58E-02	
VERSAPAK_HAC_INFH_10_A Note 1	10	100	0.350	0.0001	Yes	1.0107	0.0011	1.0129	4.25E-02	
VERSAPAK_HAC_INFH_15_A	15	100	0.350	0.0001	Yes	0.9703	0.0010	0.9723	3.69E-02	
VERSAPAK_HAC_INFH_20_A	20	100	0.350	0.0001	Yes	0.9127	0.0010	0.9147	3.46E-02	
Infinite Triangular Package Array - Homogeneous Fissile Material as a Function of Poly-Moderation Density – Bottom Filled Package Model										
VERSAPAK_HAC_INFH_10_A Note 1	10	100	0.350	0.0001	Yes	1.0107	0.0011	1.0129	4.25E-02	k_{eff} decreases with reduced poly-mod. density
VERSAPAK_HAC_INFH_10_B	10	90	0.350	0.0001	Yes	1.0051	0.0010	1.0071	4.49E-02	
VERSAPAK_HAC_INFH_10_C	10	80	0.350	0.0001	Yes	0.9955	0.0010	0.9975	4.78E-02	
Infinite Triangular Package Array - Homogeneous Fissile Material as a Function of Interspersed Moderator Density – Bottom Filled Package										
VERSAPAK_HAC_INFH_10_Aa	10	100	0.350	0.001	Yes	1.0024	0.0013	1.0050	4.24E-02	keff decreases with increased interspersed moderator density
VERSAPAK_HAC_INFH_10_Ba	10	90	0.350	0.001	Yes	0.9955	0.0011	0.9977	4.48E-02	
VERSAPAK_HAC_INFH_10_Ca	10	80	0.350	0.001	Yes	0.9821	0.0012	0.9845	4.77E-02	
VERSAPAK_HAC_INFH_10_Ab	10	100	0.350	0.01	Yes	0.9036	0.0010	0.9056	4.19E-02	
VERSAPAK_HAC_INFH_10_Bb	10	90	0.350	0.01	Yes	0.8913	0.0010	0.8933	4.41E-02	

Table 6-6 HAC Results for Homogeneous Models

Case ID	Drum Fill Percent	Poly-Moderation	^{235}U Mass (kg)	Interspersed Moderation (water volume fraction)	Close Water Reflection	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)	Comments
VERSAPAK_HAC_INFH_10_Cb	10	80	0.350	0.01	Yes	0.8710	0.0010	0.8730	4.64E-02	
VERSAPAK_HAC_INFH_10_Ac	10	100	0.350	0.1	Yes	0.6905	0.0010	0.6925	4.01E-02	
VERSAPAK_HAC_INFH_10_Bc	10	90	0.350	0.1	Yes	0.6617	0.0010	0.6637	4.17E-02	
VERSAPAK_HAC_INFH_10_Cc	10	80	0.350	0.1	Yes	0.6258	0.0010	0.6278	4.34E-02	
Infinite Triangular Package Array - Homogeneous Fissile Material as a Function of Drum Fill Percentage – Bottom Filled Inverted Bottom										
VERSAPAK_HAC_INFH2_5_A	5	100	0.350	0.0001	Yes	0.9503	0.0010	0.9523	0.0657	Bottom filled inverted model (H2) is more reactive than previous bottom filled (H) model keff decreases with reduced poly-moderation density
VERSAPAK_HAC_INFH2_5_B	5	90	0.350	0.0001	Yes	0.9241	0.0010	0.9261	0.0728	
VERSAPAK_HAC_INFH2_5_C	5	80	0.350	0.0001	Yes	0.8962	0.0011	0.8984	0.0829	
VERSAPAK_HAC_INFH2_5_D	5	70	0.350	0.0001	Yes	0.8593	0.0010	0.8613	0.0969	
VERSAPAK_HAC_INFH2_5_E	5	60	0.350	0.0001	Yes	0.8164	0.0012	0.8188	0.1195	
VERSAPAK_HAC_INFH2_5_F	5	50	0.350	0.0001	Yes	0.7667	0.0010	0.7687	0.1611	
VERSAPAK_HAC_INFH2_10_A	10	100	0.350	0.0001	Yes	1.0107	0.0010	1.0127	0.0426	
VERSAPAK_HAC_INFH2_10_B	10	90	0.350	0.0001	Yes	1.0056	0.0010	1.0076	0.0449	
VERSAPAK_HAC_INFH2_10_C	10	80	0.350	0.0001	Yes	0.9927	0.0010	0.9947	0.0477	
VERSAPAK_HAC_INFH2_10_D	10	70	0.350	0.0001	Yes	0.9773	0.0010	0.9793	0.0520	

Table 6-6 HAC Results for Homogeneous Models

Case ID	Drum Fill Percent	Poly-Moderation	^{235}U Mass (kg)	Interspersed Moderation (water volume fraction)	Close Water Reflection	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)	Comments
VERSAPAK_HAC_INFH2_10_E	10	60	0.350	0.0001	Yes	0.9503	0.0010	0.9523	0.0578	
VERSAPAK_HAC_INFH2_10_F	10	50	0.350	0.0001	Yes	0.9132	0.0012	0.9156	0.0675	
VERSAPAK_HAC_INFH2_15_A	15	100	0.350	0.0001	Yes	0.9709	0.0010	0.9728	0.0369	
VERSAPAK_HAC_INFH2_15_B	15	90	0.350	0.0001	Yes	0.9770	0.0011	0.9792	0.0382	
VERSAPAK_HAC_INFH2_15_C	15	80	0.350	0.0001	Yes	0.9809	0.0010	0.9829	0.0398	
VERSAPAK_HAC_INFH2_15_D	15	70	0.350	0.0001	Yes	0.9800	0.0010	0.9820	0.0419	
VERSAPAK_HAC_INFH2_15_E	15	60	0.350	0.0001	Yes	0.9715	0.0011	0.9737	0.0456	
VERSAPAK_HAC_INFH2_15_F	15	50	0.350	0.0001	Yes	0.9510	0.0010	0.9530	0.0503	
VERSAPAK_HAC_INFH2_20_A	20	100	0.350	0.0001	Yes	0.9113	0.0009	0.9131	0.0346	
Infinite Triangular Package Array - Homogeneous Fissile Material as a Function of Poly-Moderation Density – Bottom Filled Inverted Bottom										
VERSAPAK_HAC_INFH2_10_Aa	10	100	0.350	0.001	Yes	1.0007	0.0010	1.0027	4.24E-02	keff decreases with reduced poly-moderation density and with increased interspersed moderator density
VERSAPAK_HAC_INFH2_10_Ba	10	90	0.350	0.001	Yes	0.9938	0.0010	0.9958	4.46E-02	
VERSAPAK_HAC_INFH2_10_Ca	10	80	0.350	0.001	Yes	0.9816	0.0010	0.9836	4.78E-02	
VERSAPAK_HAC_INFH2_10_Ab	10	100	0.350	0.01	Yes	0.9046	0.0010	0.9066	4.22E-02	
VERSAPAK_HAC_INFH2_10_Bb	10	90	0.350	0.01	Yes	0.8892	0.0010	0.8912	4.40E-02	

Table 6-6 HAC Results for Homogeneous Models

Case ID	Drum Fill Percent	Poly-Moderation	^{235}U Mass (kg)	Interspersed Moderation (water volume fraction)	Close Water Reflection	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)	Comments
VERSAPAK_HAC_INFH2_10_Cb	10	80	0.350	0.01	Yes	0.8707	0.0010	0.8727	4.68E-02	
VERSAPAK_HAC_INFH2_10_Ac	10	100	0.350	0.1	Yes	0.6887	0.0010	0.6907	4.01E-02	
VERSAPAK_HAC_INFH2_10_Bc	10	90	0.350	0.1	Yes	0.6598	0.0010	0.6618	4.17E-02	
VERSAPAK_HAC_INFH2_10_Cc	10	80	0.350	0.1	Yes	0.6249	0.0010	0.6269	4.37E-02	
Infinite Square Package Array - Homogeneous Fissile Material as a Function of Drum Fill Percentage – Bottom Filled Inverted Bottom Package										
VERSAPAK_HAC_INFS2_5_A	5	100	0.350	0.0001	Yes	0.9467	0.0011	0.9489	6.56E-02	keff decreases for square array
VERSAPAK_HAC_INFS2_10_A	10	100	0.350	0.0001	Yes	1.0103	0.0010	1.0123	4.26E-02	
VERSAPAK_HAC_INFS2_15_A	15	100	0.350	0.0001	Yes	0.9697	0.0010	0.9717	3.70E-02	
VERSAPAK_HAC_INFS2_20_A	20	100	0.350	0.0001	Yes	0.9113	0.0009	0.9131	3.46E-02	
VERSAPAK_HAC_INFS2_30_A	30	100	0.350	0.0001	Yes	0.7952	0.0010	0.7971	3.23E-02	
Infinite Triangular Package Array - Homogeneous Fissile Material as a Function of Drum Fill Percentage – Bottom Filled Inverted Bottom										
VERSAPAK_HAC_INFH2_10M_A	10	100	0.350	0.0001	Yes	1.0161	0.0010	1.0181	4.28E-02	Containment radius reduced from 19.2088 to 19.05-cm

Note:

Duplicate entry for observance of trend.

Table 6-7 HAC Results for Lumped Sperical and Cylindrical Fissile Mass Models

Case ID	Radius (cm) of Sphere or Cylinder (H/D)	Modeled Package Array	Poly-Moderation	^{235}U Mass (kg)	Interspersed Moderation (water volume fraction)	Close Water Reflection	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)	Comments
Triangular Package Arrays – Lumped Spherical Fissile Mass – Initial Array Sensitivity Study											
VERSAPAK_HAC_FINH_8S_A1	8	2x2x2=8	100	0.350	0.0001	Yes	0.5932	0.0013	0.5958	8.89E-02	
VERSAPAK_HAC_FINH_8S_A2	8	4x4x4=64	100	0.350	0.0001	Yes	0.6311	0.0013	0.6337	8.84E-02	
VERSAPAK_HAC_FINH_8S_A3	8	6x6x4=144	100	0.350	0.0001	Yes	0.6672	0.0014	0.6700	8.82E-02	
VERSAPAK_HAC_FINH_8S_A4	8	6x6x6=216	100	0.350	0.0001	Yes	0.6827	0.0014	0.6855	8.79E-02	
VERSAPAK_HAC_FINH_8S_A5	8	8x8x6=384	100	0.350	0.0001	Yes	0.7182	0.0014	0.7210	8.79E-02	
VERSAPAK_HAC_FINH_8S_A6	8	8x8x8=512	100	0.350	0.0001	Yes	0.7282	0.0013	0.7308	8.76E-02	
VERSAPAK_HAC_FINH_8S_A7	8	10x10x8=800	100	0.350	0.0001	Yes	0.7695	0.0014	0.7723	8.74E-02	
VERSAPAK_HAC_FINH_10S_A1	10	2x2x2=8	100	0.350	0.0001	Yes	0.7381	0.0014	0.7409	5.11E-02	
VERSAPAK_HAC_FINH_10S_A2	10	4x4x4=64	100	0.350	0.0001	Yes	0.7804	0.0012	0.7828	5.11E-02	
VERSAPAK_HAC_FINH_10S_A3	10	6x6x4=144	100	0.350	0.0001	Yes	0.8214	0.0012	0.8238	5.10E-02	
VERSAPAK_HAC_FINH_10S_A4	10	6x6x6=216	100	0.350	0.0001	Yes	0.8346	0.0011	0.8368	5.12E-02	
VERSAPAK_HAC_FINH_10S_A5	10	8x8x6=384	100	0.350	0.0001	Yes	0.8712	0.0015	0.8742	5.11E-02	
VERSAPAK_HAC_FINH_10S_A6	10	8x8x8=512	100	0.350	0.0001	Yes	0.8841	0.0014	0.8869	5.10E-02	
VERSAPAK_HAC_FINH_10S_A7	10	10x10x8=800	100	0.350	0.0001	Yes	0.9210	0.0013	0.9236	5.11E-02	
VERSAPAK_HAC_FINH_12S_A1	12	2x2x2=8	100	0.350	0.0001	Yes	0.7973	0.0011	0.7995	3.92E-02	
VERSAPAK_HAC_FINH_12S_A2	12	4x4x4=64	100	0.350	0.0001	Yes	0.8403	0.0012	0.8427	3.93E-02	
VERSAPAK_HAC_FINH_12S_A3	12	6x6x4=144	100	0.350	0.0001	Yes	0.8791	0.0012	0.8815	3.94E-02	
VERSAPAK_HAC_FINH_12S_A4	12	6x6x6=216	100	0.350	0.0001	Yes	0.8889	0.0013	0.8915	3.94E-02	
VERSAPAK_HAC_FINH_12S_A5	12	8x8x6=384	100	0.350	0.0001	Yes	0.9220	0.0011	0.9242	3.94E-02	
VERSAPAK_HAC_FINH_12S_A6	12	8x8x8=512	100	0.350	0.0001	Yes	0.9341	0.0012	0.9365	3.94E-02	
VERSAPAK_HAC_FINH_12S_A7	12	10x10x8=800	100	0.350	0.0001	Yes	0.9623	0.0013	0.9649	3.95E-02	

Table 6-7 HAC Results for Lumped Sperical and Cylindrical Fissile Mass Models

Case ID	Radius (cm) of Sphere or Cylinder (H/D)	Modeled Package Array	Poly-Moderation	^{235}U Mass (kg)	Interspersed Moderation (water volume fraction)	Close Water Reflection	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)	Comments
VERSAPAK_HAC_FINH_14S_A1	14	2x2x2=8	100	0.350	0.0001	Yes	0.7929	0.0010	0.7949	3.41E-02	
VERSAPAK_HAC_FINH_14S_A2	14	4x4x4=64	100	0.350	0.0001	Yes	0.8359	0.0010	0.8379	3.41E-02	
VERSAPAK_HAC_FINH_14S_A3	14	6x6x4=144	100	0.350	0.0001	Yes	0.8662	0.0011	0.8684	3.42E-02	
VERSAPAK_HAC_FINH_14S_A4	14	6x6x6=216	100	0.350	0.0001	Yes	0.8762	0.0010	0.8782	3.42E-02	
VERSAPAK_HAC_FINH_14S_A5	14	8x8x6=384	100	0.350	0.0001	Yes	0.9037	0.0011	0.9059	3.43E-02	
VERSAPAK_HAC_FINH_14S_A6	14	8x8x8=512	100	0.350	0.0001	Yes	0.9084	0.0010	0.9104	3.43E-02	
VERSAPAK_HAC_FINH_14S_A7	14	10x10x8=800	100	0.350	0.0001	Yes	0.9314	0.0010	0.9334	3.43E-02	
Square Package Arrays – Lumped Spherical Fissile Mass – Initial Array Sensitivity Study											
VERSAPAK_HAC_FINS_10S_A1	10	2x2x2=8	100	0.350	0.0001	Yes	0.7348	0.0012	0.7372	5.11E-02	
VERSAPAK_HAC_FINS_10S_A2	10	4x4x4=64	100	0.350	0.0001	Yes	0.7780	0.0012	0.7804	5.12E-02	
VERSAPAK_HAC_FINS_10S_A3	10	6x6x4=144	100	0.350	0.0001	Yes	0.8118	0.0012	0.8142	5.12E-02	
VERSAPAK_HAC_FINS_10S_A4	10	6x6x6=216	100	0.350	0.0001	Yes	0.8241	0.0012	0.8265	5.11E-02	
VERSAPAK_HAC_FINS_10S_A5	10	8x8x6=384	100	0.350	0.0001	Yes	0.8583	0.0014	0.8611	5.12E-02	
VERSAPAK_HAC_FINS_10S_A6	10	8x8x8=512	100	0.350	0.0001	Yes	0.8706	0.0014	0.8734	5.13E-02	
VERSAPAK_HAC_FINS_10S_A7	10	10x10x8=800	100	0.350	0.0001	Yes	0.9056	0.0014	0.9084	5.11E-02	
VERSAPAK_HAC_FINS_12S_A1	12	2x2x2=8	100	0.350	0.0001	Yes	0.7923	0.0012	0.7947	3.92E-02	
VERSAPAK_HAC_FINS_12S_A2	12	4x4x4=64	100	0.350	0.0001	Yes	0.8381	0.0014	0.8409	3.93E-02	
VERSAPAK_HAC_FINS_12S_A3	12	6x6x4=144	100	0.350	0.0001	Yes	0.8720	0.0011	0.8742	3.93E-02	
VERSAPAK_HAC_FINS_12S_A4	12	6x6x6=216	100	0.350	0.0001	Yes	0.8814	0.0012	0.8838	3.93E-02	
VERSAPAK_HAC_FINS_12S_A5	12	8x8x6=384	100	0.350	0.0001	Yes	0.9154	0.0012	0.9178	3.94E-02	
VERSAPAK_HAC_FINS_12S_A6	12	8x8x8=512	100	0.350	0.0001	Yes	0.9219	0.0012	0.9243	3.94E-02	
VERSAPAK_HAC_FINS_12S_A7	12	10x10x8=800	100	0.350	0.0001	Yes	0.9505	0.0012	0.9529	3.95E-02	

Table 6-7 HAC Results for Lumped Sperical and Cylindrical Fissile Mass Models

Case ID	Radius (cm) of Sphere or Cylinder (H/D)	Modeled Package Array	Poly-Moderation	^{235}U Mass (kg)	Interspersed Moderation (water volume fraction)	Close Water Reflection	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)	Comments
VERSAPAK_HAC_FINS_14S_A1	14	2x2x2=8	100	0.350	0.0001	Yes	0.7926	0.0010	0.7946	3.41E-02	
VERSAPAK_HAC_FINS_14S_A2	14	4x4x4=64	100	0.350	0.0001	Yes	0.8331	0.0011	0.8353	3.42E-02	
VERSAPAK_HAC_FINS_14S_A3	14	6x6x4=144	100	0.350	0.0001	Yes	0.8573	0.0010	0.8593	3.42E-02	
VERSAPAK_HAC_FINS_14S_A4	14	6x6x6=216	100	0.350	0.0001	Yes	0.8713	0.0010	0.8733	3.42E-02	
VERSAPAK_HAC_FINS_14S_A5	14	8x8x6=384	100	0.350	0.0001	Yes	0.8962	0.0010	0.8982	3.43E-02	
VERSAPAK_HAC_FINS_14S_A6	14	8x8x8=512	100	0.350	0.0001	Yes	0.9047	0.0010	0.9067	3.43E-02	
VERSAPAK_HAC_FINS_14S_A7	14	10x10x8=800	100	0.350	0.0001	Yes	0.9236	0.0010	0.9256	3.43E-02	
Triangular Package Arrays – Lumped Cylindrical Fissile Mass – Initial Array Sensitivity Study											
VERSAPAK_HAC_FINH_8C_A1	8 (1.0)	2x2x2=8	100	0.350	0.0001	Yes	0.6623	0.0012	0.6647	6.18E-02	
VERSAPAK_HAC_FINH_8C_A2	8 (1.0)	4x4x4=64	100	0.350	0.0001	Yes	0.7005	0.0012	0.7029	6.18E-02	
VERSAPAK_HAC_FINH_8C_A3	8 (1.0)	6x6x4=144	100	0.350	0.0001	Yes	0.7433	0.0014	0.7461	6.20E-02	
VERSAPAK_HAC_FINH_8C_A4	8 (1.0)	6x6x6=216	100	0.350	0.0001	Yes	0.7562	0.0013	0.7588	6.18E-02	
VERSAPAK_HAC_FINH_8C_A5	8 (1.0)	8x8x6=384	100	0.350	0.0001	Yes	0.7955	0.0013	0.7981	6.19E-02	
VERSAPAK_HAC_FINH_8C_A6	8 (1.0)	8x8x8=512	100	0.350	0.0001	Yes	0.8075	0.0013	0.8101	6.17E-02	
VERSAPAK_HAC_FINH_8C_A7	8 (1.0)	10x10x8=800	100	0.350	0.0001	Yes	0.8462	0.0013	0.8488	6.19E-02	
VERSAPAK_HAC_FINH_10C_A1	10 (1.0)	2x2x2=8	100	0.350	0.0001	Yes	0.7741	0.0011	0.7763	4.17E-02	
VERSAPAK_HAC_FINH_10C_A2	10 (1.0)	4x4x4=64	100	0.350	0.0001	Yes	0.8179	0.0013	0.8205	4.18E-02	
VERSAPAK_HAC_FINH_10C_A3	10 (1.0)	6x6x4=144	100	0.350	0.0001	Yes	0.8546	0.0013	0.8572	4.19E-02	
VERSAPAK_HAC_FINH_10C_A4	10 (1.0)	6x6x6=216	100	0.350	0.0001	Yes	0.8657	0.0012	0.8681	4.19E-02	
VERSAPAK_HAC_FINH_10C_A5	10 (1.0)	8x8x6=384	100	0.350	0.0001	Yes	0.9033	0.0012	0.9057	4.19E-02	
VERSAPAK_HAC_FINH_10C_A6	10 (1.0)	8x8x8=512	100	0.350	0.0001	Yes	0.9126	0.0013	0.9152	4.20E-02	
VERSAPAK_HAC_FINH_10C_A7	10 (1.0)	10x10x8=800	100	0.350	0.0001	Yes	0.9427	0.0014	0.9455	4.21E-02	

Table 6-7 HAC Results for Lumped Sperical and Cylindrical Fissile Mass Models

Case ID	Radius (cm) of Sphere or Cylinder (H/D)	Modeled Package Array	Poly-Moderation	^{235}U Mass (kg)	Interspersed Moderation (water volume fraction)	Close Water Reflection	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)	Comments
VERSAPAK_HAC_FINH_12C_A1	12 (1.0)	2x2x2=8	100	0.350	0.0001	Yes	0.7854	0.0010	0.7874	3.47E-02	
VERSAPAK_HAC_FINH_12C_A2	12 (1.0)	4x4x4=64	100	0.350	0.0001	Yes	0.8248	0.0011	0.8270	3.48E-02	
VERSAPAK_HAC_FINH_12C_A3	12 (1.0)	6x6x4=144	100	0.350	0.0001	Yes	0.8592	0.0010	0.8612	3.49E-02	
VERSAPAK_HAC_FINH_12C_A4	12 (1.0)	6x6x6=216	100	0.350	0.0001	Yes	0.8674	0.0011	0.8696	3.49E-02	
VERSAPAK_HAC_FINH_12C_A5	12 (1.0)	8x8x6=384	100	0.350	0.0001	Yes	0.8958	0.0010	0.8978	3.49E-02	
VERSAPAK_HAC_FINH_12C_A6	12 (1.0)	8x8x8=512	100	0.350	0.0001	Yes	0.9000	0.0010	0.9020	3.50E-02	
VERSAPAK_HAC_FINH_12C_A7	12 (1.0)	10x10x8=800	100	0.350	0.0001	Yes	0.9227	0.0010	0.9247	3.50E-02	
VERSAPAK_HAC_FINH_14C_A1	14 (1.0)	2x2x2=8	100	0.350	0.0001	Yes	0.7377	0.0009	0.7395	3.15E-02	
VERSAPAK_HAC_FINH_14C_A2	14 (1.0)	4x4x4=64	100	0.350	0.0001	Yes	0.7737	0.0011	0.7759	3.16E-02	
VERSAPAK_HAC_FINH_14C_A3	14 (1.0)	6x6x4=144	100	0.350	0.0001	Yes	0.7985	0.0009	0.8003	3.17E-02	
VERSAPAK_HAC_FINH_14C_A4	14 (1.0)	6x6x6=216	100	0.350	0.0001	Yes	0.8057	0.0008	0.8073	3.17E-02	
VERSAPAK_HAC_FINH_14C_A5	14 (1.0)	8x8x6=384	100	0.350	0.0001	Yes	0.8247	0.0009	0.8265	3.17E-02	
VERSAPAK_HAC_FINH_14C_A6	14 (1.0)	8x8x8=512	100	0.350	0.0001	Yes	0.8296	0.0008	0.8312	3.17E-02	
VERSAPAK_HAC_FINH_14C_A7	14 (1.0)	10x10x8=800	100	0.350	0.0001	Yes	0.8436	0.0009	0.8454	3.17E-02	
Triangular Package Arrays – Lumped Cylindrical Fissile Mass – Initial Array Sensitivity Study – 10.0” Cylinder Height-to-Diameter Sensitivity											
VERSAPAK_HAC_FINH_10C12_A1	10 (1.2)	2x2x2=8	100	0.350	0.0001	Yes	0.7777	0.0013	0.7803	3.88E-02	
VERSAPAK_HAC_FINH_10C12_A2	10 (1.2)	4x4x4=64	100	0.350	0.0001	Yes	0.8204	0.0012	0.8228	3.89E-02	
VERSAPAK_HAC_FINH_10C12_A3	10 (1.2)	6x6x4=144	100	0.350	0.0001	Yes	0.8587	0.0010	0.8607	3.91E-02	
VERSAPAK_HAC_FINH_10C12_A4	10 (1.2)	6x6x6=216	100	0.350	0.0001	Yes	0.8711	0.0010	0.8731	3.90E-02	
VERSAPAK_HAC_FINH_10C12_A5	10 (1.2)	8x8x6=384	100	0.350	0.0001	Yes	0.9041	0.0011	0.9063	3.91E-02	
VERSAPAK_HAC_FINH_10C12_A6	10 (1.2)	8x8x8=512	100	0.350	0.0001	Yes	0.9130	0.0011	0.9152	3.91E-02	
VERSAPAK_HAC_FINH_10C12_A7	10 (1.2)	10x10x8=800	100	0.350	0.0001	Yes	0.9428	0.0012	0.9452	3.92E-02	

Table 6-7 HAC Results for Lumped Sperical and Cylindrical Fissile Mass Models

Case ID	Radius (cm) of Sphere or Cylinder (H/D)	Modeled Package Array	Poly-Moderation	^{235}U Mass (kg)	Interspersed Moderation (water volume fraction)	Close Water Reflection	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)	Comments
VERSAPAK_HAC_FINH_10C11_A1	10 (1.1)	2x2x2=8	100	0.350	0.0001	Yes	0.8229	0.0012	0.8253	4.34E-02	
VERSAPAK_HAC_FINH_10C11_A2	10 (1.1)	4x4x4=64	100	0.350	0.0001	Yes	0.8202	0.0011	0.8224	4.03E-02	
VERSAPAK_HAC_FINH_10C11_A3	10 (1.1)	6x6x4=144	100	0.350	0.0001	Yes	0.8570	0.0014	0.8598	4.03E-02	
VERSAPAK_HAC_FINH_10C11_A4	10 (1.1)	6x6x6=216	100	0.350	0.0001	Yes	0.8723	0.0011	0.8745	4.03E-02	
VERSAPAK_HAC_FINH_10C11_A5	10 (1.1)	8x8x6=384	100	0.350	0.0001	Yes	0.9038	0.0012	0.9062	4.04E-02	
VERSAPAK_HAC_FINH_10C11_A6	10 (1.1)	8x8x8=512	100	0.350	0.0001	Yes	0.9131	0.0014	0.9159	4.04E-02	
VERSAPAK_HAC_FINH_10C11_A7	10 (1.1)	10x10x8=800	100	0.350	0.0001	Yes	0.9430	0.0012	0.9454	4.05E-02	
VERSAPAK_HAC_FINH_10C9_A1	10 (0.9)	2x2x2=8	100	0.350	0.0001	Yes	0.7676	0.0013	0.7702	4.37E-02	
VERSAPAK_HAC_FINH_10C9_A2	10 (0.9)	4x4x4=64	100	0.350	0.0001	Yes	0.8099	0.0012	0.8123	4.38E-02	
VERSAPAK_HAC_FINH_10C9_A3	10 (0.9)	6x6x4=144	100	0.350	0.0001	Yes	0.8485	0.0012	0.8509	4.39E-02	
VERSAPAK_HAC_FINH_10C9_A4	10 (0.9)	6x6x6=216	100	0.350	0.0001	Yes	0.8581	0.0012	0.8605	4.39E-02	
VERSAPAK_HAC_FINH_10C9_A5	10 (0.9)	8x8x6=384	100	0.350	0.0001	Yes	0.8954	0.0013	0.8980	4.40E-02	
VERSAPAK_HAC_FINH_10C9_A6	10 (0.9)	8x8x8=512	100	0.350	0.0001	Yes	0.9035	0.0013	0.9061	4.41E-02	
VERSAPAK_HAC_FINH_10C9_A7	10 (0.9)	10x10x8=800	100	0.350	0.0001	Yes	0.9373	0.0013	0.9399	4.41E-02	
Triangular Package Arrays – Lumped Cylindrical Fissile Mass – Initial Array Sensitivity Study – 12.0" Cylinder Height-to-Diameter Sensitivity											
VERSAPAK_HAC_FINH_12C11_A1	12 (1.1)	2x2x2=8	100	0.350	0.0001	Yes	0.7787	0.0010	0.7807	3.39E-02	
VERSAPAK_HAC_FINH_12C11_A2	12 (1.1)	4x4x4=64	100	0.350	0.0001	Yes	0.8178	0.0009	0.8196	3.40E-02	
VERSAPAK_HAC_FINH_12C11_A3	12 (1.1)	6x6x4=144	100	0.350	0.0001	Yes	0.8481	0.0010	0.8501	3.41E-02	
VERSAPAK_HAC_FINH_12C11_A4	12 (1.1)	6x6x6=216	100	0.350	0.0001	Yes	0.8568	0.0011	0.8590	3.41E-02	
VERSAPAK_HAC_FINH_12C11_A5	12 (1.1)	8x8x6=384	100	0.350	0.0001	Yes	0.8819	0.0010	0.8839	3.41E-02	
VERSAPAK_HAC_FINH_12C11_A6	12 (1.1)	8x8x8=512	100	0.350	0.0001	Yes	0.8904	0.0010	0.8924	3.42E-02	
VERSAPAK_HAC_FINH_12C11_A7	12 (1.1)	10x10x8=800	100	0.350	0.0001	Yes	0.9103	0.0010	0.9123	3.42E-02	

Table 6-7 HAC Results for Lumped Sperical and Cylindrical Fissile Mass Models

Case ID	Radius (cm) of Sphere or Cylinder (H/D)	Modeled Package Array	Poly-Moderation	^{235}U Mass (kg)	Interspersed Moderation (water volume fraction)	Close Water Reflection	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)	Comments
VERSAPAK_HAC_FINH_12C9_A1	12 (0.9)	2x2x2=8	100	0.350	0.0001	Yes	0.7917	0.0011	0.7939	3.57E-02	
VERSAPAK_HAC_FINH_12C9_A2	12 (0.9)	4x4x4=64	100	0.350	0.0001	Yes	0.8308	0.0010	0.8328	3.58E-02	
VERSAPAK_HAC_FINH_12C9_A3	12 (0.9)	6x6x4=144	100	0.350	0.0001	Yes	0.8661	0.0009	0.8679	3.59E-02	
VERSAPAK_HAC_FINH_12C9_A4	12 (0.9)	6x6x6=216	100	0.350	0.0001	Yes	0.8769	0.0010	0.8789	3.59E-02	
VERSAPAK_HAC_FINH_12C9_A5	12 (0.9)	8x8x6=384	100	0.350	0.0001	Yes	0.9043	0.0011	0.9065	3.60E-02	
VERSAPAK_HAC_FINH_12C9_A6	12 (0.9)	8x8x8=512	100	0.350	0.0001	Yes	0.9125	0.0009	0.9143	3.60E-02	
VERSAPAK_HAC_FINH_12C9_A7	12 (0.9)	10x10x8=800	100	0.350	0.0001	Yes	0.9391	0.0009	0.9409	3.60E-02	
VERSAPAK_HAC_FINH_12C8_A1	12 (0.8)	2x2x2=8	100	0.350	0.0001	Yes	0.7908	0.0011	0.7930	3.70E-02	
VERSAPAK_HAC_FINH_12C8_A2	12 (0.8)	4x4x4=64	100	0.350	0.0001	Yes	0.8317	0.0012	0.8341	3.71E-02	
VERSAPAK_HAC_FINH_12C8_A3	12 (0.8)	6x6x4=144	100	0.350	0.0001	Yes	0.8657	0.0011	0.8679	3.72E-02	
VERSAPAK_HAC_FINH_12C8_A4	12 (0.8)	6x6x6=216	100	0.350	0.0001	Yes	0.8794	0.0011	0.8816	3.72E-02	
VERSAPAK_HAC_FINH_12C8_A5	12 (0.8)	8x8x6=384	100	0.350	0.0001	Yes	0.9061	0.0010	0.9081	3.73E-02	
VERSAPAK_HAC_FINH_12C8_A6	12 (0.8)	8x8x8=512	100	0.350	0.0001	Yes	0.9158	0.0011	0.9180	3.73E-02	
VERSAPAK_HAC_FINH_12C8_A7	12 (0.8)	10x10x8=800	100	0.350	0.0001	Yes	0.9426	0.0012	0.9450	3.73E-02	
VERSAPAK_HAC_FINH_12C6_A1	12 (0.6)	2x2x2=8	100	0.350	0.0001	Yes	0.7631	0.0013	0.7657	4.13E-02	
VERSAPAK_HAC_FINH_12C6_A2	12 (0.6)	4x4x4=64	100	0.350	0.0001	Yes	0.8088	0.0011	0.8110	4.13E-02	
VERSAPAK_HAC_FINH_12C6_A3	12 (0.6)	6x6x4=144	100	0.350	0.0001	Yes	0.8469	0.0010	0.8489	4.14E-02	
VERSAPAK_HAC_FINH_12C6_A4	12 (0.6)	6x6x6=216	100	0.350	0.0001	Yes	0.8471	0.0013	0.8497	4.14E-02	
VERSAPAK_HAC_FINH_12C6_A5	12 (0.6)	8x8x6=384	100	0.350	0.0001	Yes	0.8913	0.0012	0.8937	4.16E-02	
VERSAPAK_HAC_FINH_12C6_A6	12 (0.6)	8x8x8=512	100	0.350	0.0001	Yes	0.9029	0.0015	0.9059	4.15E-02	
VERSAPAK_HAC_FINH_12C6_A7	12 (0.6)	10x10x8=800	100	0.350	0.0001	Yes	0.9336	0.0012	0.9360	4.16E-02	

Table 6-8 HAC Results for 12-cm Radius Spherical Mass: Increased Array Size and Poly-Moderation

Case ID	Radius (cm) of Sphere	Modeled Package Array	Poly-Moderation Density	^{235}U Mass (kg)	Interspersed Moderation (water volume fraction)	Close Water Reflection	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)	Comments
Triangular Package Arrays – Lumped Spherical Fissile Mass – Normal Density Poly-Moderation Sensitivity Study											
VERSAPAK_HAC_FINH_12S_1X400	12	16x25x1=400	0.92	0.350	0.0001	Yes	0.8240	0.0011	0.8262	3.92E-02	
VERSAPAK_HAC_FINH_12S_1x416	12	16x26x1=416	0.92	0.350	0.0001	Yes	0.8273	0.0012	0.8297	3.92E-02	
VERSAPAK_HAC_FINH_12S_1x468	12	18x26x1=468	0.92	0.350	0.0001	Yes	0.8249	0.0012	0.8273	3.93E-02	
VERSAPAK_HAC_FINH_12S_2X324	12	20x18x2=720	0.92	0.350	0.0001	Yes	0.9077	0.0011	0.9099	3.95E-02	
VERSAPAK_HAC_FINH_12S_2x400	12	16x25x2=800	0.92	0.350	0.0001	Yes	0.9076	0.0010	0.9096	3.94E-02	
VERSAPAK_HAC_FINH_12S_2x416	12	16x26x2=832	0.92	0.350	0.0001	Yes	0.9074	0.0013	0.9100	3.94E-02	
VERSAPAK_HAC_FINH_12S_2x468	12	18x26x2=936	0.92	0.350	0.0001	Yes	0.9110	0.0012	0.9134	3.94E-02	
VERSAPAK_HAC_FINH_12S_3X120	12	10x12x3=360	0.92	0.350	0.0001	Yes	0.9202	0.0012	0.9226	3.94E-02	
VERSAPAK_HAC_FINH_12S_3X144	12	12x12x3=432	0.92	0.350	0.0001	Yes	0.9253	0.0011	0.9275	3.94E-02	
VERSAPAK_HAC_FINH_12S_3X224	12	14x16x3=672	0.92	0.350	0.0001	Yes	0.9371	0.0013	0.9397	3.95E-02	
VERSAPAK_HAC_FINH_12S_3X324	12	20x18x3=1080	0.92	0.350	0.0001	Yes	0.9500	0.0011	0.9522	3.95E-02	
VERSAPAK_HAC_FINH_12S_3x400	12	16x25x3=1200	0.92	0.350	0.0001	Yes	0.9491	0.0012	0.9515	3.95E-02	
VERSAPAK_HAC_FINH_12S_3x416	12	16x26x3=1248	0.92	0.350	0.0001	Yes	0.9504	0.0011	0.9526	3.94E-02	
VERSAPAK_HAC_FINH_12S_3x468	12	18x26x3=1404	0.92	0.350	0.0001	Yes	0.9548	0.0011	0.9570	3.94E-02	
VERSAPAK_HAC_FINS_12_A3	12	6x6x4=144	0.92	0.350	0.0001	Yes	0.8720	0.0011	0.8742	3.93E-02	
VERSAPAK_HAC_FINH_12S_4X120	12	10x12x4=480	0.92	0.350	0.0001	Yes	0.9359	0.0011	0.9381	3.95E-02	
VERSAPAK_HAC_FINH_12S_4x400	12	16x25x4=1600	0.92	0.350	0.0001	Yes	0.9779	0.0010	0.9799	3.95E-02	
VERSAPAK_HAC_FINH_12S_4x416	12	16x26x4=1664	0.92	0.350	0.0001	Yes	0.9754	0.0011	0.9776	3.95E-02	
VERSAPAK_HAC_FINH_12S_4x468	12	18x26x4=1872	0.92	0.350	0.0001	Yes	0.9825	0.0012	0.9849	3.95E-02	
VERSAPAK_HAC_FINH_12S_5X080	12	8x10x5=400	0.92	0.350	0.0001	Yes	0.9322	0.0012	0.9346	3.95E-02	
VERSAPAK_HAC_FINH_12S_5X120	12	10x12x5=600	0.92	0.350	0.0001	Yes	0.9554	0.0012	0.9578	3.94E-02	
VERSAPAK_HAC_FINS_12_A4	12	6x6x6=216	0.92	0.350	0.0001	Yes	0.8814	0.0012	0.8838	3.93E-02	

Table 6-8 HAC Results for 12-cm Radius Spherical Mass: Increased Array Size and Poly-Moderation

Case ID	Radius (cm) of Sphere	Modeled Package Array	Poly-Moderation Density	^{235}U Mass (kg)	Interspersed Moderation (water volume fraction)	Close Water Reflection	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)	Comments
VERSAPAK_HAC_FINS_12_A5	12	8x8x6=384	0.92	0.350	0.0001	Yes	0.9154	0.0012	0.9178	3.94E-02	
VERSAPAK_HAC_FINH_12S_6X080	12	8x10x6=480	0.92	0.350	0.0001	Yes	0.9373	0.0012	0.9397	3.94E-02	
VERSAPAK_HAC_FINH_12S_7X064	12	8x8x7=448	0.92	0.350	0.0001	Yes	0.9319	0.0012	0.9343	3.94E-02	
VERSAPAK_HAC_FINH_12S_7X080	12	8x10x7=560	0.92	0.350	0.0001	Yes	0.9436	0.0012	0.9460	3.95E-02	
VERSAPAK_HAC_FINS_12_A6	12	8x8x8=512	0.92	0.350	0.0001	Yes	0.9219	0.0012	0.9243	3.94E-02	
VERSAPAK_HAC_FINH_12S_8X080	12	8x10x8=640	0.92	0.350	0.0001	Yes	0.9507	0.0012	0.9531	3.94E-02	
VERSAPAK_HAC_FINS_12_A7	12	10x10x8=800	0.92	0.350	0.0001	Yes	0.9505	0.0012	0.9529	3.95E-02	
VERSAPAK_HAC_FINH_12S_8X064	12	8x8x10=640	0.92	0.350	0.0001	Yes	0.9380	0.0011	0.9402	3.94E-02	
Triangular Package Arrays – Lumped Spherical Fissile Mass – Increased Density Poly-Moderation Sensitivity Study											
VERSAPAK_HAC_FINH_12S_1X400PM	12	16x25x1=400	0.98	0.350	0.0001	Yes	0.8572	0.0013	0.8598	3.82E-02	Increasing the poly-moderation density from 0.92 to 0.98 g/cc results in an average increase in the $k_{eff} + 2\sigma$ of 0.0221. This results in an array reduction from 400 to 300 packages to remain within the established USL of 0.94.
VERSAPAK_HAC_FINH_12S_1x416PM	12	16x26x1=416	0.98	0.350	0.0001	Yes	0.8520	0.0012	0.8544	3.82E-02	
VERSAPAK_HAC_FINH_12S_1x468PM	12	18x26x1=468	0.98	0.350	0.0001	Yes	0.8542	0.0011	0.8564	3.83E-02	
VERSAPAK_HAC_FINH_12S_2X324PM	12	20x18x2=720	0.98	0.350	0.0001	Yes	0.9270	0.0012	0.9294	3.84E-02	
VERSAPAK_HAC_FINH_12S_2x400PM	12	16x25x2=800	0.98	0.350	0.0001	Yes	0.9313	0.0011	0.9335	3.84E-02	
VERSAPAK_HAC_FINH_12S_2x416PM	12	16x26x2=832	0.98	0.350	0.0001	Yes	0.9301	0.0012	0.9325	3.84E-02	
VERSAPAK_HAC_FINH_12S_2x468PM	12	18x26x2=936	0.98	0.350	0.0001	Yes	0.9317	0.0011	0.9339	3.84E-02	
VERSAPAK_HAC_FINH_12S_3X120PM	12	10x12x3=360	0.98	0.350	0.0001	Yes	0.9413	0.0010	0.9433	3.84E-02	
VERSAPAK_HAC_FINH_12S_3X144PM	12	12x12x3=432	0.98	0.350	0.0001	Yes	0.9460	0.0011	0.9482	3.84E-02	
VERSAPAK_HAC_FINH_12S_3X224PM	12	14x16x3=672	0.98	0.350	0.0001	Yes	0.9574	0.0012	0.9598	3.84E-02	
VERSAPAK_HAC_FINH_12S_3X324PM	12	20x18x3=1080	0.98	0.350	0.0001	Yes	0.9694	0.0011	0.9716	3.84E-02	
VERSAPAK_HAC_FINH_12S_3x400PM	12	16x25x3=1200	0.98	0.350	0.0001	Yes	0.9703	0.0011	0.9725	3.84E-02	
VERSAPAK_HAC_FINH_12S_3x416PM	12	16x26x3=1248	0.98	0.350	0.0001	Yes	0.9672	0.0011	0.9694	3.84E-02	
VERSAPAK_HAC_FINH_12S_3x468PM	12	18x26x3=1404	0.98	0.350	0.0001	Yes	0.9728	0.0010	0.9748	3.85E-02	

Table 6-8 HAC Results for 12-cm Radius Spherical Mass: Increased Array Size and Poly-Moderation

Case ID	Radius (cm) of Sphere	Modeled Package Array	Poly-Moderation Density	^{235}U Mass (kg)	Interspersed Moderation (water volume fraction)	Close Water Reflection	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)	Comments
VERSAPAK_HAC_FINS_12_A3PM	12	6x6x4=144	0.98	0.350	0.0001	Yes	0.9026	0.0013	0.9052	3.83E-02	
VERSAPAK_HAC_FINH_12S_4X120PM	12	10x12x4=480	0.98	0.350	0.0001	Yes	0.9532	0.0012	0.9556	3.84E-02	
VERSAPAK_HAC_FINH_12S_4x400PM	12	16x25x4=1600	0.98	0.350	0.0001	Yes	0.9937	0.0011	0.9959	3.85E-02	
VERSAPAK_HAC_FINH_12S_4x416PM	12	16x26x4=1664	0.98	0.350	0.0001	Yes	0.9957	0.0012	0.9981	3.85E-02	
VERSAPAK_HAC_FINH_12S_4x468PM	12	18x26x4=1872	0.98	0.350	0.0001	Yes	0.9984	0.0011	1.0006	3.85E-02	
VERSAPAK_HAC_FINH_12S_5X080PM	12	8x10x5=400	0.98	0.350	0.0001	Yes	0.9523	0.0012	0.9547	3.84E-02	
VERSAPAK_HAC_FINH_12S_5X120PM	12	10x12x5=600	0.98	0.350	0.0001	Yes	0.9722	0.0012	0.9746	3.84E-02	
VERSAPAK_HAC_FINS_12_A4PM	12	6x6x6=216	0.98	0.350	0.0001	Yes	0.9101	0.0012	0.9125	3.83E-02	
VERSAPAK_HAC_FINS_12_A5PM	12	8x8x6=384	0.98	0.350	0.0001	Yes	0.9434	0.0011	0.9456	3.84E-02	
VERSAPAK_HAC_FINH_12S_6X080PM	12	8x10x6=480	0.98	0.350	0.0001	Yes	0.9571	0.0012	0.9595	3.84E-02	
VERSAPAK_HAC_FINH_12S_7X064PM	12	8x8x7=448	0.98	0.350	0.0001	Yes	0.9514	0.0012	0.9538	3.84E-02	
VERSAPAK_HAC_FINH_12S_7X080PM	12	8x10x7=560	0.98	0.350	0.0001	Yes	0.9648	0.0012	0.9672	3.84E-02	
VERSAPAK_HAC_FINS_12_A6PM	12	8x8x8=512	0.98	0.350	0.0001	Yes	0.9540	0.0011	0.9562	3.84E-02	
VERSAPAK_HAC_FINH_12S_8X080PM	12	8x10x8=640	0.98	0.350	0.0001	Yes	0.9672	0.0011	0.9694	3.84E-02	
VERSAPAK_HAC_FINS_12_A7PM	12	10x10x8=800	0.98	0.350	0.0001	Yes	0.9815	0.0015	0.9845	3.84E-02	
VERSAPAK_HAC_FINH_12S_8X064PM	12	8x8x10=640	0.98	0.350	0.0001	Yes	0.9579	0.0012	0.9603	3.84E-02	
Triangular Package Arrays – Lumped Spherical Fissile Mass – Paraffin Moderation Sensitivity Study											
VERSAPAK_HAC_FINH_12S_1X400PF	12	16x25x1=400	0.90	0.350	0.0001	Yes	0.8266	0.0012	0.8290	3.91E-02	All poly-moderation cases with density of 0.98 g/cc are higher than the paraffin cases with an average increase in the $k_{eff} + 2\sigma$ of 0.0194.
VERSAPAK_HAC_FINH_12S_1X416PF	12	16x26x1=416	0.90	0.350	0.0001	Yes	0.8272	0.0011	0.8294	3.91E-02	
VERSAPAK_HAC_FINH_12S_1X468PF	12	18x26x1=468	0.90	0.350	0.0001	Yes	0.8281	0.0011	0.8303	3.90E-02	
VERSAPAK_HAC_FINH_12S_2X324PF	12	20x18x2=720	0.90	0.350	0.0001	Yes	0.9075	0.0013	0.9101	3.93E-02	
VERSAPAK_HAC_FINH_12S_2X400PF	12	16x25x2=800	0.90	0.350	0.0001	Yes	0.9099	0.0010	0.9119	3.93E-02	
VERSAPAK_HAC_FINH_12S_2X416 PF	12	16x26x2=832	0.90	0.350	0.0001	Yes	0.9107	0.0011	0.9129	3.92E-02	

Table 6-8 HAC Results for 12-cm Radius Spherical Mass: Increased Array Size and Poly-Moderation

Case ID	Radius (cm) of Sphere	Modeled Package Array	Poly-Moderation Density	^{235}U Mass (kg)	Interspersed Moderation (water volume fraction)	Close Water Reflection	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)	Comments
VERSAPAK_HAC_FINH_12S_2X468 PF	12	18x26x2=936	0.90	0.350	0.0001	Yes	0.9118	0.0011	0.9140	3.93E-02	
VERSAPAK_HAC_FINH_12S_3X120 PF	12	10x12x3=360	0.90	0.350	0.0001	Yes	0.9202	0.0012	0.9226	3.93E-02	
VERSAPAK_HAC_FINH_12S_3X144 PF	12	12x12x3=432	0.90	0.350	0.0001	Yes	0.9256	0.0011	0.9278	3.93E-02	
VERSAPAK_HAC_FINH_12S_3X224 PF	12	14x16x3=672	0.90	0.350	0.0001	Yes	0.9410	0.0012	0.9434	3.92E-02	
VERSAPAK_HAC_FINH_12S_3X324 PF	12	20x18x3=1080	0.90	0.350	0.0001	Yes	0.9502	0.0011	0.9524	3.93E-02	
VERSAPAK_HAC_FINH_12S_3X400 PF	12	16x25x3=1200	0.90	0.350	0.0001	Yes	0.9531	0.0010	0.9551	3.93E-02	
VERSAPAK_HAC_FINH_12S_3X416 PF	12	16x26x3=1248	0.90	0.350	0.0001	Yes	0.9519	0.0012	0.9543	3.93E-02	
VERSAPAK_HAC_FINH_12S_3X468 PF	12	18x26x3=1404	0.90	0.350	0.0001	Yes	0.9530	0.0010	0.9550	3.93E-02	
VERSAPAK_HAC_FINH_12S_4X120 PF	12	10x12x4=480	0.90	0.350	0.0001	Yes	0.9382	0.0010	0.9402	3.93E-02	
VERSAPAK_HAC_FINH_12S_4X400 PF	12	16x25x4=1600	0.90	0.350	0.0001	Yes	0.9770	0.0013	0.9796	3.93E-02	
VERSAPAK_HAC_FINH_12S_4X416 PF	12	16x26x4=1664	0.90	0.350	0.0001	Yes	0.9790	0.0013	0.9816	3.93E-02	
VERSAPAK_HAC_FINH_12S_4X468 PF	12	18x26x4=1872	0.90	0.350	0.0001	Yes	0.9842	0.0010	0.9862	3.93E-02	
VERSAPAK_HAC_FINH_12S_5X080 PF	12	8x10x5=400	0.90	0.350	0.0001	Yes	0.9315	0.0010	0.9335	3.93E-02	
VERSAPAK_HAC_FINH_12S_5X120 PF	12	10x12x5=600	0.90	0.350	0.0001	Yes	0.9541	0.0011	0.9563	3.93E-02	
VERSAPAK_HAC_FINH_12S_6X080 PF	12	6x6x6=216	0.90	0.350	0.0001	Yes	0.9384	0.0012	0.9408	3.93E-02	
VERSAPAK_HAC_FINH_12S_7X064 PF	12	8x10x6=480	0.90	0.350	0.0001	Yes	0.9313	0.0013	0.9339	3.92E-02	
VERSAPAK_HAC_FINH_12S_7X080 PF	12	8x10x7=560	0.90	0.350	0.0001	Yes	0.9458	0.0011	0.9480	3.93E-02	
VERSAPAK_HAC_FINH_12S_8X080 PF	12	8x10x8=640	0.90	0.350	0.0001	Yes	0.9488	0.0011	0.9510	3.93E-02	
VERSAPAK_HAC_FINH_12S_10X064 PF	12	8x8x10=640	0.90	0.350	0.0001	Yes	0.9389	0.0013	0.9415	3.92E-02	

Table 6-9 HAC Results for 12-cm Radius Spherical Mass: Mutiple Sensitivity Studies

Case ID	Radius (cm) of Sphere	Modeled Package Array	Poly-Moderation	^{235}U Mass (kg)	Interspersed Moderation (water volume fraction)	Close Water Reflection	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)	Comments
Triangular Package Arrays – Lumped Spherical Fissile Mass – Normal Density Poly-Moderation - Cross Section Sensitivity Study											
VERSAPAK_HAC_FINH_12S_A7	12	10x10x8=800	100	0.350	0.0001	Yes	0.9623	0.0013	0.9649	3.95E-02	44 Group
VERSAPAK_HAC_FINH_12S_A7X	12	10x10x8=800	100	0.350	0.0001	Yes	0.9624	0.0012	0.9648	4.12E-02	238 Group
VERSAPAK_HAC_FINH_12S_A7X1	12	10x10x8=800	100	0.350	0.0001	Yes	0.9650	0.0008	0.9666	4.11E-02	238 Group Increased Histories
VERSAPAK_HAC_FINH_12S_A7XN	12	10x10x8=800	100	0.350	0.0001	Yes	0.9633	0.0008	0.9649	3.95E-02	44 Group Increased Histories
Triangular Package Arrays – Lumped Spherical Fissile Mass – Normal Density Poly-Moderation – Increased Fissile Mass Sensitivity Study											
VERSAPAK_HAC_FINH_12S_A1_375	12	2x2x2=8	100	0.375	0.0001	Yes	0.8135	0.0012	0.8159	4.01E-02	Increasing the fissile mass above 350 gcarbon steel content requires array size reduction
VERSAPAK_HAC_FINH_12S_A2_375	12	4x4x4=64	100	0.375	0.0001	Yes	0.8585	0.0011	0.8607	4.02E-02	
VERSAPAK_HAC_FINH_12S_A3_375	12	6x6x4=144	100	0.375	0.0001	Yes	0.8957	0.0011	0.8979	4.03E-02	
VERSAPAK_HAC_FINH_12S_A4_375	12	6x6x6=216	100	0.375	0.0001	Yes	0.9094	0.0014	0.9122	4.03E-02	
VERSAPAK_HAC_FINH_12S_A5_375	12	8x8x6=384	100	0.375	0.0001	Yes	0.9416	0.0012	0.9440	4.04E-02	
VERSAPAK_HAC_FINH_12S_A6_375	12	8x8x8=512	100	0.375	0.0001	Yes	0.9502	0.0011	0.9524	4.04E-02	
VERSAPAK_HAC_FINH_12S_A7_375	12	10x10x8=800	100	0.375	0.0001	Yes	0.9818	0.0010	0.9838	4.04E-02	
VERSAPAK_HAC_FINH_12S_A1_400	12	2x2x2=8	100	0.400	0.0001	Yes	0.8276	0.0012	0.8300	4.11E-02	
VERSAPAK_HAC_FINH_12S_A2_400	12	4x4x4=64	100	0.400	0.0001	Yes	0.8741	0.0013	0.8767	4.12E-02	
VERSAPAK_HAC_FINH_12S_A3_400	12	6x6x4=144	100	0.400	0.0001	Yes	0.9118	0.0012	0.9142	4.13E-02	
VERSAPAK_HAC_FINH_12S_A4_400	12	6x6x6=216	100	0.400	0.0001	Yes	0.9258	0.0012	0.9282	4.12E-02	
VERSAPAK_HAC_FINH_12S_A5_400	12	8x8x6=384	100	0.400	0.0001	Yes	0.9594	0.0012	0.9618	4.14E-02	
VERSAPAK_HAC_FINH_12S_A6_400	12	8x8x8=512	100	0.400	0.0001	Yes	0.9704	0.0013	0.9730	4.14E-02	
VERSAPAK_HAC_FINH_12S_A7_400	12	10x10x8=800	100	0.400	0.0001	Yes	1.0043	0.0011	1.0065	4.13E-02	
Triangular Package Arrays – Lumped Spherical Fissile Mass – Normal Density Poly-Moderation – Interspersed Moderation Sensitivity Study											
VERSAPAK_HAC_FINH_12S_A7	12	10x10x8=800	100	0.350	0.0001	Yes	0.9623	0.0013	0.9649	3.95E-02	Increased interspersed moderation reduces k_{ef}
VERSAPAK_HAC_FINH_12S_A7a	12	10x10x8=800	100	0.350	0.001	Yes	0.9621	0.0011	0.9643	3.94E-02	

Table 6-9 HAC Results for 12-cm Radius Spherical Mass: Mutiple Sensitivity Studies

Case ID	Radius (cm) of Sphere	Modeled Package Array	Poly-Moderation	^{235}U Mass (kg)	Interspersed Moderation (water volume fraction)	Close Water Reflection	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)	Comments
VERSAPAK_HAC_FINH_12S_A7b	12	10x10x8=800	100	0.350	0.01	Yes	0.9405	0.0012	0.9429	3.93E-02	
VERSAPAK_HAC_FINH_12S_A7c	12	10x10x8=800	100	0.350	0.1	Yes	0.8527	0.0012	0.8551	3.83E-02	
VERSAPAK_HAC_FINH_12S_A7d	12	10x10x8=800	100	0.350	0.5	Yes	0.8517	0.0013	0.8543	3.72E-02	
VERSAPAK_HAC_FINH_12S_A7e	12	10x10x8=800	100	0.350	1.0	Yes	0.8793	0.0016	0.8825	3.67E-02	
Triangular Package Arrays – Lumped Spherical Fissile Mass – Normal Density Poly-Moderation – Reduced Poly-Moderation Sensitivity Study											
VERSAPAK_HAC_FINH_12S_A7	12	10x10x8=800	100	0.350	0.0001	Yes	0.9623	0.0013	0.9649	3.95E-02	Reduced poly-moderation reduces k_{eff}
VERSAPAK_HAC_FINH_12S_A7B	12	10x10x8=800	90	0.350	0.0001	Yes	0.9315	0.0012	0.9339	4.14E-02	
VERSAPAK_HAC_FINH_12S_A7C	12	10x10x8=800	80	0.350	0.0001	Yes	0.8906	0.0013	0.8932	4.40E-02	
VERSAPAK_HAC_FINH_12S_A7D	12	10x10x8=800	70	0.350	0.0001	Yes	0.8358	0.0012	0.8382	4.76E-02	
VERSAPAK_HAC_FINH_12S_A7E	12	10x10x8=800	60	0.350	0.0001	Yes	0.7677	0.0014	0.7705	5.30E-02	
VERSAPAK_HAC_FINH_12S_A7F	12	10x10x8=800	50	0.350	0.0001	Yes	0.6809	0.0012	0.6833	6.15E-02	
Triangular Package Arrays – Lumped Spherical Fissile Mass – Normal Density Poly-Moderation – No Carbon Steel Sensitivity Study											
VERSAPAK_HAC_FINH_12S_A1NS	12	2x2x2=8	100	0.350	0.0001	Yes	0.8046	0.0010	0.8066	3.81E-02	Not crediting the minimum carbon steel content requires array size reduction
VERSAPAK_HAC_FINH_12S_A2NS	12	4x4x4=64	100	0.350	0.0001	Yes	0.8666	0.0011	0.8688	3.76E-02	
VERSAPAK_HAC_FINH_12S_A3NS	12	6x6x4=144	100	0.350	0.0001	Yes	0.9097	0.0012	0.9121	3.73E-02	
VERSAPAK_HAC_FINH_12S_A4NS	12	6x6x6=216	100	0.350	0.0001	Yes	0.9276	0.0012	0.9300	3.72E-02	
VERSAPAK_HAC_FINH_12S_A5NS	12	8x8x6=384	100	0.350	0.0001	Yes	0.9677	0.0013	0.9703	3.69E-02	
VERSAPAK_HAC_FINH_12S_A6NS	12	8x8x8=512	100	0.350	0.0001	Yes	0.9793	0.0011	0.9815	3.69E-02	
VERSAPAK_HAC_FINH_12S_A7NS	12	10x10x8=800	100	0.350	0.0001	Yes	1.0168	0.0010	1.0188	3.69E-02	
Triangular Package Arrays – Lumped Spherical Fissile Mass – Graphite Moderation Sensitivity Study											
VERSAPAK_HAC_FINH_12S_A7G	12	10x10x8=800	100	0.350	0.0001	Yes	0.1544	0.0005	0.1554	3.43E+00	

Table 6-10 Detailed Mass Placement Sensitivity Calculations for MOD0 - MOD4 Configurations

(Note: values exceeding the USL of 0.94 are high-lighted yellow)

CASE ID	ARRAY HEIGHT	# PACKAGES	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)
MOD0 - INITIAL ARRAY STUDY						
VERSAPAK_HAC_FINH_12S_1X306P	1	306	0.8514	0.0012	0.8538	3.82E-02
VERSAPAK_HAC_FINH_12S_1x315P	1	315	0.8541	0.0013	0.8567	3.82E-02
VERSAPAK_HAC_FINH_12S_1x324P	1	324	0.8536	0.0012	0.8560	3.82E-02
VERSAPAK_HAC_FINH_12S_2X312P	2	312	0.9162	0.0011	0.9184	3.83E-02
VERSAPAK_HAC_FINH_12S_2X326P	2	326	0.9172	0.0013	0.9198	3.84E-02
VERSAPAK_HAC_FINH_12S_2X338P	2	338	0.9184	0.0010	0.9204	3.84E-02
VERSAPAK_HAC_FINH_12S_3X300P	3	300	0.9333	0.0011	0.9355	3.84E-02
VERSAPAK_HAC_FINH_12S_4X272P	4	272	0.9298	0.0012	0.9322	3.84E-02
VERSAPAK_HAC_FINH_12S_4X308P	4	308	0.9360	0.0011	0.9382	3.84E-02
VERSAPAK_HAC_FINH_12S_5X260P	5	260	0.9299	0.0012	0.9323	3.83E-02
VERSAPAK_HAC_FINH_12S_5X280P	5	280	0.9364	0.0011	0.9386	3.83E-02
VERSAPAK_HAC_FINH_12S_5x300P	5	300	0.9361	0.0012	0.9385	3.84E-02
VERSAPAK_HAC_FINH_12S_6X312P	6	312	0.9341	0.0011	0.9363	3.83E-02
VERSAPAK_HAC_FINH_12S_6X336P	6	336	0.9376	0.0012	0.9400	3.83E-02
VERSAPAK_HAC_FINH_12S_7X322P	7	322	0.9303	0.0011	0.9325	3.83E-02
VERSAPAK_HAC_FINH_12S_7X343P	7	343	0.9360	0.0011	0.9382	3.83E-02
VERSAPAK_HAC_FINH_12S_8X312P	8	312	0.9212	0.0010	0.9232	3.84E-02
VERSAPAK_HAC_FINH_12S_8X336P	8	336	0.9280	0.0011	0.9302	3.83E-02
VERSAPAK_HAC_FINH_12S_8X368P	8	368	0.9313	0.0011	0.9335	3.83E-02
VERSAPAK_HAC_FINH_12S_8X392P	8	392	0.9370	0.0012	0.9394	3.83E-02
VERSAPAK_HAC_FINH_12S_9X324P	9	324	0.9224	0.0012	0.9248	3.83E-02
VERSAPAK_HAC_FINH_12S_10X300P	10	300	0.9121	0.0013	0.9147	3.83E-02

Table 6-10 Detailed Mass Placement Sensitivity Calculations for MOD0 - MOD4 Configurations

(Note: values exceeding the USL of 0.94 are high-lighted yellow)

CASE ID	ARRAY HEIGHT	# PACKAGES	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)
VERSAPAK_HAC_FINH_12S_10X330P	10	330	0.9153	0.0014	0.9181	3.83E-02
VERSAPAK_HAC_FINH_12S_10X360P	10	360	0.9220	0.0010	0.9240	3.83E-02
VERSAPAK_HAC_FINH_12S_12X300P	12	300	0.9028	0.0013	0.9054	3.83E-02
MOD1						
VERSAPAK_HAC_FINH_12S_4x272P	4	272	0.9378	0.0010	0.9398	3.84E-02
VERSAPAK_HAC_FINH_12S_4x288P	4	288	0.9390	0.0013	0.9416	3.84E-02
VERSAPAK_HAC_FINH_12S_4x308P	4	308	0.9431	0.0011	0.9453	3.84E-02
VERSAPAK_HAC_FINH_12S_5x280P	5	280	0.9358	0.0011	0.9380	3.84E-02
VERSAPAK_HAC_FINH_12S_6x288P	6	288	0.9345	0.0012	0.9369	3.84E-02
VERSAPAK_HAC_FINH_12S_6x312P	6	312	0.9409	0.0013	0.9435	3.84E-02
VERSAPAK_HAC_FINH_12S_7x322P	7	322	0.9330	0.0015	0.9360	3.83E-02
VERSAPAK_HAC_FINH_12S_8x312P	8	312	0.9246	0.0012	0.9270	3.83E-02
VERSAPAK_HAC_FINH_12S_9x324P	9	324	0.9214	0.0012	0.9238	3.83E-02
VERSAPAK_HAC_FINH_12S_10x300P	10	300	0.9114	0.0011	0.9136	3.83E-02
VERSAPAK_HAC_FINH_12S_12x300P	12	300	0.9032	0.0011	0.9054	3.83E-02
MOD2						
VERSAPAK_HAC_FINH_12S_4x272P	4	272	0.9076	0.0013	0.9102	3.83E-02
VERSAPAK_HAC_FINH_12S_4x288P	4	288	0.9088	0.0011	0.9110	3.83E-02
VERSAPAK_HAC_FINH_12S_4x308P	4	308	0.9118	0.0013	0.9144	3.83E-02
VERSAPAK_HAC_FINH_12S_5x280P	5	280	0.9115	0.0012	0.9139	3.83E-02
VERSAPAK_HAC_FINH_12S_6x288P	6	288	0.9063	0.0010	0.9083	3.83E-02
VERSAPAK_HAC_FINH_12S_6x312P	6	312	0.9152	0.0012	0.9176	3.83E-02
VERSAPAK_HAC_FINH_12S_7x322P	7	322	0.9121	0.0010	0.9141	3.83E-02

Table 6-10 Detailed Mass Placement Sensitivity Calculations for MOD0 - MOD4 Configurations

(Note: values exceeding the USL of 0.94 are high-lighted yellow)

CASE ID	ARRAY HEIGHT	# PACKAGES	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)
VERSAPAK_HAC_FINH_12S_8x312P	8	312	0.9070	0.0011	0.9092	3.83E-02
VERSAPAK_HAC_FINH_12S_9x324P	9	324	0.9054	0.0012	0.9078	3.83E-02
VERSAPAK_HAC_FINH_12S_10x300P	10	300	0.8972	0.0011	0.8994	3.83E-02
VERSAPAK_HAC_FINH_12S_12x300P	12	300	0.8900	0.0012	0.8924	3.83E-02
MOD3						
VERSAPAK_HAC_FINH_12S_4x272P	4	272	0.9353	0.0012	0.9377	3.84E-02
VERSAPAK_HAC_FINH_12S_4x288P	4	288	0.9372	0.0012	0.9396	3.84E-02
VERSAPAK_HAC_FINH_12S_4x308P	4	308	0.9377	0.0010	0.9397	3.84E-02
VERSAPAK_HAC_FINH_12S_5x280P	5	280	0.9347	0.0011	0.9369	3.84E-02
VERSAPAK_HAC_FINH_12S_6x288P	6	288	0.9318	0.0012	0.9342	3.84E-02
VERSAPAK_HAC_FINH_12S_6x312P	6	312	0.9358	0.0012	0.9382	3.84E-02
VERSAPAK_HAC_FINH_12S_7x322P	7	322	0.9302	0.0012	0.9326	3.84E-02
VERSAPAK_HAC_FINH_12S_8x312P	8	312	0.9234	0.0012	0.9258	3.83E-02
VERSAPAK_HAC_FINH_12S_9x324P	9	324	0.9214	0.0010	0.9234	3.83E-02
VERSAPAK_HAC_FINH_12S_10x300P	10	300	0.9092	0.0012	0.9116	3.83E-02
VERSAPAK_HAC_FINH_12S_12x300P	12	300	0.8985	0.0013	0.9011	3.83E-02
MOD4						
VERSAPAK_HAC_FINH_12S_4x272P	4	272	0.9323	0.0012	0.9347	3.84E-02
VERSAPAK_HAC_FINH_12S_4x288P	4	288	0.9367	0.0011	0.9389	3.84E-02
VERSAPAK_HAC_FINH_12S_4x308P	4	308	0.9370	0.0011	0.9392	3.84E-02
VERSAPAK_HAC_FINH_12S_6x288P	6	288	0.9258	0.0013	0.9284	3.84E-02
VERSAPAK_HAC_FINH_12S_6x312P	6	312	0.9314	0.0013	0.9340	3.84E-02

Table 6-11 Summary Mass Placement Sensitivity Calculations for MOD0 - MOD4 Configurations

(note: yellow high-lighted cells represent the bounding case, interspersed moderator VF=0.0001, poly-moderation density=0.98 g/cc)

CASE ID	ARRAY HEIGHT	# PACKAGES	$k_{eff} + 2\sigma$				
			MOD0	MOD1	MOD2	MOD3	MOD4
VERSAPAK_HAC_FINH_12S_1x324P	1	324	0.8560	0.8560	n/a	n/a	n/a
VERSAPAK_HAC_FINH_12S_2X338P	2	338	0.9204	0.9204	n/a	n/a	n/a
VERSAPAK_HAC_FINH_12S_3X300P	3	300	0.9355	0.9355	n/a	n/a	n/a
VERSAPAK_HAC_FINH_12S_4x272P	4	272	0.9322	0.9398	0.9102	0.9377	0.9347
VERSAPAK_HAC_FINH_12S_4x288P	4	288	n/a	0.9416	0.9110	0.9396	0.9389
VERSAPAK_HAC_FINH_12S_4X308P	4	308	0.9382	0.9453	0.9144	0.9397	0.9392
VERSAPAK_HAC_FINH_12S_5X260P	5	260	0.9323	n/a	n/a	n/a	n/a
VERSAPAK_HAC_FINH_12S_5X280P	5	280	0.9386	0.9380	0.9139	0.9369	n/a
VERSAPAK_HAC_FINH_12S_5x300P	5	300	0.9385	n/a	n/a	n/a	n/a
VERSAPAK_HAC_FINH_12S_6x288P	6	288	n/a	0.9369	0.9083	0.9342	0.9284
VERSAPAK_HAC_FINH_12S_6X312P	6	312	0.9363	0.9435	0.9176	0.9382	0.9340
VERSAPAK_HAC_FINH_12S_6X336P	6	336	0.9400	n/a	n/a	n/a	n/a
VERSAPAK_HAC_FINH_12S_7X322P	7	322	0.9325	0.9360	0.9141	0.9326	n/a
VERSAPAK_HAC_FINH_12S_7X343P	7	343	0.9382	n/a	n/a	n/a	n/a
VERSAPAK_HAC_FINH_12S_8X312P	8	312	0.9232	0.9270	0.9092	0.9258	n/a
VERSAPAK_HAC_FINH_12S_8X336P	8	336	0.9302	n/a	n/a	n/a	n/a
VERSAPAK_HAC_FINH_12S_8X368P	8	368	0.9335	n/a	n/a	n/a	n/a
VERSAPAK_HAC_FINH_12S_8X392P	8	392	0.9394	n/a	n/a	n/a	n/a
VERSAPAK_HAC_FINH_12S_9X324P	9	324	0.9248	0.9238	0.9078	0.9234	n/a
VERSAPAK_HAC_FINH_12S_10X300P	10	300	0.9147	0.9136	0.8994	0.9116	n/a
VERSAPAK_HAC_FINH_12S_10X330P	10	330	0.9181	n/a	n/a	n/a	n/a
VERSAPAK_HAC_FINH_12S_10X360P	10	360	0.9240	n/a	n/a	n/a	n/a
VERSAPAK_HAC_FINH_12S_12X300P	12	300	0.9054	0.9054	0.8924	0.9011	n/a

Table 6-12 Interspersed Moderation Sensitivity Calculations for MOD0 and MOD1 Configurations

(note: yellow high-lighted cells represent the bounding case)

CASE ID	Region/Mixture Moderator Volume Fraction	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)
MOD1 – Region/Mixture 5 – Payload Region					
VERSAPAK_HAC_FINH_12S_1x324P	0.0001	0.8536	0.0012	0.8560	3.82E-02
VERSAPAK_HAC_FINH_12S_1X324Pb	0.001	0.8531	0.0012	0.8555	3.82E-02
VERSAPAK_HAC_FINH_12S_1X324Pc	0.01	0.8532	0.0012	0.8556	3.81E-02
VERSAPAK_HAC_FINH_12S_1X324Pd	0.1	0.8565	0.0013	0.8591	3.77E-02
VERSAPAK_HAC_FINH_12S_1X324Pe	0.5	0.8780	0.0012	0.8804	3.67E-02
VERSAPAK_HAC_FINH_12S_1X324Pf	1	0.8988	0.0011	0.9010	3.63E-02
VERSAPAK_HAC_FINH_12S_2X338P	0.0001	0.9184	0.0010	0.9204	3.84E-02
VERSAPAK_HAC_FINH_12S_2X338Pb	0.001	0.9174	0.0012	0.9198	3.84E-02
VERSAPAK_HAC_FINH_12S_2X338Pc	0.01	0.9189	0.0012	0.9213	3.83E-02
VERSAPAK_HAC_FINH_12S_2X338Pd	0.1	0.9101	0.0011	0.9123	3.77E-02
VERSAPAK_HAC_FINH_12S_2X338Pe	0.5	0.9067	0.0012	0.9091	3.67E-02
VERSAPAK_HAC_FINH_12S_2X338Pf	1	0.9153	0.0011	0.9175	3.62E-02
VERSAPAK_HAC_FINH_12S_3X300P	0.0001	0.9333	0.0011	0.9355	3.84E-02
VERSAPAK_HAC_FINH_12S_3X300Pb	0.001	0.9347	0.0012	0.9371	3.83E-02
VERSAPAK_HAC_FINH_12S_3X300Pc	0.01	0.9329	0.0011	0.9351	3.83E-02
VERSAPAK_HAC_FINH_12S_3X300Pd	0.1	0.9163	0.0012	0.9187	3.77E-02
VERSAPAK_HAC_FINH_12S_3X300Pe	0.5	0.9035	0.0011	0.9057	3.66E-02
VERSAPAK_HAC_FINH_12S_3X300Pf	1	0.9136	0.0011	0.9158	3.62E-02
VERSAPAK_HAC_FINH_12S_4x272P	0.0001	0.9378	0.0010	0.9398	3.84E-02
VERSAPAK_HAC_FINH_12S_4x272Pb	0.001	0.9374	0.0012	0.9398	3.84E-02
VERSAPAK_HAC_FINH_12S_4x272Pc	0.01	0.9374	0.0010	0.9394	3.83E-02
VERSAPAK_HAC_FINH_12S_4x272Pd	0.1	0.9167	0.0011	0.9189	3.77E-02

Table 6-12 Interspersed Moderation Sensitivity Calculations for MOD0 and MOD1 Configurations

(note: yellow high-lighted cells represent the bounding case)

CASE ID	Region/Mixture Moderator Volume Fraction	k_{eff}	σ	k_{eff} + 2σ	EALF (eV)
VERSAPAK_HAC_FINH_12S_4x272Pe	0.5	0.9071	0.0013	0.9097	3.66E-02
VERSAPAK_HAC_FINH_12S_4x272Pf	1.0	0.9142	0.0012	0.9166	3.62E-02
VERSAPAK_HAC_FINH_12S_5x280P	0.0001	0.9358	0.0011	0.9380	3.84E-02
VERSAPAK_HAC_FINH_12S_5X280Pb	0.001	0.9358	0.0011	0.9380	3.83E-02
VERSAPAK_HAC_FINH_12S_5X280Pc	0.01	0.9345	0.0013	0.9371	3.83E-02
VERSAPAK_HAC_FINH_12S_5X280Pd	0.1	0.9144	0.0012	0.9168	3.76E-02
VERSAPAK_HAC_FINH_12S_5X280Pe	0.5	0.8629	0.0012	0.8653	3.80E-02
VERSAPAK_HAC_FINH_12S_5X280Pf	1.0	0.9163	0.0011	0.9185	3.62E-02
VERSAPAK_HAC_FINH_12S_6x288P	0.0001	0.9345	0.0012	0.9369	3.84E-02
VERSAPAK_HAC_FINH_12S_6X288Pb	0.001	0.9348	0.0013	0.9374	3.84E-02
VERSAPAK_HAC_FINH_12S_6X288Pc	0.01	0.9326	0.0013	0.9352	3.83E-02
VERSAPAK_HAC_FINH_12S_6X288Pd	0.1	0.9117	0.0012	0.9141	3.76E-02
VERSAPAK_HAC_FINH_12S_6X288Pe	0.5	0.9050	0.0013	0.9076	3.66E-02
VERSAPAK_HAC_FINH_12S_6X288Pf	1.0	0.9132	0.0012	0.9156	3.63E-02
VERSAPAK_HAC_FINH_12S_7x322P	0.0001	0.9330	0.0015	0.9360	3.83E-02
VERSAPAK_HAC_FINH_12S_7X322Pb	0.001	0.9327	0.0011	0.9349	3.84E-02
VERSAPAK_HAC_FINH_12S_7X322Pc	0.01	0.9306	0.0011	0.9328	3.83E-02
VERSAPAK_HAC_FINH_12S_7X322Pd	0.1	0.9124	0.0012	0.9148	3.76E-02
VERSAPAK_HAC_FINH_12S_7X322Pe	0.5	0.9045	0.0013	0.9071	3.66E-02
VERSAPAK_HAC_FINH_12S_7X322Pf	1.0	0.9133	0.0013	0.9159	3.62E-02
VERSAPAK_HAC_FINH_12S_8x312P	0.0001	0.9246	0.0012	0.9270	3.83E-02
VERSAPAK_HAC_FINH_12S_8X312Pb	0.001	0.9246	0.0013	0.9272	3.83E-02
VERSAPAK_HAC_FINH_12S_8X312Pc	0.01	0.9263	0.0011	0.9285	3.82E-02

Table 6-12 Interspersed Moderation Sensitivity Calculations for MOD0 and MOD1 Configurations

(note: yellow high-lighted cells represent the bounding case)

CASE ID	Region/Mixture Moderator Volume Fraction	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)
VERSAPAK_HAC_FINH_12S_8X312Pd	0.1	0.9049	0.0011	0.9071	3.76E-02
VERSAPAK_HAC_FINH_12S_8X312Pe	0.5	0.9034	0.0013	0.9060	3.66E-02
VERSAPAK_HAC_FINH_12S_8X312Pf	1.0	0.9162	0.0011	0.9184	3.62E-02
VERSAPAK_HAC_FINH_12S_9x324P	0.0001	0.9214	0.0012	0.9238	3.83E-02
VERSAPAK_HAC_FINH_12S_9X324Pb	0.001	0.9250	0.0012	0.9274	3.83E-02
VERSAPAK_HAC_FINH_12S_9X324Pc	0.01	0.9232	0.0012	0.9256	3.83E-02
VERSAPAK_HAC_FINH_12S_9X324Pd	0.1	0.9055	0.0015	0.9085	3.77E-02
VERSAPAK_HAC_FINH_12S_9X324Pe	0.5	0.9060	0.0011	0.9082	3.66E-02
VERSAPAK_HAC_FINH_12S_9X324Pf	1.0	0.9026	0.0012	0.9050	3.63E-02
VERSAPAK_HAC_FINH_12S_10x300P	0.0001	0.9114	0.0011	0.9136	3.83E-02
VERSAPAK_HAC_FINH_12S_10X300Pb	0.001	0.9142	0.0013	0.9168	3.83E-02
VERSAPAK_HAC_FINH_12S_10X300Pc	0.01	0.9119	0.0012	0.9143	3.83E-02
VERSAPAK_HAC_FINH_12S_10X300Pd	0.1	0.8974	0.0013	0.9000	3.76E-02
VERSAPAK_HAC_FINH_12S_10X300Pe	0.5	0.8985	0.0013	0.9011	3.67E-02
VERSAPAK_HAC_FINH_12S_10X300Pf	1.0	0.9112	0.0010	0.9132	3.62E-02
VERSAPAK_HAC_FINH_12S_12x300P	0.0001	0.9032	0.0011	0.9054	3.83E-02
VERSAPAK_HAC_FINH_12S_12X300Pb	0.001	0.9039	0.0012	0.9063	3.83E-02
VERSAPAK_HAC_FINH_12S_12X300Pc	0.01	0.8994	0.0011	0.9016	3.82E-02
VERSAPAK_HAC_FINH_12S_12X300Pd	0.1	0.8962	0.0013	0.8988	3.76E-02
VERSAPAK_HAC_FINH_12S_12X300Pe	0.5	0.8995	0.0013	0.9021	3.67E-02
VERSAPAK_HAC_FINH_12S_12X300Pf	1.0	0.9084	0.0013	0.9110	3.63E-02
MOD0 – Region/Mixture 5 – Payload Region					
VERSAPAK_HAC_FINH_12S_4X272P	0.0001	0.9298	0.0012	0.9322	3.84E-02

Table 6-12 Interspersed Moderation Sensitivity Calculations for MOD0 and MOD1 Configurations

(note: yellow high-lighted cells represent the bounding case)

CASE ID	Region/Mixture Moderator Volume Fraction	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)
VERSAPAK_HAC_FINH_12S_4X272Pb	0.001	0.9342	0.0012	0.9366	3.83E-02
VERSAPAK_HAC_FINH_12S_4X272Pc	0.01	0.9302	0.0013	0.9328	3.83E-02
VERSAPAK_HAC_FINH_12S_4X272Pd	0.1	0.9110	0.0011	0.9132	3.76E-02
VERSAPAK_HAC_FINH_12S_4X272Pe	0.5	0.9037	0.0011	0.9059	3.66E-02
VERSAPAK_HAC_FINH_12S_4X272Pf	1.0	0.9158	0.0013	0.9184	3.63E-02
VERSAPAK_HAC_FINH_12S_5X280P	0.0001	0.9364	0.0011	0.9386	3.83E-02
VERSAPAK_HAC_FINH_12S_5X280Pb	0.001	0.9349	0.0011	0.9371	3.84E-02
VERSAPAK_HAC_FINH_12S_5X280Pc	0.01	0.9320	0.0013	0.9346	3.83E-02
VERSAPAK_HAC_FINH_12S_5X280Pd	0.1	0.9118	0.0012	0.9142	3.77E-02
VERSAPAK_HAC_FINH_12S_5X280Pe	0.5	0.8996	0.0013	0.9022	3.66E-02
VERSAPAK_HAC_FINH_12S_5X280Pf	1.0	0.9159	0.0013	0.9185	3.63E-02
MOD1 – Region/Mixture 6 – Payload Radial Insulation Region					
VERSAPAK_HAC_FINH_12S_1x324P	0.0001	0.8536	0.0012	0.8560	3.82E-02
VERSAPAK_HAC_FINH_12S_1X324Pb	0.001	0.8529	0.0013	0.8555	3.82E-02
VERSAPAK_HAC_FINH_12S_1X324Pc	0.01	0.8530	0.0013	0.8556	3.81E-02
VERSAPAK_HAC_FINH_12S_1X324Pd	0.1	0.8398	0.0010	0.8418	3.80E-02
VERSAPAK_HAC_FINH_12S_1X324Pe	0.5	0.8153	0.0012	0.8177	3.77E-02
VERSAPAK_HAC_FINH_12S_1X324Pf	1	0.8081	0.0013	0.8107	3.77E-02
VERSAPAK_HAC_FINH_12S_2X338P	0.0001	0.9184	0.0010	0.9204	3.84E-02
VERSAPAK_HAC_FINH_12S_2X338Pb	0.001	0.9174	0.0011	0.9196	3.84E-02
VERSAPAK_HAC_FINH_12S_2X338Pc	0.01	0.9176	0.0012	0.9200	3.84E-02
VERSAPAK_HAC_FINH_12S_2X338Pd	0.1	0.8919	0.0011	0.8941	3.81E-02
VERSAPAK_HAC_FINH_12S_2X338Pe	0.5	0.8495	0.0013	0.8521	3.77E-02

Table 6-12 Interspersed Moderation Sensitivity Calculations for MOD0 and MOD1 Configurations

(note: yellow high-lighted cells represent the bounding case)

CASE ID	Region/Mixture Moderator Volume Fraction	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)
VERSAPAK_HAC_FINH_12S_2X338Pf	1	0.8296	0.0012	0.8320	3.77E-02
VERSAPAK_HAC_FINH_12S_3X300P	0.0001	0.9333	0.0011	0.9355	3.84E-02
VERSAPAK_HAC_FINH_12S_3X300Pb	0.001	0.9341	0.0010	0.9361	3.83E-02
VERSAPAK_HAC_FINH_12S_3X300Pc	0.01	0.9288	0.0010	0.9308	3.83E-02
VERSAPAK_HAC_FINH_12S_3X300Pd	0.1	0.8983	0.0012	0.9007	3.81E-02
VERSAPAK_HAC_FINH_12S_3X300Pe	0.5	0.8476	0.0012	0.8500	3.77E-02
VERSAPAK_HAC_FINH_12S_3X300Pf	1	0.8290	0.0012	0.8314	3.77E-02
VERSAPAK_HAC_FINH_12S_4x272P	0.0001	0.9378	0.0010	0.9398	3.84E-02
VERSAPAK_HAC_FINH_12S_4x272Pb	0.001	0.9370	0.0011	0.9392	3.84E-02
VERSAPAK_HAC_FINH_12S_4x272Pc	0.01	0.9316	0.0013	0.9342	3.84E-02
VERSAPAK_HAC_FINH_12S_4x272Pd	0.1	0.9017	0.0011	0.9039	3.81E-02
VERSAPAK_HAC_FINH_12S_4x272Pe	0.5	0.8468	0.0016	0.8500	3.77E-02
VERSAPAK_HAC_FINH_12S_4x272Pf	1.0	0.8315	0.0012	0.8339	3.77E-02
VERSAPAK_HAC_FINH_12S_5x280P	0.0001	0.9358	0.0011	0.9380	3.84E-02
VERSAPAK_HAC_FINH_12S_5x280Pb	0.001	0.9376	0.0012	0.9400	3.83E-02
VERSAPAK_HAC_FINH_12S_5X280Pc	0.01	0.9330	0.0015	0.9360	3.84E-02
VERSAPAK_HAC_FINH_12S_5X280Pd	0.1	0.9007	0.0012	0.9031	3.80E-02
VERSAPAK_HAC_FINH_12S_5X280Pe	0.5	0.8465	0.0012	0.8489	3.77E-02
VERSAPAK_HAC_FINH_12S_5X280Pf	1.0	0.8318	0.0012	0.8342	3.77E-02
VERSAPAK_HAC_FINH_12S_6x288P	0.0001	0.9345	0.0012	0.9369	3.84E-02
VERSAPAK_HAC_FINH_12S_6X288Pb	0.001	0.9373	0.0012	0.9397	3.83E-02
VERSAPAK_HAC_FINH_12S_6X288Pc	0.01	0.9310	0.0014	0.9338	3.83E-02
VERSAPAK_HAC_FINH_12S_6X288Pd	0.1	0.8973	0.0013	0.8999	3.81E-02

Table 6-12 Interspersed Moderation Sensitivity Calculations for MOD0 and MOD1 Configurations

(note: yellow high-lighted cells represent the bounding case)

CASE ID	Region/Mixture Moderator Volume Fraction	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)
VERSAPAK_HAC_FINH_12S_6X288Pe	0.5	0.8473	0.0010	0.8493	3.77E-02
VERSAPAK_HAC_FINH_12S_6X288Pf	1.0	0.8295	0.0011	0.8317	3.76E-02
VERSAPAK_HAC_FINH_12S_7x322P	0.0001	0.9330	0.0015	0.9360	3.83E-02
VERSAPAK_HAC_FINH_12S_7X322Pb	0.001	0.9361	0.0012	0.9385	3.83E-02
VERSAPAK_HAC_FINH_12S_7X322Pc	0.01	0.9312	0.0012	0.9336	3.83E-02
VERSAPAK_HAC_FINH_12S_7X322Pd	0.1	0.8965	0.0012	0.8989	3.80E-02
VERSAPAK_HAC_FINH_12S_7X322Pe	0.5	0.8437	0.0011	0.8459	3.77E-02
VERSAPAK_HAC_FINH_12S_7X322Pf	1.0	0.8287	0.0014	0.8315	3.77E-02
VERSAPAK_HAC_FINH_12S_8x312P	0.0001	0.9246	0.0012	0.9270	3.83E-02
VERSAPAK_HAC_FINH_12S_8X312Pb	0.001	0.9265	0.0012	0.9289	3.83E-02
VERSAPAK_HAC_FINH_12S_8X312Pc	0.01	0.9223	0.0012	0.9247	3.83E-02
VERSAPAK_HAC_FINH_12S_8X312Pd	0.1	0.8970	0.0013	0.8996	3.80E-02
VERSAPAK_HAC_FINH_12S_8X312Pe	0.5	0.8429	0.0012	0.8453	3.77E-02
VERSAPAK_HAC_FINH_12S_8X312Pf	1.0	0.8288	0.0011	0.8310	3.77E-02
VERSAPAK_HAC_FINH_12S_9x324P	0.0001	0.9214	0.0012	0.9238	3.83E-02
VERSAPAK_HAC_FINH_12S_9X324Pb	0.001	0.9235	0.0011	0.9257	3.83E-02
VERSAPAK_HAC_FINH_12S_9X324Pc	0.01	0.9202	0.0013	0.9228	3.83E-02
VERSAPAK_HAC_FINH_12S_9X324Pd	0.1	0.8940	0.0012	0.8964	3.80E-02
VERSAPAK_HAC_FINH_12S_9X324Pe	0.5	0.8468	0.0011	0.8490	3.77E-02
VERSAPAK_HAC_FINH_12S_9X324Pf	1.0	0.8293	0.0012	0.8317	3.77E-02
VERSAPAK_HAC_FINH_12S_10x300P	0.0001	0.9114	0.0011	0.9136	3.83E-02
VERSAPAK_HAC_FINH_12S_10X300Pb	0.001	0.9119	0.0012	0.9143	3.83E-02
VERSAPAK_HAC_FINH_12S_10X300Pc	0.01	0.9115	0.0012	0.9139	3.83E-02

Table 6-12 Interspersed Moderation Sensitivity Calculations for MOD0 and MOD1 Configurations

(note: yellow high-lighted cells represent the bounding case)

CASE ID	Region/Mixture Moderator Volume Fraction	k_{eff}	σ	k_{eff} + 2σ	EALF (eV)
VERSAPAK_HAC_FINH_12S_10X300Pd	0.1	0.8867	0.0013	0.8893	3.80E-02
VERSAPAK_HAC_FINH_12S_10X300Pe	0.5	0.8464	0.0013	0.8490	3.76E-02
VERSAPAK_HAC_FINH_12S_10X300Pf	1.0	0.8279	0.0012	0.8303	3.77E-02
VERSAPAK_HAC_FINH_12S_12x300P	0.0001	0.9032	0.0011	0.9054	3.83E-02
VERSAPAK_HAC_FINH_12S_12X300Pb	0.001	0.9020	0.0010	0.9040	3.83E-02
VERSAPAK_HAC_FINH_12S_12X300Pc	0.01	0.9030	0.0012	0.9054	3.83E-02
VERSAPAK_HAC_FINH_12S_12X300Pd	0.1	0.8809	0.0012	0.8833	3.81E-02
VERSAPAK_HAC_FINH_12S_12X300Pe	0.5	0.8419	0.0012	0.8443	3.77E-02
VERSAPAK_HAC_FINH_12S_12X300Pf	1.0	0.8305	0.0012	0.8329	3.77E-02
MOD0 – Region/Mixture 6 – Payload Radial Insulation Region					
VERSAPAK_HAC_FINH_12S_4X272P	0.0001	0.9298	0.0012	0.9322	3.84E-02
VERSAPAK_HAC_FINH_12S_4X272Pb	0.001	0.9304	0.0012	0.9328	3.84E-02
VERSAPAK_HAC_FINH_12S_4X272Pc	0.01	0.9281	0.0012	0.9305	3.83E-02
VERSAPAK_HAC_FINH_12S_4X272Pd	0.1	0.8973	0.0011	0.8995	3.80E-02
VERSAPAK_HAC_FINH_12S_4X272Pe	0.5	0.8468	0.0012	0.8492	3.77E-02
VERSAPAK_HAC_FINH_12S_4X272Pf	1.0	0.8306	0.0011	0.8328	3.77E-02
VERSAPAK_HAC_FINH_12S_5X280P	0.0001	0.9364	0.0011	0.9386	3.83E-02
VERSAPAK_HAC_FINH_12S_5X280Pb	0.001	0.9332	0.0012	0.9356	3.84E-02
VERSAPAK_HAC_FINH_12S_5X280Pc	0.01	0.931	0.001	0.9330	3.83E-02
VERSAPAK_HAC_FINH_12S_5X280Pd	0.1	0.8991	0.0015	0.9021	3.81E-02
VERSAPAK_HAC_FINH_12S_5X280Pe	0.5	0.8465	0.0013	0.8491	3.77E-02
VERSAPAK_HAC_FINH_12S_5X280Pf	1.0	0.8295	0.0011	0.8317	3.77E-02
MOD1 – Region/Mixture 7 – Top/Bottom Insulation Region					

Table 6-12 Interspersed Moderation Sensitivity Calculations for MOD0 and MOD1 Configurations

(note: yellow high-lighted cells represent the bounding case)

CASE ID	Region/Mixture Moderator Volume Fraction	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)
VERSAPAK_HAC_FINH_12S_1x324P	0.0001	0.8536	0.0012	0.8560	3.82E-02
VERSAPAK_HAC_FINH_12S_1X324Pb	0.001	0.8525	0.0015	0.8555	3.82E-02
VERSAPAK_HAC_FINH_12S_1X324Pc	0.01	0.8569	0.0011	0.8591	3.82E-02
VERSAPAK_HAC_FINH_12S_1X324Pd	0.1	0.8537	0.0012	0.8561	3.82E-02
VERSAPAK_HAC_FINH_12S_1X324Pe	0.5	0.8540	0.0012	0.8564	3.81E-02
VERSAPAK_HAC_FINH_12S_1X324Pf	1	0.8536	0.0011	0.8558	3.80E-02
VERSAPAK_HAC_FINH_12S_2X338P	0.0001	0.9184	0.0010	0.9204	3.84E-02
VERSAPAK_HAC_FINH_12S_2X338Pb	0.001	0.9158	0.0011	0.9180	3.83E-02
VERSAPAK_HAC_FINH_12S_2X338Pc	0.01	0.9156	0.0012	0.9180	3.84E-02
VERSAPAK_HAC_FINH_12S_2X338Pd	0.1	0.9046	0.0012	0.9070	3.82E-02
VERSAPAK_HAC_FINH_12S_2X338Pe	0.5	0.8719	0.0012	0.8743	3.80E-02
VERSAPAK_HAC_FINH_12S_2X338Pf	1	0.8579	0.0013	0.8605	3.80E-02
VERSAPAK_HAC_FINH_12S_3X300P	0.0001	0.9333	0.0011	0.9355	3.84E-02
VERSAPAK_HAC_FINH_12S_3X300Pb	0.001	0.9328	0.0012	0.9352	3.84E-02
VERSAPAK_HAC_FINH_12S_3X300Pc	0.01	0.9347	0.0011	0.9369	3.84E-02
VERSAPAK_HAC_FINH_12S_3X300Pd	0.1	0.9132	0.0011	0.9154	3.82E-02
VERSAPAK_HAC_FINH_12S_3X300Pe	0.5	0.8695	0.0011	0.8717	3.79E-02
VERSAPAK_HAC_FINH_12S_3X300Pf	1	0.8544	0.0011	0.8566	3.80E-02
VERSAPAK_HAC_FINH_12S_4x272P	0.0001	0.9378	0.0010	0.9398	3.84E-02
VERSAPAK_HAC_FINH_12S_4x272Pb	0.001	0.9371	0.0012	0.9395	3.84E-02
VERSAPAK_HAC_FINH_12S_4x272Pc	0.01	0.9371	0.0012	0.9395	3.83E-02
VERSAPAK_HAC_FINH_12S_4x272Pd	0.1	0.9172	0.0012	0.9196	3.82E-02
VERSAPAK_HAC_FINH_12S_4x272Pe	0.5	0.8670	0.0012	0.8694	3.80E-02

Table 6-12 Interspersed Moderation Sensitivity Calculations for MOD0 and MOD1 Configurations

(note: yellow high-lighted cells represent the bounding case)

CASE ID	Region/Mixture Moderator Volume Fraction	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)
VERSAPAK_HAC_FINH_12S_4x272Pf	1.0	0.8522	0.0012	0.8546	3.80E-02
VERSAPAK_HAC_FINH_12S_5x280P	0.0001	0.9358	0.0011	0.9380	3.84E-02
VERSAPAK_HAC_FINH_12S_5X280Pb	0.001	0.9351	0.0012	0.9375	3.84E-02
VERSAPAK_HAC_FINH_12S_5X280Pc	0.01	0.9359	0.0012	0.9383	3.83E-02
VERSAPAK_HAC_FINH_12S_5X280Pd	0.1	0.9158	0.0011	0.9180	3.82E-02
VERSAPAK_HAC_FINH_12S_5X280Pe	0.5	0.8629	0.0012	0.8653	3.80E-02
VERSAPAK_HAC_FINH_12S_5X280Pf	1.0	0.8489	0.0012	0.8513	3.80E-02
VERSAPAK_HAC_FINH_12S_6x288P	0.0001	0.9345	0.0012	0.9369	3.84E-02
VERSAPAK_HAC_FINH_12S_6X288Pb	0.001	0.9351	0.0014	0.9379	3.83E-02
VERSAPAK_HAC_FINH_12S_6X288Pc	0.01	0.9335	0.0012	0.9359	3.83E-02
VERSAPAK_HAC_FINH_12S_6X288Pd	0.1	0.9122	0.0011	0.9144	3.82E-02
VERSAPAK_HAC_FINH_12S_6X288Pe	0.5	0.8641	0.0012	0.8665	3.80E-02
VERSAPAK_HAC_FINH_12S_6X288Pf	1.0	0.8492	0.0012	0.8516	3.80E-02
VERSAPAK_HAC_FINH_12S_7x322P	0.0001	0.9330	0.0015	0.9360	3.83E-02
VERSAPAK_HAC_FINH_12S_7X322Pb	0.001	0.9345	0.0012	0.9369	3.84E-02
VERSAPAK_HAC_FINH_12S_7X322Pc	0.01	0.9328	0.0011	0.9350	3.83E-02
VERSAPAK_HAC_FINH_12S_7X322Pd	0.1	0.9093	0.0014	0.9121	3.82E-02
VERSAPAK_HAC_FINH_12S_7X322Pe	0.5	0.8639	0.0012	0.8663	3.79E-02
VERSAPAK_HAC_FINH_12S_7X322Pf	1.0	0.8465	0.0013	0.8491	3.80E-02
VERSAPAK_HAC_FINH_12S_8x312P	0.0001	0.9246	0.0012	0.9270	3.83E-02
VERSAPAK_HAC_FINH_12S_8X312Pb	0.001	0.9277	0.0013	0.9303	3.83E-02
VERSAPAK_HAC_FINH_12S_8X312Pc	0.01	0.9239	0.0013	0.9265	3.83E-02
VERSAPAK_HAC_FINH_12S_8X312Pd	0.1	0.9037	0.0013	0.9063	3.82E-02

Table 6-12 Interspersed Moderation Sensitivity Calculations for MOD0 and MOD1 Configurations

(note: yellow high-lighted cells represent the bounding case)

CASE ID	Region/Mixture Moderator Volume Fraction	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)
VERSAPAK_HAC_FINH_12S_8X312Pe	0.5	0.8589	0.0011	0.8611	3.80E-02
VERSAPAK_HAC_FINH_12S_8X312Pf	1.0	0.8443	0.0012	0.8467	3.80E-02
VERSAPAK_HAC_FINH_12S_9x324P	0.0001	0.9214	0.0012	0.9238	3.83E-02
VERSAPAK_HAC_FINH_12S_9X324Pb	0.001	0.9229	0.0011	0.9251	3.84E-02
VERSAPAK_HAC_FINH_12S_9X324Pc	0.01	0.9227	0.0012	0.9251	3.83E-02
VERSAPAK_HAC_FINH_12S_9X324Pd	0.1	0.9022	0.0011	0.9044	3.82E-02
VERSAPAK_HAC_FINH_12S_9X324Pe	0.5	0.8501	0.0012	0.8525	3.79E-02
VERSAPAK_HAC_FINH_12S_9X324Pf	1.0	0.8441	0.0011	0.8463	3.80E-02
VERSAPAK_HAC_FINH_12S_10x300P	0.0001	0.9114	0.0011	0.9136	3.83E-02
VERSAPAK_HAC_FINH_12S_10X300Pb	0.001	0.9118	0.0012	0.9142	3.83E-02
VERSAPAK_HAC_FINH_12S_10X300Pc	0.01	0.9110	0.0014	0.9138	3.83E-02
VERSAPAK_HAC_FINH_12S_10X300Pd	0.1	0.8953	0.0014	0.8981	3.81E-02
VERSAPAK_HAC_FINH_12S_10X300Pe	0.5	0.8527	0.0011	0.8549	3.80E-02
VERSAPAK_HAC_FINH_12S_10X300Pf	1.0	0.8415	0.0013	0.8441	3.80E-02
VERSAPAK_HAC_FINH_12S_12x300P	0.0001	0.9032	0.0011	0.9054	3.83E-02
VERSAPAK_HAC_FINH_12S_12X300Pb	0.001	0.9014	0.0011	0.9036	3.83E-02
VERSAPAK_HAC_FINH_12S_12X300Pc	0.01	0.9026	0.0012	0.9050	3.82E-02
VERSAPAK_HAC_FINH_12S_12X300Pd	0.1	0.8862	0.0011	0.8884	3.81E-02
VERSAPAK_HAC_FINH_12S_12X300Pe	0.5	0.8533	0.0013	0.8559	3.80E-02
VERSAPAK_HAC_FINH_12S_12X300Pf	1.0	0.8392	0.0012	0.8416	3.80E-02
MOD0 – Region/Mixture 7 – Top/Bottom Insulation Region					
VERSAPAK_HAC_FINH_12S_4X272P	0.0001	0.9298	0.0012	0.9322	3.84E-02
VERSAPAK_HAC_FINH_12S_4X272Pb	0.001	0.9258	0.0012	0.9282	3.83E-02

Table 6-12 Interspersed Moderation Sensitivity Calculations for MOD0 and MOD1 Configurations

(note: yellow high-lighted cells represent the bounding case)

CASE ID	Region/Mixture Moderator Volume Fraction	k_{eff}	σ	k_{eff} + 2σ	EALF (eV)
VERSAPAK_HAC_FINH_12S_4X272Pc	0.01	0.9290	0.0012	0.9314	3.83E-02
VERSAPAK_HAC_FINH_12S_4X272Pd	0.1	0.9110	0.0013	0.9136	3.82E-02
VERSAPAK_HAC_FINH_12S_4X272Pe	0.5	0.8688	0.0011	0.8710	3.80E-02
VERSAPAK_HAC_FINH_12S_4X272Pf	1.0	0.8507	0.0013	0.8533	3.80E-02
VERSAPAK_HAC_FINH_12S_5X280P	0.0001	0.9364	0.0011	0.9386	3.83E-02
VERSAPAK_HAC_FINH_12S_5X280Pb	0.001	0.9330	0.0012	0.9354	3.83E-02
VERSAPAK_HAC_FINH_12S_5X280Pc	0.01	0.9314	0.0010	0.9334	3.83E-02
VERSAPAK_HAC_FINH_12S_5X280Pd	0.1	0.9112	0.0010	0.9132	3.82E-02
VERSAPAK_HAC_FINH_12S_5X280Pe	0.5	0.8626	0.0014	0.8654	3.80E-02
VERSAPAK_HAC_FINH_12S_5X280Pf	1.0	0.8512	0.0012	0.8536	3.80E-02
MOD1 – Region/Mixture 8 – Payload Radial Inner/Outer Liner Insulation Region					
VERSAPAK_HAC_FINH_12S_1x324P	0.0001	0.8536	0.0012	0.8560	3.82E-02
VERSAPAK_HAC_FINH_12S_1X324Pb	0.001	0.8539	0.0011	0.8561	3.82E-02
VERSAPAK_HAC_FINH_12S_1X324Pc	0.01	0.8530	0.0012	0.8554	3.82E-02
VERSAPAK_HAC_FINH_12S_1X324Pd	0.1	0.8523	0.0013	0.8549	3.82E-02
VERSAPAK_HAC_FINH_12S_1X324Pe	0.5	0.8459	0.0012	0.8483	3.81E-02
VERSAPAK_HAC_FINH_12S_1X324Pf	1	0.8357	0.0011	0.8379	3.80E-02
VERSAPAK_HAC_FINH_12S_2X338P	0.0001	0.9184	0.0010	0.9204	3.84E-02
VERSAPAK_HAC_FINH_12S_2X338Pb	0.001	0.9172	0.0011	0.9194	3.84E-02
VERSAPAK_HAC_FINH_12S_2X338Pc	0.01	0.9184	0.0011	0.9206	3.84E-02
VERSAPAK_HAC_FINH_12S_2X338Pd	0.1	0.9140	0.0012	0.9164	3.83E-02
VERSAPAK_HAC_FINH_12S_2X338Pe	0.5	0.8962	0.0011	0.8984	3.82E-02
VERSAPAK_HAC_FINH_12S_2X338Pf	1	0.8802	0.0013	0.8828	3.81E-02

Table 6-12 Interspersed Moderation Sensitivity Calculations for MOD0 and MOD1 Configurations

(note: yellow high-lighted cells represent the bounding case)

CASE ID	Region/Mixture Moderator Volume Fraction	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)
VERSAPAK_HAC_FINH_12S_3X300P	0.0001	0.9333	0.0011	0.9355	3.84E-02
VERSAPAK_HAC_FINH_12S_3X300Pb	0.001	0.9342	0.0012	0.9366	3.84E-02
VERSAPAK_HAC_FINH_12S_3X300Pc	0.01	0.9345	0.0013	0.9371	3.84E-02
VERSAPAK_HAC_FINH_12S_3X300Pd	0.1	0.9286	0.0011	0.9308	3.83E-02
VERSAPAK_HAC_FINH_12S_3X300Pe	0.5	0.9046	0.0012	0.9070	3.82E-02
VERSAPAK_HAC_FINH_12S_3X300Pf	1	0.8842	0.0011	0.8864	3.80E-02
VERSAPAK_HAC_FINH_12S_1x324P	0.0001	0.8536	0.0012	0.8560	3.82E-02
VERSAPAK_HAC_FINH_12S_4x272P	0.0001	0.9378	0.0010	0.9398	3.84E-02
VERSAPAK_HAC_FINH_12S_4x272Pb	0.001	0.9374	0.0012	0.9398	3.84E-02
VERSAPAK_HAC_FINH_12S_4x272Pc	0.01	0.9373	0.0011	0.9395	3.83E-02
VERSAPAK_HAC_FINH_12S_4x272Pd	0.1	0.9315	0.0013	0.9341	3.83E-02
VERSAPAK_HAC_FINH_12S_4x272Pe	0.5	0.9075	0.0013	0.9101	3.82E-02
VERSAPAK_HAC_FINH_12S_4x272Pf	1.0	0.8833	0.0012	0.8857	3.81E-02
VERSAPAK_HAC_FINH_12S_5x280P	0.0001	0.9358	0.0011	0.9380	3.84E-02
VERSAPAK_HAC_FINH_12S_5X280Pb	0.001	0.9363	0.0012	0.9387	3.84E-02
VERSAPAK_HAC_FINH_12S_5X280Pc	0.01	0.9364	0.0012	0.9388	3.84E-02
VERSAPAK_HAC_FINH_12S_5X280Pd	0.1	0.9306	0.0011	0.9328	3.84E-02
VERSAPAK_HAC_FINH_12S_5X280Pe	0.5	0.9061	0.0013	0.9087	3.82E-02
VERSAPAK_HAC_FINH_12S_5X280Pf	1.0	0.8835	0.0011	0.8857	3.80E-02
VERSAPAK_HAC_FINH_12S_6x288P	0.0001	0.9345	0.0012	0.9369	3.84E-02
VERSAPAK_HAC_FINH_12S_6X288Pb	0.001	0.9347	0.0011	0.9369	3.83E-02
VERSAPAK_HAC_FINH_12S_6X288Pc	0.01	0.9338	0.0013	0.9364	3.83E-02
VERSAPAK_HAC_FINH_12S_6X288Pd	0.1	0.9285	0.0011	0.9307	3.83E-02

Table 6-12 Interspersed Moderation Sensitivity Calculations for MOD0 and MOD1 Configurations

(note: yellow high-lighted cells represent the bounding case)

CASE ID	Region/Mixture Moderator Volume Fraction	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)
VERSAPAK_HAC_FINH_12S_6X288Pe	0.5	0.9061	0.0011	0.9083	3.81E-02
VERSAPAK_HAC_FINH_12S_6X288Pf	1.0	0.8836	0.0013	0.8862	3.80E-02
VERSAPAK_HAC_FINH_12S_7x322P	0.0001	0.9330	0.0015	0.9360	3.83E-02
VERSAPAK_HAC_FINH_12S_7X322Pb	0.001	0.9329	0.0013	0.9355	3.84E-02
VERSAPAK_HAC_FINH_12S_7X322Pc	0.01	0.9326	0.0012	0.9350	3.84E-02
VERSAPAK_HAC_FINH_12S_7X322Pd	0.1	0.9275	0.0011	0.9297	3.83E-02
VERSAPAK_HAC_FINH_12S_7X322Pe	0.5	0.9025	0.0012	0.9049	3.81E-02
VERSAPAK_HAC_FINH_12S_7X322Pf	1.0	0.8804	0.0011	0.8826	3.80E-02
VERSAPAK_HAC_FINH_12S_8x312P	0.0001	0.9246	0.0012	0.9270	3.83E-02
VERSAPAK_HAC_FINH_12S_8X312Pb	0.001	0.9266	0.0012	0.9290	3.83E-02
VERSAPAK_HAC_FINH_12S_8X312Pc	0.01	0.9249	0.0012	0.9273	3.83E-02
VERSAPAK_HAC_FINH_12S_8X312Pd	0.1	0.9213	0.0012	0.9237	3.83E-02
VERSAPAK_HAC_FINH_12S_8X312Pe	0.5	0.9004	0.0013	0.9030	3.82E-02
VERSAPAK_HAC_FINH_12S_8X312Pf	1.0	0.8777	0.0012	0.8801	3.80E-02
VERSAPAK_HAC_FINH_12S_9x324P	0.0001	0.9214	0.0012	0.9238	3.83E-02
VERSAPAK_HAC_FINH_12S_9X324Pb	0.001	0.9238	0.0012	0.9262	3.83E-02
VERSAPAK_HAC_FINH_12S_9X324Pc	0.01	0.9252	0.0012	0.9276	3.83E-02
VERSAPAK_HAC_FINH_12S_9X324Pd	0.1	0.9208	0.0012	0.9232	3.83E-02
VERSAPAK_HAC_FINH_12S_9X324Pe	0.5	0.8991	0.0011	0.9013	3.81E-02
VERSAPAK_HAC_FINH_12S_9X324Pf	1.0	0.8777	0.0012	0.8801	3.80E-02
VERSAPAK_HAC_FINH_12S_10x300P	0.0001	0.9114	0.0011	0.9136	3.83E-02
VERSAPAK_HAC_FINH_12S_10X300Pb	0.001	0.9130	0.0013	0.9156	3.83E-02
VERSAPAK_HAC_FINH_12S_10X300Pc	0.01	0.9126	0.0012	0.9150	3.83E-02

Table 6-12 Interspersed Moderation Sensitivity Calculations for MOD0 and MOD1 Configurations

(note: yellow high-lighted cells represent the bounding case)

CASE ID	Region/Mixture Moderator Volume Fraction	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)
VERSAPAK_HAC_FINH_12S_10X300Pd	0.1	0.9101	0.0011	0.9123	3.83E-02
VERSAPAK_HAC_FINH_12S_10X300Pe	0.5	0.8905	0.0016	0.8937	3.82E-02
VERSAPAK_HAC_FINH_12S_10X300Pf	1.0	0.8726	0.0012	0.8750	3.80E-02
VERSAPAK_HAC_FINH_12S_12x300P	0.0001	0.9032	0.0011	0.9054	3.83E-02
VERSAPAK_HAC_FINH_12S_12X300Pb	0.001	0.9012	0.0013	0.9038	3.83E-02
VERSAPAK_HAC_FINH_12S_12X300Pc	0.01	0.9018	0.0013	0.9044	3.83E-02
VERSAPAK_HAC_FINH_12S_12X300Pd	0.1	0.9001	0.0012	0.9025	3.83E-02
VERSAPAK_HAC_FINH_12S_12X300Pe	0.5	0.8817	0.0012	0.8841	3.82E-02
VERSAPAK_HAC_FINH_12S_12X300Pf	1.0	0.8647	0.0013	0.8673	3.80E-02
MOD0 – Region/Mixture 8 – Payload Radial Inner/Outer Liner Insulation Region					
VERSAPAK_HAC_FINH_12S_4X272P	0.0001	0.9298	0.0012	0.9322	3.84E-02
VERSAPAK_HAC_FINH_12S_4X272Pb	0.001	0.9341	0.0012	0.9365	3.83E-02
VERSAPAK_HAC_FINH_12S_4X272Pc	0.01	0.9301	0.0011	0.9323	3.83E-02
VERSAPAK_HAC_FINH_12S_4X272Pd	0.1	0.9237	0.0011	0.9259	3.83E-02
VERSAPAK_HAC_FINH_12S_4X272Pe	0.5	0.9009	0.0012	0.9033	3.81E-02
VERSAPAK_HAC_FINH_12S_4X272Pf	1.0	0.881	0.0013	0.8836	3.80E-02
VERSAPAK_HAC_FINH_12S_5X280P	0.0001	0.9364	0.0011	0.9386	3.83E-02
VERSAPAK_HAC_FINH_12S_5X280Pb	0.001	0.9339	0.0011	0.9361	3.84E-02
VERSAPAK_HAC_FINH_12S_5X280Pc	0.01	0.9336	0.0011	0.9358	3.83E-02
VERSAPAK_HAC_FINH_12S_5X280Pd	0.1	0.9267	0.0011	0.9289	3.83E-02
VERSAPAK_HAC_FINH_12S_5X280Pe	0.5	0.9049	0.0015	0.9079	3.82E-02
VERSAPAK_HAC_FINH_12S_5X280Pf	1.0	0.8814	0.0012	0.8838	3.80E-02
MOD1 – Region/Mixture 9 – Exterior Package Region					

Table 6-12 Interspersed Moderation Sensitivity Calculations for MOD0 and MOD1 Configurations

(note: yellow high-lighted cells represent the bounding case)

CASE ID	Region/Mixture Moderator Volume Fraction	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)
VERSAPAK_HAC_FINH_12S_1x324P	0.0001	0.8536	0.0012	0.8560	3.82E-02
VERSAPAK_HAC_FINH_12S_1X324Pb	0.001	0.8538	0.0011	0.8560	3.82E-02
VERSAPAK_HAC_FINH_12S_1X324Pc	0.01	0.8535	0.0012	0.8559	3.81E-02
VERSAPAK_HAC_FINH_12S_1X324Pd	0.1	0.8510	0.0012	0.8534	3.81E-02
VERSAPAK_HAC_FINH_12S_1X324Pe	0.5	0.8319	0.0014	0.8347	3.81E-02
VERSAPAK_HAC_FINH_12S_1X324Pf	1	0.8248	0.0011	0.8270	3.80E-02
VERSAPAK_HAC_FINH_12S_2X338P	0.0001	0.9184	0.0010	0.9204	3.84E-02
VERSAPAK_HAC_FINH_12S_2X338Pb	0.001	0.9184	0.0012	0.9208	3.83E-02
VERSAPAK_HAC_FINH_12S_2X338Pc	0.01	0.9171	0.0011	0.9193	3.83E-02
VERSAPAK_HAC_FINH_12S_2X338Pd	0.1	0.9104	0.0012	0.9128	3.83E-02
VERSAPAK_HAC_FINH_12S_2X338Pe	0.5	0.8790	0.0011	0.8812	3.80E-02
VERSAPAK_HAC_FINH_12S_2X338Pf	1	0.8559	0.0011	0.8581	3.80E-02
VERSAPAK_HAC_FINH_12S_3X300P	0.0001	0.9333	0.0011	0.9355	3.84E-02
VERSAPAK_HAC_FINH_12S_3X300Pb	0.001	0.9324	0.0011	0.9346	3.84E-02
VERSAPAK_HAC_FINH_12S_3X300Pc	0.01	0.9323	0.0011	0.9345	3.84E-02
VERSAPAK_HAC_FINH_12S_3X300Pd	0.1	0.9216	0.0011	0.9238	3.83E-02
VERSAPAK_HAC_FINH_12S_3X300Pe	0.5	0.8826	0.0011	0.8848	3.80E-02
VERSAPAK_HAC_FINH_12S_3X300Pf	1	0.8577	0.0010	0.8597	3.80E-02
VERSAPAK_HAC_FINH_12S_4x272P	0.0001	0.9378	0.0010	0.9398	3.84E-02
VERSAPAK_HAC_FINH_12S_4X272Pb	0.001	0.9367	0.0011	0.9389	3.84E-02
VERSAPAK_HAC_FINH_12S_4x272Pc	0.01	0.9353	0.0011	0.9375	3.84E-02
VERSAPAK_HAC_FINH_12S_4x272Pd	0.1	0.9247	0.0011	0.9269	3.83E-02
VERSAPAK_HAC_FINH_12S_4x272Pe	0.5	0.8839	0.0011	0.8861	3.81E-02

Table 6-12 Interspersed Moderation Sensitivity Calculations for MOD0 and MOD1 Configurations

(note: yellow high-lighted cells represent the bounding case)

CASE ID	Region/Mixture Moderator Volume Fraction	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)
VERSAPAK_HAC_FINH_12S_4x272Pf	1.0	0.8602	0.0013	0.8628	3.80E-02
VERSAPAK_HAC_FINH_12S_5x280P	0.0001	0.9358	0.0011	0.9380	3.84E-02
VERSAPAK_HAC_FINH_12S_5X280Pb	0.001	0.9352	0.0012	0.9376	3.83E-02
VERSAPAK_HAC_FINH_12S_5X280Pc	0.01	0.9354	0.0013	0.9380	3.84E-02
VERSAPAK_HAC_FINH_12S_5X280Pd	0.1	0.9235	0.0010	0.9255	3.83E-02
VERSAPAK_HAC_FINH_12S_5X280Pe	0.5	0.8831	0.0011	0.8853	3.80E-02
VERSAPAK_HAC_FINH_12S_5X280Pf	1.0	0.8580	0.0012	0.8604	3.80E-02
VERSAPAK_HAC_FINH_12S_6x288P	0.0001	0.9345	0.0012	0.9369	3.84E-02
VERSAPAK_HAC_FINH_12S_6X288Pb	0.001	0.9353	0.0011	0.9375	3.83E-02
VERSAPAK_HAC_FINH_12S_6X288Pc	0.01	0.9337	0.0011	0.9359	3.84E-02
VERSAPAK_HAC_FINH_12S_6X288Pd	0.1	0.9211	0.0012	0.9235	3.83E-02
VERSAPAK_HAC_FINH_12S_6X288Pe	0.5	0.8802	0.0012	0.8826	3.80E-02
VERSAPAK_HAC_FINH_12S_6X288Pf	1.0	0.8567	0.0011	0.8589	3.80E-02
VERSAPAK_HAC_FINH_12S_7x322P	0.0001	0.9330	0.0015	0.9360	3.83E-02
VERSAPAK_HAC_FINH_12S_7X322Pb	0.001	0.9345	0.0013	0.9371	3.83E-02
VERSAPAK_HAC_FINH_12S_7X322Pc	0.01	0.9340	0.0011	0.9362	3.83E-02
VERSAPAK_HAC_FINH_12S_7X322Pd	0.1	0.9197	0.0011	0.9219	3.82E-02
VERSAPAK_HAC_FINH_12S_7X322Pe	0.5	0.8786	0.0011	0.8808	3.81E-02
VERSAPAK_HAC_FINH_12S_7X322Pf	1.0	0.8574	0.0013	0.8600	3.80E-02
VERSAPAK_HAC_FINH_12S_8x312P	0.0001	0.9246	0.0012	0.9270	3.83E-02
VERSAPAK_HAC_FINH_12S_8X312Pb	0.001	0.9259	0.0012	0.9283	3.84E-02
VERSAPAK_HAC_FINH_12S_8X312Pc	0.01	0.9210	0.0012	0.9234	3.83E-02
VERSAPAK_HAC_FINH_12S_8X312Pd	0.1	0.9159	0.0012	0.9183	3.82E-02

Table 6-12 Interspersed Moderation Sensitivity Calculations for MOD0 and MOD1 Configurations

(note: yellow high-lighted cells represent the bounding case)

CASE ID	Region/Mixture Moderator Volume Fraction	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)
VERSAPAK_HAC_FINH_12S_8X312Pe	0.5	0.8798	0.0011	0.8820	3.80E-02
VERSAPAK_HAC_FINH_12S_8X312Pf	1.0	0.8548	0.0012	0.8572	3.80E-02
VERSAPAK_HAC_FINH_12S_9x324P	0.0001	0.9214	0.0012	0.9238	3.83E-02
VERSAPAK_HAC_FINH_12S_9X324Pb	0.001	0.9227	0.0013	0.9253	3.84E-02
VERSAPAK_HAC_FINH_12S_9X324Pc	0.01	0.9221	0.0012	0.9245	3.83E-02
VERSAPAK_HAC_FINH_12S_9X324Pd	0.1	0.9158	0.0013	0.9184	3.83E-02
VERSAPAK_HAC_FINH_12S_9X324Pe	0.5	0.8771	0.0012	0.8795	3.81E-02
VERSAPAK_HAC_FINH_12S_9X324Pf	1.0	0.8557	0.0011	0.8579	3.80E-02
VERSAPAK_HAC_FINH_12S_10x300P	0.0001	0.9114	0.0011	0.9136	3.83E-02
VERSAPAK_HAC_FINH_12S_10X300Pb	0.001	0.9145	0.0012	0.9169	3.83E-02
VERSAPAK_HAC_FINH_12S_10X300Pc	0.01	0.9086	0.0011	0.9108	3.83E-02
VERSAPAK_HAC_FINH_12S_10X300Pd	0.1	0.9032	0.0013	0.9058	3.83E-02
VERSAPAK_HAC_FINH_12S_10X300Pe	0.5	0.8712	0.0011	0.8734	3.80E-02
VERSAPAK_HAC_FINH_12S_10X300Pf	1.0	0.8559	0.0012	0.8583	3.80E-02
VERSAPAK_HAC_FINH_12S_12x300P	0.0001	0.9032	0.0011	0.9054	3.83E-02
VERSAPAK_HAC_FINH_12S_12X300Pb	0.001	0.9035	0.0014	0.9063	3.83E-02
VERSAPAK_HAC_FINH_12S_12X300Pc	0.01	0.8998	0.0011	0.9020	3.83E-02
VERSAPAK_HAC_FINH_12S_12X300Pd	0.1	0.8950	0.0012	0.8974	3.82E-02
VERSAPAK_HAC_FINH_12S_12X300Pe	0.5	0.8669	0.0012	0.8693	3.81E-02
VERSAPAK_HAC_FINH_12S_12X300Pf	1.0	0.8498	0.0012	0.8522	3.80E-02
MOD0 – Region/Mixture 9 – Exterior Package Region					
VERSAPAK_HAC_FINH_12S_4X272P	0.0001	0.9298	0.0012	0.9322	3.84E-02
VERSAPAK_HAC_FINH_12S_4X272Pb	0.001	0.9290	0.0011	0.9312	3.84E-02

Table 6-12 Interspersed Moderation Sensitivity Calculations for MOD0 and MOD1 Configurations

(note: yellow high-lighted cells represent the bounding case)

CASE ID	Region/Mixture Moderator Volume Fraction	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)
VERSAPAK_HAC_FINH_12S_4X272Pc	0.01	0.9293	0.0012	0.9317	3.83E-02
VERSAPAK_HAC_FINH_12S_4X272Pd	0.1	0.9195	0.0013	0.9221	3.83E-02
VERSAPAK_HAC_FINH_12S_4X272Pe	0.5	0.8808	0.0012	0.8832	3.80E-02
VERSAPAK_HAC_FINH_12S_4X272Pf	1.0	0.8575	0.0012	0.8599	3.80E-02
VERSAPAK_HAC_FINH_12S_5X280P	0.0001	0.9364	0.0011	0.9386	3.83E-02
VERSAPAK_HAC_FINH_12S_5X280Pb	0.001	0.9359	0.0012	0.9383	3.84E-02
VERSAPAK_HAC_FINH_12S_5X280Pc	0.01	0.9363	0.0014	0.9391	3.83E-02
VERSAPAK_HAC_FINH_12S_5X280Pd	0.1	0.9216	0.0012	0.9240	3.82E-02
VERSAPAK_HAC_FINH_12S_5X280Pe	0.5	0.8774	0.0012	0.8798	3.80E-02
VERSAPAK_HAC_FINH_12S_5X280Pf	1.0	0.8594	0.0012	0.8618	3.80E-02

Table 6-13 Distributed Fissile Mass at Varying Fill Levels in Limiting Finite Array (N=272)

Fill Percentage	k_{eff}	sigma	k_{eff} + 2 sig	EALF (eV)
5	0.5129	0.001	0.5149	6.41E-02
8	0.6778	0.001	0.6798	4.62E-02
10	0.7417	0.0012	0.7441	4.15E-02
12	0.7754	0.0012	0.7778	3.86E-02
15	0.7963	0.001	0.7983	3.62E-02
16	0.7977	0.001	0.7997	3.55E-02
17	0.79959	0.00097	0.8015	3.51E-02
18	0.8	0.001	0.8020	3.47E-02
20	0.7918	0.0011	0.7940	3.38E-02
30	0.7264	0.001	0.7284	3.19E-02

Table 6-14 Comparison of Distributed Fissile Mass and Lumped Spherical Mass in Finite Arrays

	Lumped Fissile Mass		Distributed Fissile mass		Difference in k_{eff} plus 2 sigma (%)
	k_{eff} + 2 sigma	EALF (eV)	k_{eff} + 2 sigma	EALF (eV)	
MOD0 - INITIAL ARRAY STUDY					
VERSAPAK_HAC_FINH_12S_1X306P	0.8538	3.82E-02	0.6822	3.46E-02	-20.10
VERSAPAK_HAC_FINH_12S_1X315P	0.8567	3.82E-02	0.6855	3.46E-02	-19.98
VERSAPAK_HAC_FINH_12S_1X324P	0.856	3.82E-02	0.6828	3.46E-02	-20.23
VERSAPAK_HAC_FINH_12S_2X312P	0.9184	3.83E-02	0.7760	3.45E-02	-15.51
VERSAPAK_HAC_FINH_12S_2X326P	0.9198	3.84E-02	0.7762	3.45E-02	-15.61
VERSAPAK_HAC_FINH_12S_2X338P	0.9204	3.84E-02	0.7778	3.46E-02	-15.49
VERSAPAK_HAC_FINH_12S_3X300P	0.9355	3.84E-02	0.7938	3.45E-02	-15.15
VERSAPAK_HAC_FINH_12S_4X272P	0.9322	3.84E-02	0.7924	3.47E-02	-15.00
VERSAPAK_HAC_FINH_12S_4X308P	0.9382	3.84E-02	0.7962	3.45E-02	-15.14
VERSAPAK_HAC_FINH_12S_5X260P	0.9323	3.83E-02	0.7894	3.47E-02	-15.33
VERSAPAK_HAC_FINH_12S_5X280P	0.9386	3.83E-02	0.7904	3.45E-02	-15.79
VERSAPAK_HAC_FINH_12S_5X300P	0.9385	3.84E-02	0.7935	3.45E-02	-15.45
VERSAPAK_HAC_FINH_12S_6X312P	0.9363	3.83E-02	0.7991	3.46E-02	-14.65
VERSAPAK_HAC_FINH_12S_6X336P	0.9400	3.83E-02	0.8000	3.46E-02	-14.89
VERSAPAK_HAC_FINH_12S_7X322P	0.9325	3.83E-02	0.7916	3.46E-02	-15.11
VERSAPAK_HAC_FINH_12S_7X343P	0.9382	3.83E-02	0.7976	3.47E-02	-14.98
VERSAPAK_HAC_FINH_12S_8X312P	0.9232	3.84E-02	0.7896	3.46E-02	-14.47
VERSAPAK_HAC_FINH_12S_8X336P	0.9302	3.83E-02	0.7934	3.45E-02	-14.71
VERSAPAK_HAC_FINH_12S_8X368P	0.9335	3.83E-02	0.7980	3.46E-02	-14.52
VERSAPAK_HAC_FINH_12S_8X392P	0.9394	3.83E-02	0.7994	3.46E-02	-14.90
VERSAPAK_HAC_FINH_12S_9X324P	0.9248	3.83E-02	0.7879	3.47E-02	-14.80

Table 6-14 Comparison of Distributed Fissile Mass and Lumped Spherical Mass in Finite Arrays

	Lumped Fissile Mass		Distributed Fissile mass		Difference in k_{eff} plus 2 sigma (%)
	k_{eff} + 2 sigma	EALF (eV)	k_{eff} + 2 sigma	EALF (eV)	
VERSAPAK_HAC_FINH_12S_10X300P	0.9147	3.83E-02	0.7809	3.45E-02	-14.63
VERSAPAK_HAC_FINH_12S_10X330P	0.9181	3.83E-02	0.7862	3.46E-02	-14.37
VERSAPAK_HAC_FINH_12S_10X360P	0.9240	3.83E-02	0.7882	3.47E-02	-14.70
VERSAPAK_HAC_FINH_12S_12X300P	0.9054	3.83E-02	0.7742	3.46E-02	-14.49
MOD1					
VERSAPAK_HAC_FINH_12S_4X272P	0.9398	3.84E-02	0.8020	3.47E-02	-14.66
VERSAPAK_HAC_FINH_12S_4X288P	0.9416	3.84E-02	0.8030	3.46E-02	-14.72
VERSAPAK_HAC_FINH_12S_4X308P	0.9453	3.84E-02	0.8060	3.46E-02	-14.74
VERSAPAK_HAC_FINH_12S_5X280P	0.9380	3.84E-02	0.8010	3.45E-02	-14.61
VERSAPAK_HAC_FINH_12S_6X288P	0.9369	3.84E-02	0.7986	3.45E-02	-14.76
VERSAPAK_HAC_FINH_12S_6X312P	0.9435	3.84E-02	0.8026	3.47E-02	-14.93
VERSAPAK_HAC_FINH_12S_7X322P	0.9360	3.83E-02	0.7973	3.46E-02	-14.82
VERSAPAK_HAC_FINH_12S_8X312P	0.9270	3.83E-02	0.7932	3.47E-02	-14.43
VERSAPAK_HAC_FINH_12S_9X324P	0.9238	3.83E-02	0.7887	3.47E-02	-14.62
VERSAPAK_HAC_FINH_12S_10X300P	0.9136	3.83E-02	0.7819	3.48E-02	-14.42
VERSAPAK_HAC_FINH_12S_12X300P	0.9054	3.83E-02	0.7738	3.47E-02	-14.54
MOD2					
VERSAPAK_HAC_FINH_12S_4X272P	0.9102	3.83E-02	0.7527	3.46E-02	-17.30
VERSAPAK_HAC_FINH_12S_4X288P	0.9110	3.83E-02	0.7557	3.47E-02	-17.05
VERSAPAK_HAC_FINH_12S_4X308P	0.9144	3.83E-02	0.7596	3.46E-02	-16.93
VERSAPAK_HAC_FINH_12S_5X280P	0.9139	3.83E-02	0.7601	3.46E-02	-16.82
VERSAPAK_HAC_FINH_12S_6X288P	0.9083	3.83E-02	0.7608	3.48E-02	-16.24
VERSAPAK_HAC_FINH_12S_6X312P	0.9192	3.83E-02	0.7630	3.45E-02	-16.99
VERSAPAK_HAC_FINH_12S_7X322P	0.9141	3.83E-02	0.763	3.46E-02	-16.53

Table 6-14 Comparison of Distributed Fissile Mass and Lumped Spherical Mass in Finite Arrays

	Lumped Fissile Mass		Distributed Fissile mass		Difference in k_{eff} plus 2 sigma (%)
	k_{eff} + 2 sigma	EALF (eV)	k_{eff} + 2 sigma	EALF (eV)	
VERSAPAK_HAC_FINH_12S_8X312P	0.9092	3.83E-02	0.759	3.47E-02	-16.52
VERSAPAK_HAC_FINH_12S_9X324P	0.9078	3.83E-02	0.7607	3.46E-02	-16.20
VERSAPAK_HAC_FINH_12S_10X300P	0.8994	3.83E-02	0.7502	3.45E-02	-16.59
VERSAPAK_HAC_FINH_12S_12X300P	0.8924	3.83E-02	0.7439	3.46E-02	-16.64
MOD4					
VERSAPAK_HAC_FINH_12S_4X272P	0.9347	3.84E-02	0.7930	3.46E-02	-15.16
VERSAPAK_HAC_FINH_12S_4X288P	0.9389	3.84E-02	0.7955	3.47E-02	-15.27
VERSAPAK_HAC_FINH_12S_4X308P	0.9392	3.84E-02	0.7980	3.48E-02	-15.03
VERSAPAK_HAC_FINH_12S_6X288P	0.9284	3.84E-02	0.7871	3.46E-02	-15.22
VERSAPAK_HAC_FINH_12S_6X312P	0.9340	3.84E-02	0.7925	3.47E-02	-15.15

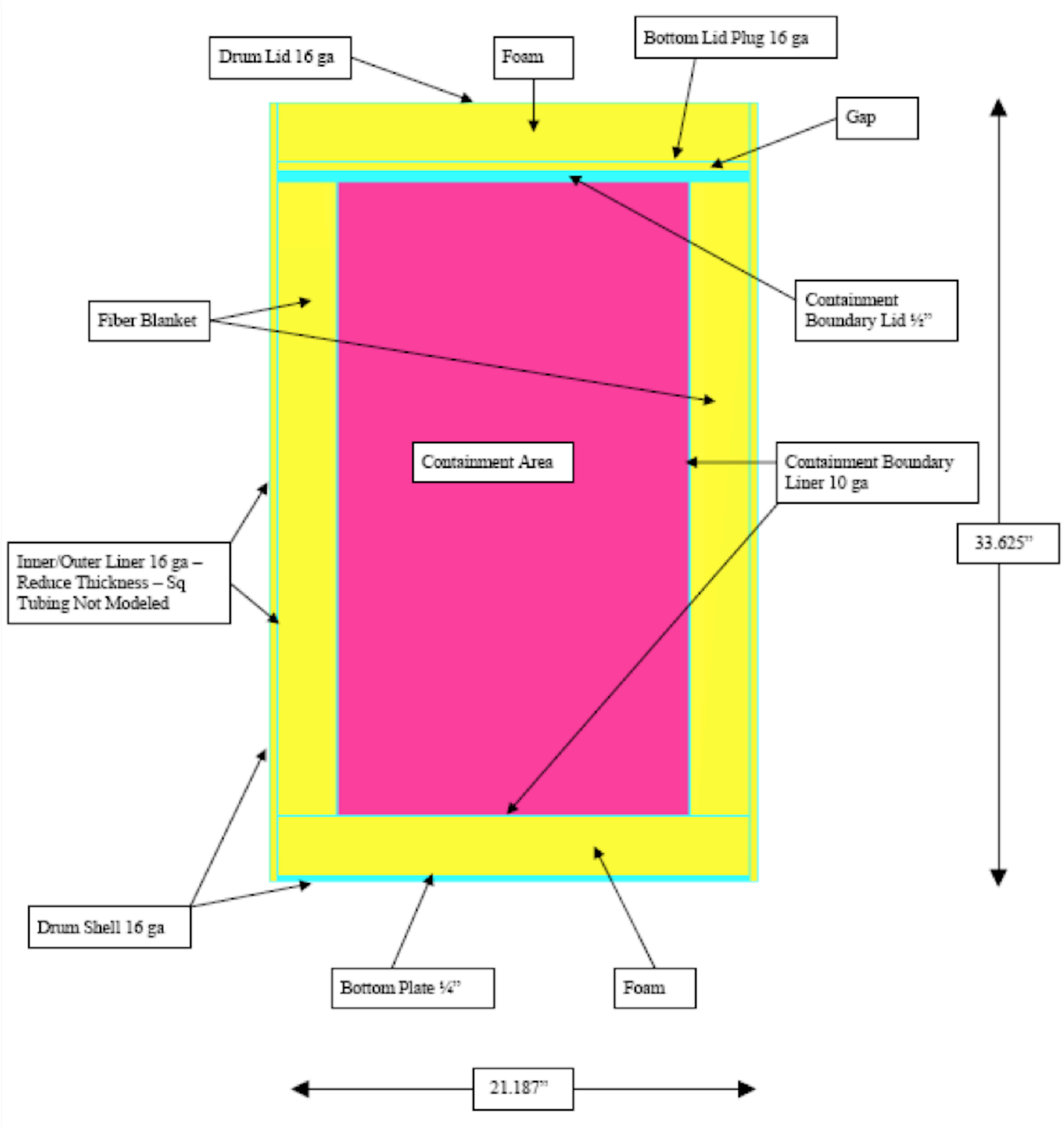

Figure 6-1 KENO Model of the Versa-Pac for NCT and HAC

[Removed]

Figure 6-2 [Removed]

[Removed]

Figure 6-3 [Removed]

[Removed]

Figure 6-4 [Removed]

.

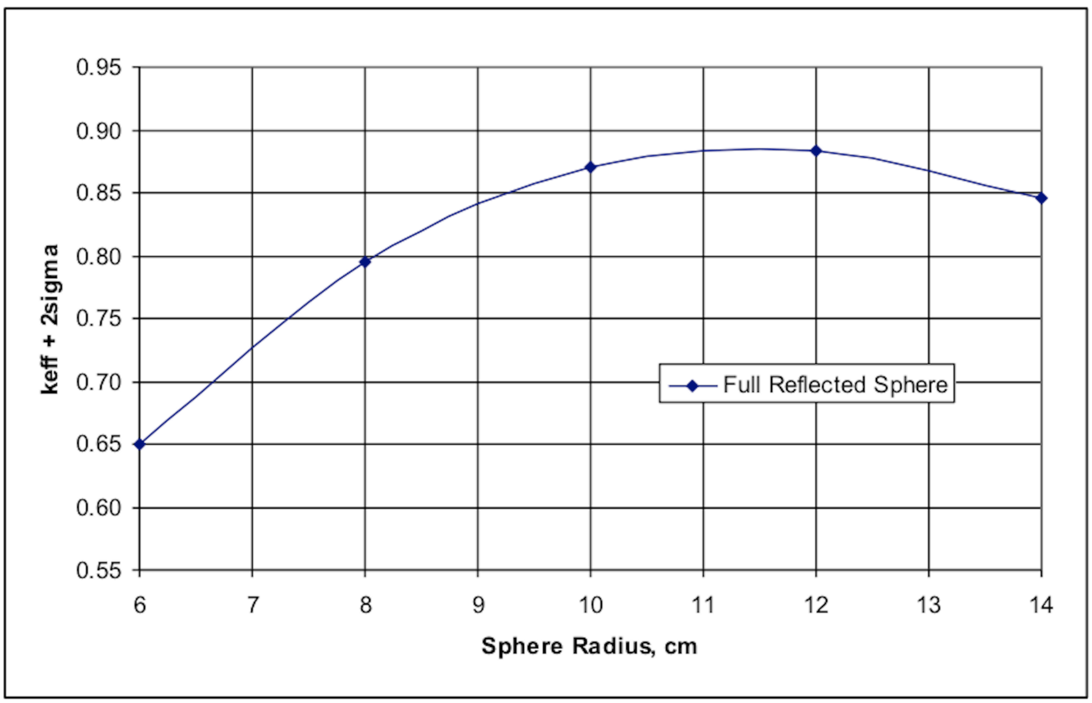

Figure 6-5 KENO VI results for fully reflected spheres representing the Normal Condition of Transport and Hypothetical Condition for a single package

[Removed]

Figure 6-6 [Removed]

[Removed]

Figure 6-7 [Removed]

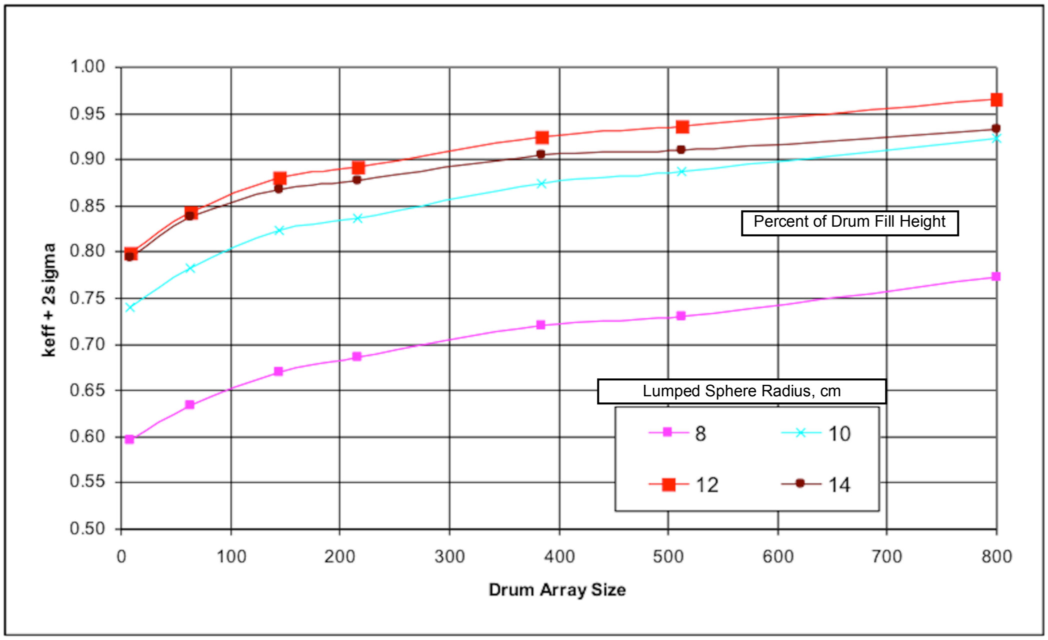

Figure 6-8 KENO VI results for triangular package array model calculation with lumped spheres as a function of package array size for the Normal Condition of Transport and Hypothetical Condition

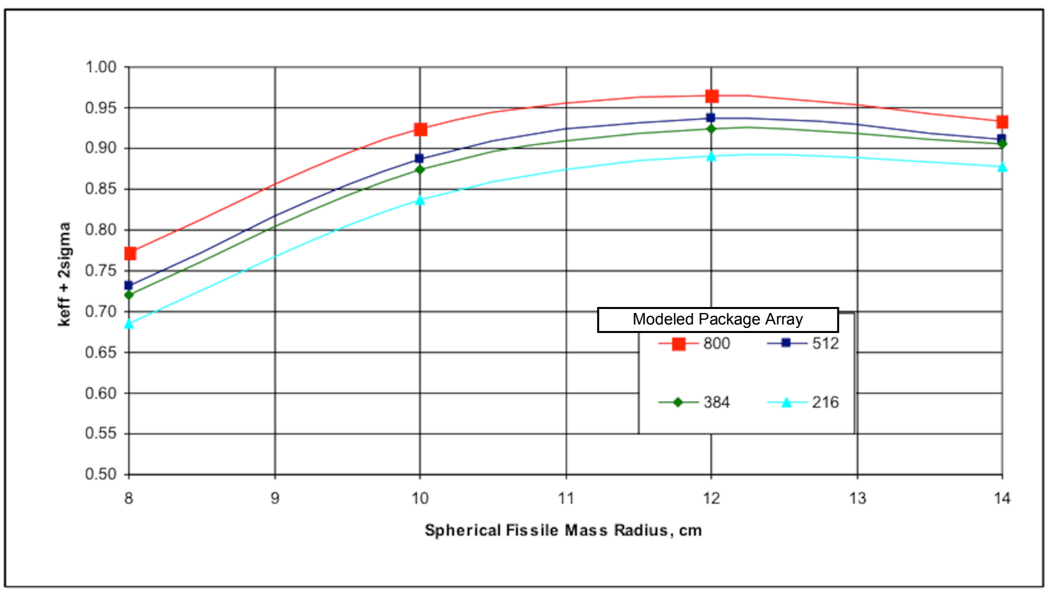

Figure 6-9 KENO VI results for triangular package array model calculation with lumped spheres as a function of sphere diameter for the Normal Condition of Transport and Hypothetical Condition

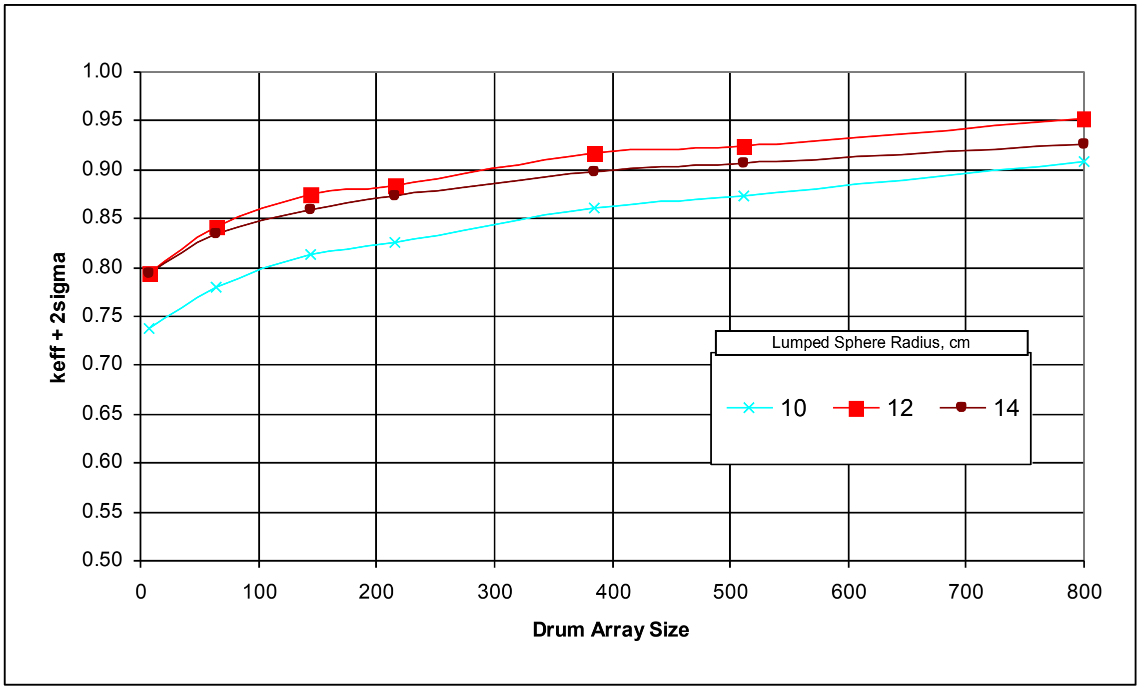

Figure 6-10 KENO VI results for square package array model calculation with lumped spheres as a function of package array size for the Normal Condition of Transport and Hypothetical Condition

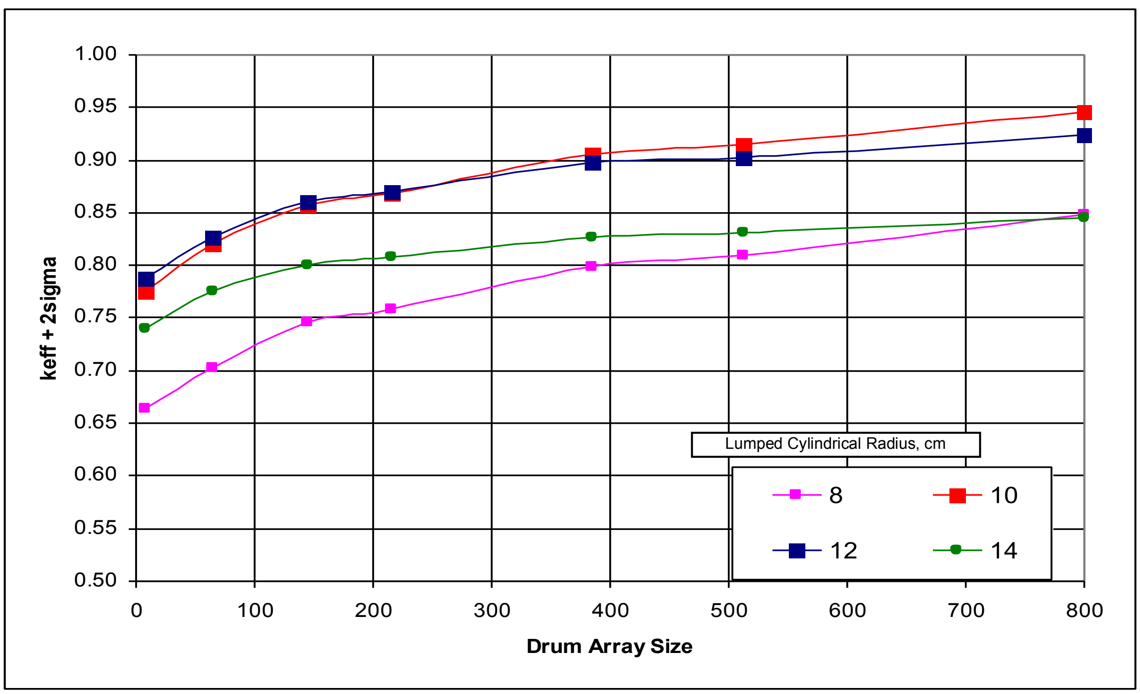

Figure 6-11 KENO VI results for triangular package array model calculation with lumped cylinders as a function of package array size for the Normal Condition of Transport and Hypothetical Condition

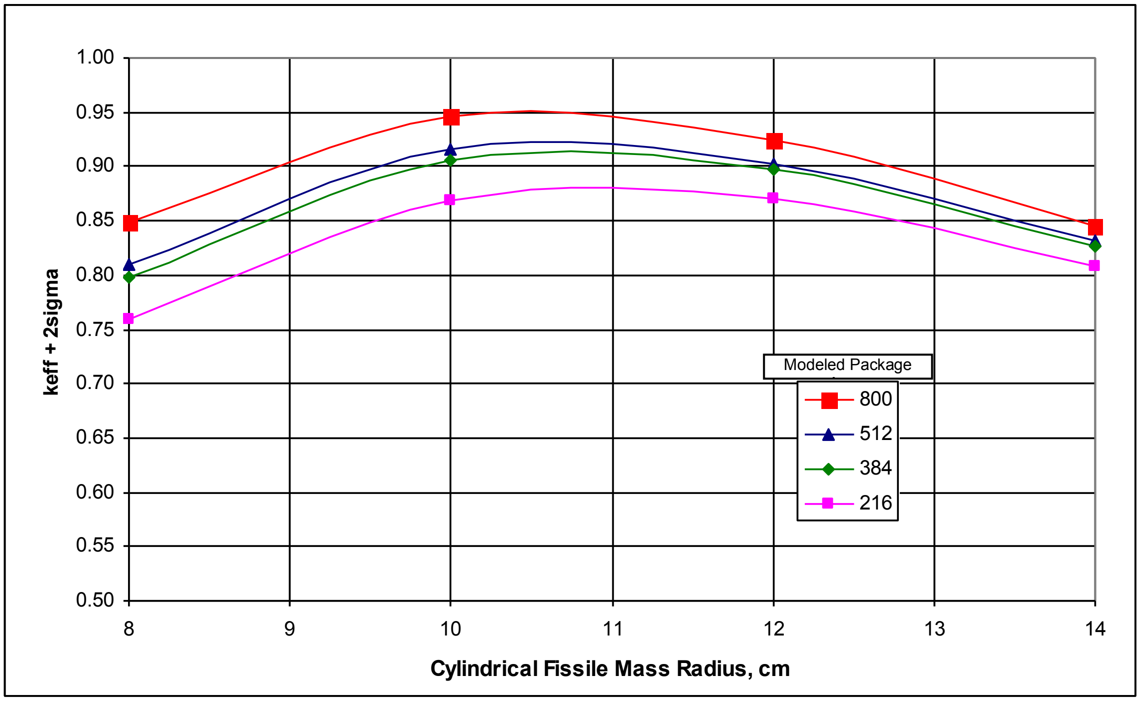

Figure 6-12 KENO VI results for triangular package array model calculation with lumped cylinders as a function of cylinder diameter for the Normal Condition of Transport and Hypothetical Condition

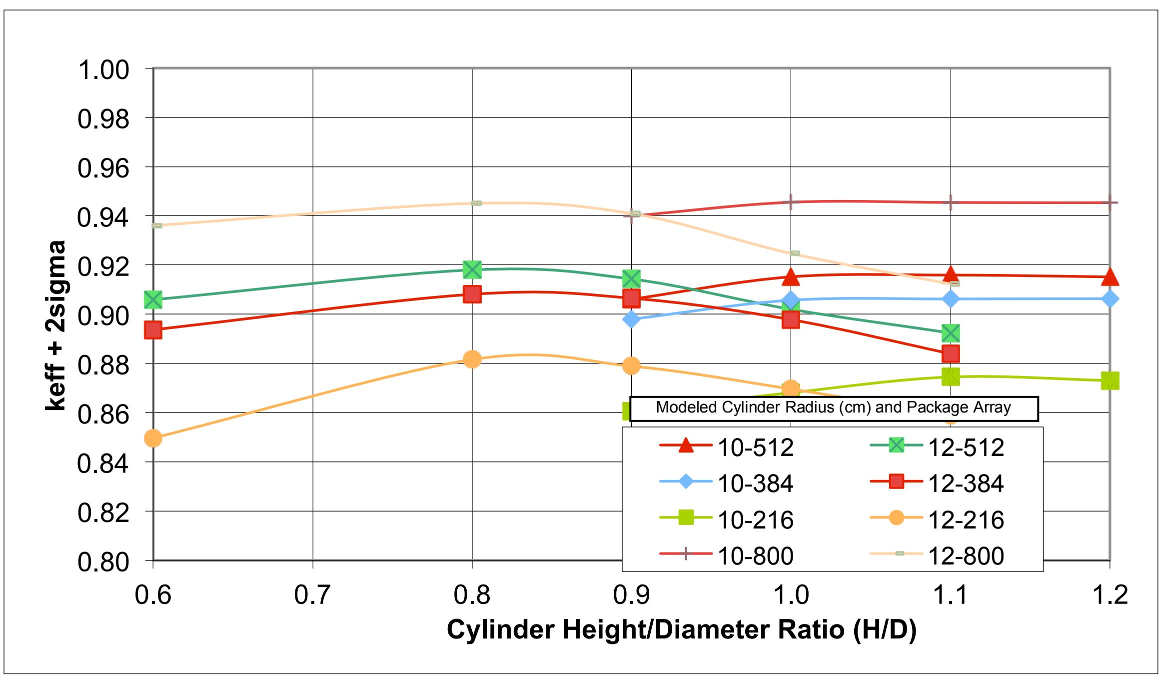

Figure 6-13 KENO VI results for triangular package array model calculation with lumped cylinders as a function of cylinder height-to-diameter ratio for the Normal Condition of Transport and Hypothetical Condition

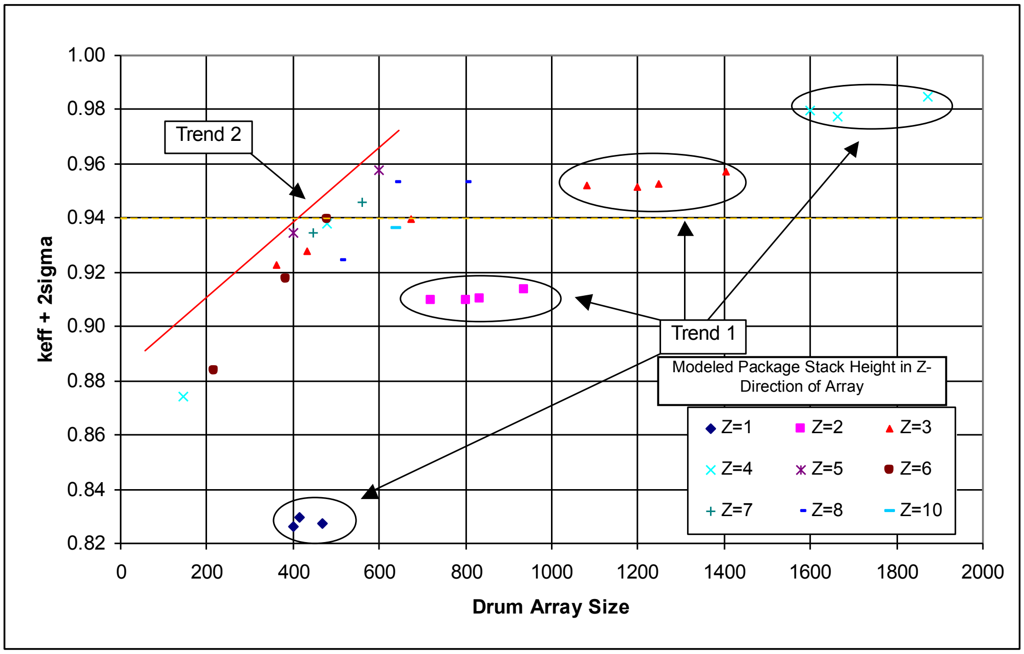

Figure 6-14 KENO VI results for triangular package array model calculation with poly-moderated (0.92 g/cc) lumped spheres as a function of package array size for the Normal Condition of Transport and Hypothetical Condition

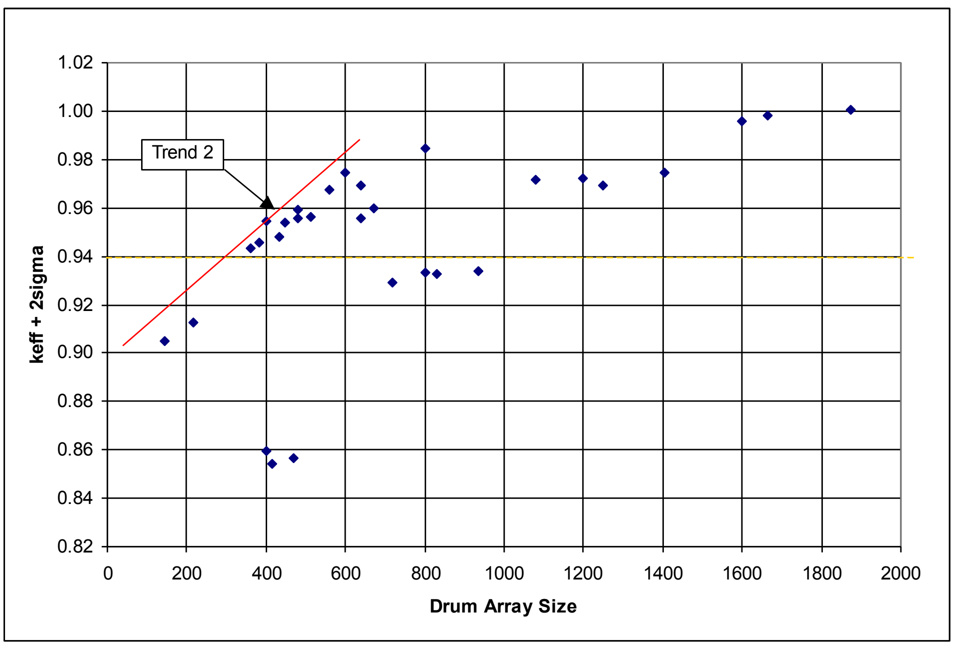

Figure 6-15 KENO VI results for triangular package array model calculation with poly-moderated (0.98 g/cc) lumped spheres as a function of package array size for the Normal Condition of Transport and Hypothetical Condition

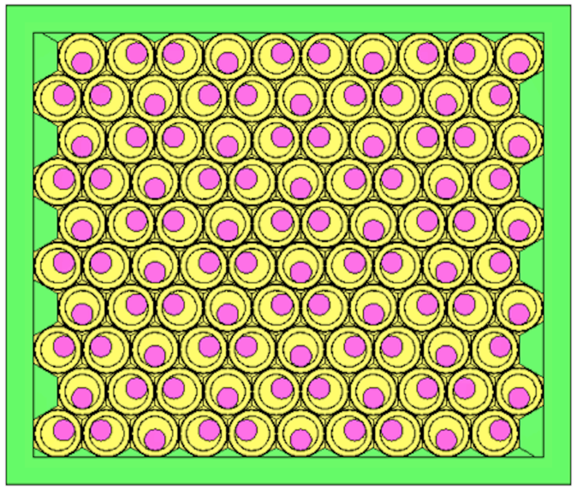

Figure 6-16 Illustration of KENO VI triangular package array model with orientation of lumped fissile mass for the Normal Condition of Transport and Hypothetical Condition

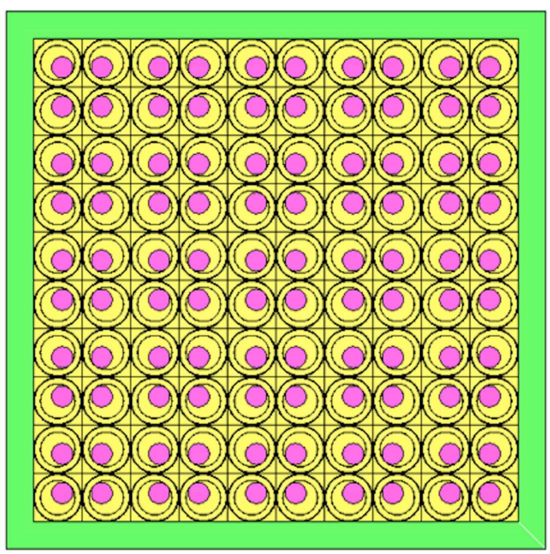

Figure 6-17 Illustration of KENO VI square package array model with orientation of lumped fissile mass for the Normal Condition of Transport and Hypothetical Condition

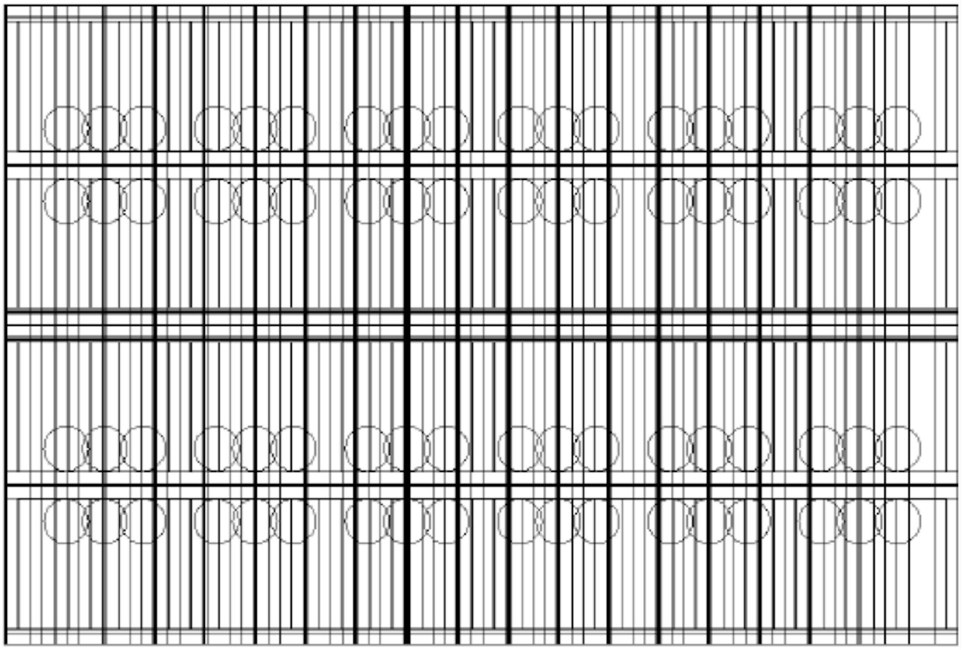

Figure 6-18 Illustration of KENO VI stacked X-Z view of the inverted bottom package and normally orientated top package in a triangular package array model with orientation of lumped fissile mass for the NCT and HAC (Initial MOD0 Configuration)

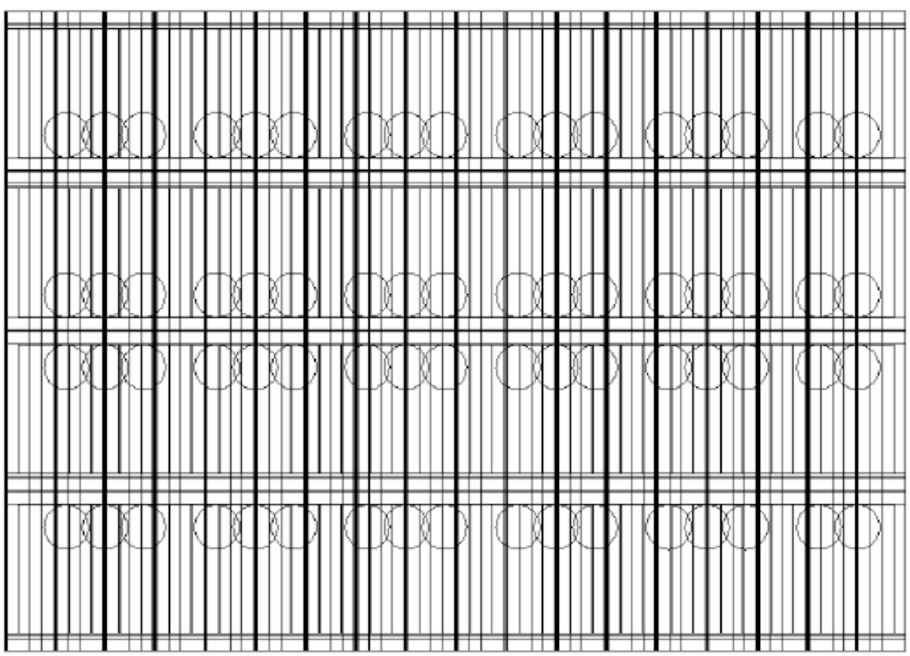

Figure 6-19 Illustration of KENO VI stacked X-Z view for the triangular package array model with orientation of lumped fissile mass for the NCT and HAC (MOD1 Configuration)

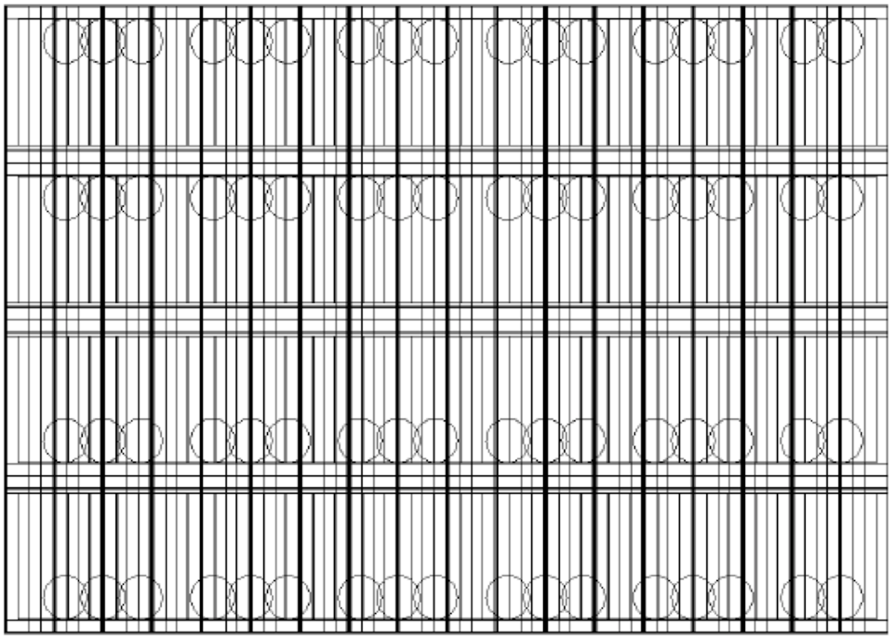

Figure 6-20 Illustration of KENO VI stacked X-Z view for the triangular package array model with orientation of lumped fissile mass for the NCT and HAC (MOD2 Configuration)

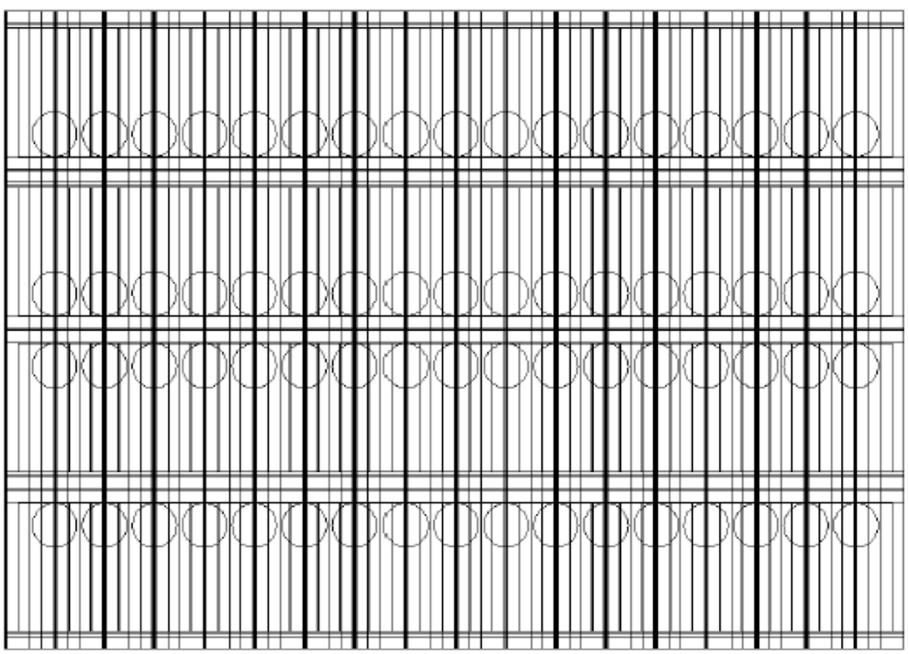

Figure 6-21 Illustration of KENO VI stacked X-Z view for the triangular package array model with orientation of lumped fissile mass for the NCT and HAC (MOD3 Configuration – note centered spheres as opposed to overlapping view as observed in Figure 6-19)

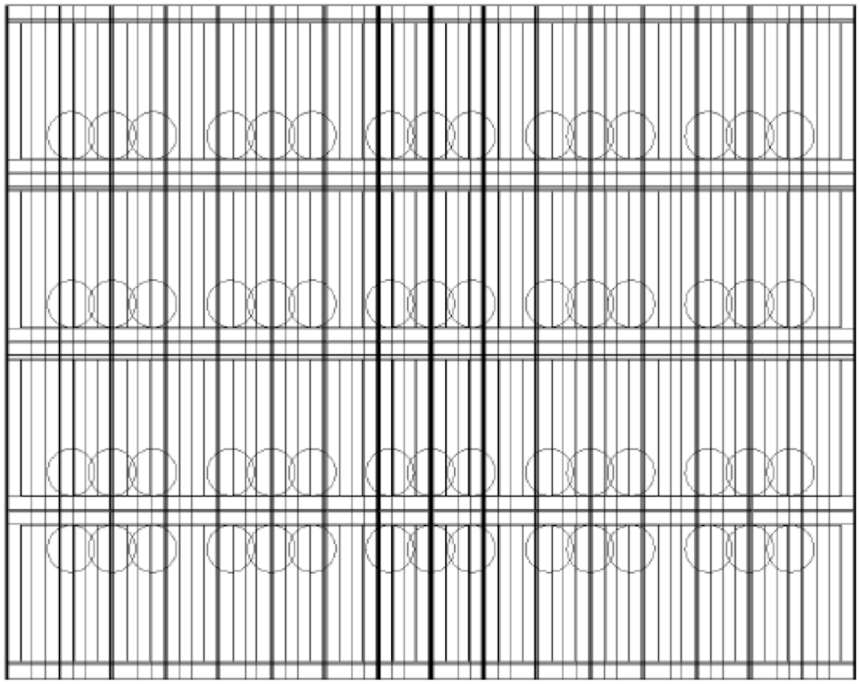

Figure 6-22 Illustration of KENO VI stacked X-Z view for the triangular package array model with orientation of lumped fissile mass for the NCT and HAC (MOD4 Configuration)

6.10.1 Appendix 6.10.1: Selected SCALE 4.4a Input Cases

Input Case: VERSA_HAC_INFH_15_A
HAC Case Infinite Homogeneous Hexagonal 15% Fill

```
'Input generated by GeeWiz SCALE 6.1
=csas6
versa hac infh 350g 15 a
ce_v7_endf
read composition
 u           1 0.00153013 294
                                 92235 100   end
 polyethylene 1 0.9984699 294   end
 h2o         2 1 294   end
 carbonsteel 3 1 294   end
 h2o         4 1 294   end
 h2o         5 0.0001 294   end
end composition
read parameter
 gen=600
 nsk=5
 htm=no
end parameter
read geometry
unit 10
com="unit 10"
 cylinder 1  19.2088  -24.1697  -34.5281
 cylinder 2  19.2088  34.5281  -34.5281
 cylinder 3  19.5163  34.5281  -34.8357
 cylinder 4  25.8663  34.5281  -34.8357
 cylinder 5  25.8663  35.7727  -34.8357
 cylinder 6  25.8663   36.856  -34.8357
 cylinder 7  25.8663  36.9914  -34.8357
 cylinder 8  25.8663  43.3414  -41.1857
 cylinder 9  26.0017  43.3414  -41.7953
 cylinder 10  26.6374  43.3414  -41.7963
 cylinder 11  26.7727  43.3414  -41.7953
 cylinder 12  26.9081  43.4768  -41.9307
 hexprism 13  26.9081  43.4768  -41.9307
 media 1 1 1
 media 5 1 2 -1
 media 3 1 3 -2 -1
 media 5 1 4 -3 -2 -1
 media 3 1 5 -4 -3 -2 -1
 media 5 1 6 -5 -4 -3 -2 -1
 media 3 1 7 -6 -5 -4 -3 -2 -1
 media 5 1 8 -7 -6 -5 -4 -3 -2 -1
 media 3 1 9 -8 -7 -6 -5 -4 -3 -2 -1
 media 5 1 10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 media 3 1 11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 media 3 1 12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 media 5 1 13 -12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -
1
 boundary 13
global unit 100
com="global unit 100 references array 1"
 cuboid 10  26.9081  -26.9081  93.2124        0
85.4075        0
 array 1 10  place 2 1 1 0 0 41.9307
 boundary 10
end geometry
read array
ara=1 nux=3 nuy=3 nuz=1 typ=triangular gbl=1
 fill
   10   10   10
   10   10   10
   10   10   10  end fill
end array
read bnds
  body=10
    all=mirror
  end bnds
end data
end
```

Input Case: VERSA_HAC_FINH_18_D_4x272P

```
'Input generated by GeeWiz SCALE 6.1
=csas6
versa hac finh 18D 4x272p
ce_v7_endf
read composition
 u           1 0.00127511 294
                                 92235 100   end
 polyethylene 1 den=0.98 0.99872489 294   end
 h2o         2 1 294   end
 carbonsteel 3 1 294   end
 h2o         4 1 294   end
 h2o         5 0.0001 294   end
end composition
read parameter
 gen=600
 nsk=5
 htm=no
end parameter
read geometry
unit 10
 cylinder 1  19.2088  34.5281  -34.5281
 hole 100   origin  x=0 y=0 z=-0
 cylinder 2  19.5163  34.5281  -34.8357
 cylinder 3  25.8663  34.5281  -34.8357
 cylinder 4  25.8663  35.7727  -34.8357
 cylinder 5  25.8663   36.856  -34.8357
 cylinder 6  25.8663  36.9914  -34.8357
 cylinder 7  25.8663  43.3414  -41.1857
 cylinder 8  26.0017  43.3414  -41.7953
 cylinder 9  26.6374  43.3414  -41.7963
 cylinder 10  26.7727  43.3414  -41.7953
 cylinder 11  26.9081  43.4768  -41.9307
 hexprism 12  26.9081  43.4768  -41.9307
 media 5 1 1
 media 3 1 2 -1
 media 5 1 3 -2 -1
 media 3 1 4 -3 -2 -1
 media 5 1 5 -4 -3 -2 -1
 media 3 1 6 -5 -4 -3 -2 -1
 media 5 1 7 -6 -5 -4 -3 -2 -1
 media 3 1 8 -7 -6 -5 -4 -3 -2 -1
 media 5 1 9 -8 -7 -6 -5 -4 -3 -2 -1
 media 3 1 10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 media 3 1 11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 media 5 1 12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 boundary 12
unit 11
 cylinder 1  19.2088  34.5281  -34.5281
 hole 100   origin  x=0 y=0 z=0  rotate a1=0 a2=180
a3=0
 cylinder 2  19.5163  34.8357  -34.5281
 cylinder 3  25.8663  34.8357  -34.5281
 cylinder 4  25.8663  34.8357  -35.7727
 cylinder 5  25.8663  34.8357  -36.856
 cylinder 6  25.8663  34.8357  -36.9914
 cylinder 7  25.8663  41.1857  -43.3414
 cylinder 8  26.0017  41.7953  -43.3414
 cylinder 9  26.6374  41.7963  -43.3414
 cylinder 10  26.7727  41.7953  -43.3414
```

```
 cylinder 11  26.9081  41.9307  -43.4768
 hexprism 12  26.9081  41.9307  -43.4768
 media 5 1 1
 media 3 1 2 -1
 media 5 1 3 -2 -1
 media 3 1 4 -3 -2 -1
 media 5 1 5 -4 -3 -2 -1
 media 3 1 6 -5 -4 -3 -2 -1
 media 5 1 7 -6 -5 -4 -3 -2 -1
 media 3 1 8 -7 -6 -5 -4 -3 -2 -1
 media 5 1 9 -8 -7 -6 -5 -4 -3 -2 -1
 media 3 1 10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 media 3 1 11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 media 5 1 12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 boundary 12
unit 20
 cylinder 1  19.2088  34.5281  -34.5281
 hole 100   origin  x=0 y=0 z=-0
 cylinder 2  19.5163  34.5281  -34.8357
 cylinder 3  25.8663  34.5281  -34.8357
 cylinder 4  25.8663  35.7727  -34.8357
 cylinder 5  25.8663   36.856  -34.8357
 cylinder 6  25.8663  36.9914  -34.8357
 cylinder 7  25.8663  43.3414  -41.1857
 cylinder 8  26.0017  43.3414  -41.7953
 cylinder 9  26.6374  43.3414  -41.7963
 cylinder 10  26.7727  43.3414  -41.7953
 cylinder 11  26.9081  43.4768  -41.9307
 hexprism 12  26.9081  43.4768  -41.9307
 media 5 1 1
 media 3 1 2 -1
 media 5 1 3 -2 -1
 media 3 1 4 -3 -2 -1
 media 5 1 5 -4 -3 -2 -1
 media 3 1 6 -5 -4 -3 -2 -1
 media 5 1 7 -6 -5 -4 -3 -2 -1
 media 3 1 8 -7 -6 -5 -4 -3 -2 -1
 media 5 1 9 -8 -7 -6 -5 -4 -3 -2 -1
 media 3 1 10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 media 3 1 11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 media 5 1 12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 boundary 12
unit 21
 cylinder 1  19.2088  34.5281  -34.5281
 hole 100   origin  x=0 y=0 z=0  rotate a1=0 a2=180
a3=0
 cylinder 2  19.5163  34.8357  -34.5281
 cylinder 3  25.8663  34.8357  -34.5281
 cylinder 4  25.8663  34.8357  -35.7727
 cylinder 5  25.8663  34.8357  -36.856
 cylinder 6  25.8663  34.8357  -36.9914
 cylinder 7  25.8663  41.1857  -43.3414
 cylinder 8  26.0017  41.7953  -43.3414
 cylinder 9  26.6374  41.7963  -43.3414
 cylinder 10  26.7727  41.7953  -43.3414
 cylinder 11  26.9081  41.9307  -43.4768
 hexprism 12  26.9081  41.9307  -43.4768
 media 5 1 1
 media 3 1 2 -1
 media 5 1 3 -2 -1
 media 3 1 4 -3 -2 -1
 media 5 1 5 -4 -3 -2 -1
 media 3 1 6 -5 -4 -3 -2 -1
 media 5 1 7 -6 -5 -4 -3 -2 -1
 media 3 1 8 -7 -6 -5 -4 -3 -2 -1
 media 5 1 9 -8 -7 -6 -5 -4 -3 -2 -1
 media 3 1 10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 media 3 1 11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 media 5 1 12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 boundary 12
unit 30
 cylinder 1  19.2088  34.5281  -34.5281
 hole 100   origin  x=0 y=0 z=-0
 cylinder 2  19.5163  34.5281  -34.8357
 cylinder 3  25.8663  34.5281  -34.8357
 cylinder 4  25.8663  35.7727  -34.8357
 cylinder 5  25.8663   36.856  -34.8357
 cylinder 6  25.8663  36.9914  -34.8357
 cylinder 7  25.8663  43.3414  -41.1857
 cylinder 8  26.0017  43.3414  -41.7953
 cylinder 9  26.6374  43.3414  -41.7963
 cylinder 10  26.7727  43.3414  -41.7953
 cylinder 11  26.9081  43.4768  -41.9307
 hexprism 12  26.9081  43.4768  -41.9307
 media 5 1 1
 media 3 1 2 -1
 media 5 1 3 -2 -1
 media 3 1 4 -3 -2 -1
 media 5 1 5 -4 -3 -2 -1
 media 3 1 6 -5 -4 -3 -2 -1
 media 5 1 7 -6 -5 -4 -3 -2 -1
 media 3 1 8 -7 -6 -5 -4 -3 -2 -1
 media 5 1 9 -8 -7 -6 -5 -4 -3 -2 -1
 media 3 1 10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 media 3 1 11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 media 5 1 12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 boundary 12
unit 31
 cylinder 1  19.2088  34.5281  -34.5281
 hole 100   origin  x=0 y=0 z=0  rotate a1=0 a2=180
a3=0
 cylinder 2  19.5163  34.8357  -34.5281
 cylinder 3  25.8663  34.8357  -34.5281
 cylinder 4  25.8663  34.8357  -35.7727
 cylinder 5  25.8663  34.8357  -36.856
 cylinder 6  25.8663  34.8357  -36.9914
 cylinder 7  25.8663  41.1857  -43.3414
 cylinder 8  26.0017  41.7953  -43.3414
 cylinder 9  26.6374  41.7963  -43.3414
 cylinder 10  26.7727  41.7953  -43.3414
 cylinder 11  26.9081  41.9307  -43.4768
 hexprism 12  26.9081  41.9307  -43.4768
 media 5 1 1
 media 3 1 2 -1
 media 5 1 3 -2 -1
 media 3 1 4 -3 -2 -1
 media 5 1 5 -4 -3 -2 -1
 media 3 1 6 -5 -4 -3 -2 -1
 media 5 1 7 -6 -5 -4 -3 -2 -1
 media 3 1 8 -7 -6 -5 -4 -3 -2 -1
 media 5 1 9 -8 -7 -6 -5 -4 -3 -2 -1
 media 3 1 10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 media 3 1 11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 media 5 1 12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 boundary 12
unit 40
 cylinder 1  19.2088  34.5281  -34.5281
 hole 100   origin  x=0 y=0 z=-0
 cylinder 2  19.5163  34.5281  -34.8357
 cylinder 3  25.8663  34.5281  -34.8357
 cylinder 4  25.8663  35.7727  -34.8357
 cylinder 5  25.8663   36.856  -34.8357
 cylinder 6  25.8663  36.9914  -34.8357
 cylinder 7  25.8663  43.3414  -41.1857
 cylinder 8  26.0017  43.3414  -41.7953
 cylinder 9  26.6374  43.3414  -41.7963
 cylinder 10  26.7727  43.3414  -41.7953
 cylinder 11  26.9081  43.4768  -41.9307
 hexprism 12  26.9081  43.4768  -41.9307
 media 5 1 1
 media 3 1 2 -1
 media 5 1 3 -2 -1
 media 3 1 4 -3 -2 -1
 media 5 1 5 -4 -3 -2 -1
 media 3 1 6 -5 -4 -3 -2 -1
 media 5 1 7 -6 -5 -4 -3 -2 -1
 media 3 1 8 -7 -6 -5 -4 -3 -2 -1
 media 5 1 9 -8 -7 -6 -5 -4 -3 -2 -1
 media 3 1 10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 media 3 1 11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 media 5 1 12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 boundary 12
unit 41
 cylinder 1  19.2088  34.5281  -34.5281
 hole 100   origin  x=0 y=0 z=0  rotate a1=0 a2=180
a3=0
```

```
 cylinder 2  19.5163  34.8357  -34.5281
 cylinder 3  25.8663  34.8357  -34.5281
 cylinder 4  25.8663  34.8357  -35.7727
 cylinder 5  25.8663  34.8357  -36.856
 cylinder 6  25.8663  34.8357  -36.9914
 cylinder 7  25.8663  41.1857  -43.3414
 cylinder 8  26.0017  41.7953  -43.3414
 cylinder 9  26.6374  41.7963  -43.3414
 cylinder 10  26.7727  41.7953  -43.3414
 cylinder 11  26.9081  41.9307  -43.4768
 hexprism 12  26.9081  41.9307  -43.4768
 media 5 1 1
 media 3 1 2 -1
 media 5 1 3 -2 -1
 media 3 1 4 -3 -2 -1
 media 5 1 5 -4 -3 -2 -1
 media 3 1 6 -5 -4 -3 -2 -1
 media 5 1 7 -6 -5 -4 -3 -2 -1
 media 3 1 8 -7 -6 -5 -4 -3 -2 -1
 media 5 1 9 -8 -7 -6 -5 -4 -3 -2 -1
 media 3 1 10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 media 3 1 11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 media 5 1 12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1
 boundary 12
unit 50
 hexprism 10  26.9081  43.4768  -41.9307
 media 4 1 10
 boundary 10
unit 51
 hexprism 10  26.9081  41.9307  -43.4768
 media 4 1 10
 boundary 10
unit 100
 cylinder 1    19.2088  -22.098  -34.5281
 media 1 1 1
 boundary 1
global unit 1000
 cuboid 10  430.5296       0  426.6658        0
341.63        0
 array 1 10  place 6 2 1 26.9081 26.9081 43.4768
 cuboid 20  461.0096   -30.48  457.1458   -30.48
372.11   -30.48
 media 4 1 20 -10
 boundary 20
end geometry
read array
ara=1 nux=15 nuy=11 nuz=4 typ=triangular gbl=1
 fill
   51   51   51   51   51   51   51   51   51   51
51   51   51   51   51
   51   51   51   51   51   11   21   31   11   21
31   11   21   51   51
   51   51   51   51   51   31   11   21   31   11
21   31   51   51   51
   51   51   51   51   11   21   31   11   21   31
11   21   51   51   51
   51   51   51   51   31   11   21   31   11   21
31   51   51   51   51
   51   51   51   11   21   31   11   21   31   11
21   51   51   51   51
   51   51   51   31   11   21   31   11   21   31
51   51   51   51   51
   51   51   11   21   31   11   21   31   11   21
51   51   51   51   51
   51   51   31   11   21   31   11   21   31   51
51   51   51   51   51
   51   11   21   31   11   21   31   11   21   51
51   51   51   51   51
   51   51   51   51   51   51   51   51   51   51
51   51   51   51   51
   51   51   51   51   51   51   51   51   51   51
51   51   51   51   51
   51   51   51   51   51   11   21   31   11   21
31   11   21   51   51
   51   51   51   51   51   31   11   21   31   11
21   31   51   51   51
   51   51   51   51   11   21   31   11   21   31
11   21   51   51   51
   51   51   51   51   31   11   21   31   11   21
31   51   51   51   51
   51   51   51   11   21   31   11   21   31   11
21   51   51   51   51
   51   51   51   31   11   21   31   11   21   31
51   51   51   51   51
   51   51   11   21   31   11   21   31   11   21
51   51   51   51   51
   51   51   31   11   21   31   11   21   31   51
51   51   51   51   51
   51   11   21   31   11   21   31   11   21   51
51   51   51   51   51
   51   51   51   51   51   51   51   51   51   51
51   51   51   51   51
   50   50   50   50   50   50   50   50   50   50
50   50   50   50   50
   50   50   50   50   50   10   20   30   10   20
30   10   20   50   50
   50   50   50   50   50   30   10   20   30   10
20   30   50   50   50
   50   50   50   50   10   20   30   10   20   30
10   20   50   50   50
   50   50   50   50   30   10   20   30   10   20
30   50   50   50   50
   50   50   50   10   20   30   10   20   30   10
20   50   50   50   50
   50   50   50   30   10   20   30   10   20   30
50   50   50   50   50
   50   50   10   20   30   10   20   30   10   20
50   50   50   50   50
   50   50   30   10   20   30   10   20   30   50
50   50   50   50   50
   50   10   20   30   10   20   30   10   20   50
50   50   50   50   50
   50   50   50   50   50   50   50   50   50   50
50   50   50   50   50
   50   50   50   50   50   50   50   50   50   50
50   50   50   50   50
   50   50   50   50   50   10   20   30   10   20
30   10   20   50   50
   50   50   50   50   50   30   10   20   30   10
20   30   50   50   50
   50   50   50   50   10   20   30   10   20   30
10   20   50   50   50
   50   50   50   50   30   10   20   30   10   20
30   50   50   50   50
   50   50   50   10   20   30   10   20   30   10
20   50   50   50   50
   50   50   50   30   10   20   30   10   20   30
50   50   50   50   50
   50   50   10   20   30   10   20   30   10   20
50   50   50   50   50
   50   50   30   10   20   30   10   20   30   50
50   50   50   50   50
   50   10   20   30   10   20   30   10   20   50
50   50   50   50   50
   50   50   50   50   50   50   50   50   50   50
50   50   50   50   50  end fill
end array
end data
end
```

Input Case: VERSA_HAC_FINS_12S_A7 (MOD0 Array Configuration)
HAC Case Finite In-Homogeneous Square Lattice 12-cm Spheres 800 Packages

```
=CSAS26     PARM='SIZE=00100000'
CENTURY INDUSTRIES VERSA-PAK
44GR     INFHOM
'URANIUM METAL
U          1 0.00253829 294.0 92235 100.0 END
POLYETHYLENE     1 0.99746 294.0   END
'GRAPHITE   1 0.100 294.0  END
'INTERSPERSED MODERATOR
H2O          2 1.0   294.0   END
'PACKAGE STEEL
CARBONSTEEL  3 1.0   294.0   END
```

```
'REFLECTOR
H2O          4 1.0   294.0  END
'INSULATION
H2O          5 0.0001 294.0 END
END COMP
READ PARM  NUB=YES GEN=600 NPG=1000 NSK=5
END PARM
READ GEOMETRY

UNIT  10
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=5.097 Y=5.097  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
CUBOID  12  4P26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  11
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=5.097 Y=5.097  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
CUBOID  12  4P26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  20
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-5.097 Y=5.097  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
CUBOID  12  4P26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  21
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-5.097 Y=5.097  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
CUBOID  12  4P26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  30
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=5.097 Y=-5.097  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
CUBOID  12  4P26.9081  43.4768  -41.9307
```

```
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  31
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=5.097 Y=-5.097  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
CUBOID  12  4P26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  40
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-5.097 Y=-5.097  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
CUBOID  12  4P26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  41
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-5.097 Y=-5.097  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
CUBOID  12  4P26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  100
SPHERE  1  12.00
MEDIA  1  1  1
BOUNDARY  1

UNIT  200
CUBOID  10  107.6324  0.00  107.6324  0.00  170.815
0.00
ARRAY  1  10  PLACE 1 1 1 26.9081  26.9081  43.4768
BOUNDARY  10
GLOBAL
UNIT  300
CUBOID  10  538.16  0.00  538.16  0.00  683.260
0.00
ARRAY  2  10  PLACE 1 1 1  3*0.00
CUBOID  20  568.64  -30.48  568.64  -30.48  713.74
-30.48
MEDIA  4  10  20  -10
BOUNDARY  20
END GEOMETRY
READ ARRAY
ARA=1 NUX=2 NUY=2 NUZ=2
      FILL 11 21 31 41 10 20 30 40  END FILL
ARA=2 NUX=5 NUY=5 NUZ=4
      FILL  F200  END FILL
END ARRAY
READ BOUNDS
ALL=VACUUM
END BOUNDS
END DATA
END
```

Input Case: VERSA_HAC_FINH_12S_A7 (MOD0 Array Configuration)
HAC Case Finite In-Homogeneous Hexagonal Lattice 12-cm Spheres 800 Packages

```
=CSAS26     PARM='SIZE=00100000'
CENTURY INDUSTRIES VERSA-PAK
44GR     INFHOM
'URANIUM METAL
U          1 0.00253829 294.0 92235 100.0 END
POLYETHYLENE    1 0.99746 294.0   END
'SUB FOR HIGH DENSITY POLY
'POLYETHYLENE    1  DEN=0.98   0.99746 294.0   END
'SUB FOR GRAPHITE
'GRAPHITE   1 0.99746 294.0   END
'INTERSPERSED MODERATOR
H2O          2 1.0   294.0   END
'PACKAGE STEEL
CARBONSTEEL  3 1.0   294.0   END
'REFLECTOR
H2O          4 1.0    294.0   END
'INSULATION
H2O          5 0.0001 294.0 END
END COMP
READ PARM  NUB=YES GEN=600 NPG=1000 NSK=5
END PARM
READ GEOMETRY

UNIT  10
```

```
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  11
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE  100  ORIGIN X=6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  20
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  21
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  30
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  31
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
```

```
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  40
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  41
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT 50
HEXPRISM  10  26.9081  43.4768 -41.9307
MEDIA  4  1  10
BOUNDARY  10

UNIT 51
HEXPRISM  10  26.9081  41.9307 -43.4768
MEDIA  4  1  10
BOUNDARY  10

UNIT  100
SPHERE  1  12.00
MEDIA  1  1  1
BOUNDARY  1

GLOBAL
UNIT  1000
CUBOID  10  565.1  0.00  473.3  0.00  683.260  0.00
ARRAY  1  10  PLACE 6 2 1  26.9081  26.9081
43.4768
CUBOID  20  595.55  -30.48  503.75  -30.48  713.74
-30.48
MEDIA  4  10  20  -10
BOUNDARY  20
END GEOMETRY
READ ARRAY
GBL=1 ARA=1 TYP=TRIANGULAR NUX=16 NUY=12 NUZ=8
      FILL 51 51 51 51 51 51 51 51 51 51 51 51 51
51 51 51
          51 51 51 51 51 11 21 31 11 21 31 11 21 31
11 51
         51 51 51 51 51 31 11 21 31 11 21 31 11 21
31 51
        51 51 51 51 11 21 31 11 21 31 11 21 31 11
51 51
       51 51 51 51 31 11 21 31 11 21 31 11 21 31 51
51
      51 51 51 11 21 31 11 21 31 11 21 31 11 51 51
51
     51 51 51 31 11 21 31 11 21 31 11 21 31 51 51
51
    51 51 11 21 31 11 21 31 11 21 31 11 51 51 51 51
   51 51 31 11 21 31 11 21 31 11 21 31 51 51 51 51
  51 11 21 31 11 21 31 11 21 31 11 51 51 51 51 51
 51 31 11 21 31 11 21 31 11 21 31 51 51 51 51 51
51 51 51 51 51 51 51 51 51 51 51 51 51 51 51 51
           50 50 50 50 50 50 50 50 50 50 50 50 50
50 50 50
          50 50 50 50 50 10 20 30 10 20 30 10 20 30
10 50
         50 50 50 50 50 30 10 20 30 10 20 30 10 20
30 50
        50 50 50 50 10 20 30 10 20 30 10 20 30 10
50 50
       50 50 50 50 30 10 20 30 10 20 30 10 20 30 50
50
      50 50 50 10 20 30 10 20 30 10 20 30 10 50 50
50
     50 50 50 30 10 20 30 10 20 30 10 20 30 50 50
50
    50 50 10 20 30 10 20 30 10 20 30 10 50 50 50 50
   50 50 30 10 20 30 10 20 30 10 20 30 50 50 50 50
  50 10 20 30 10 20 30 10 20 30 10 50 50 50 50 50
 50 30 10 20 30 10 20 30 10 20 30 50 50 50 50 50
50 50 50 50 50 50 50 50 50 50 50 50 50 50 50 50
3Q384 END FILL
END ARRAY
READ BOUNDS
ALL=VACUUM
END BOUNDS
END DATA
END
```

Input Case: VERSA_HAC_FINH_12S_10X064 (MOD0 Array Configuration)
HAC Case Finite In-Homogeneous Hexagonal Lattice 12-cm Spheres 8X8X10 Packages

```
=CSAS26     PARM='SIZE=00100000'
CENTURY INDUSTRIES VERSA-PAK
44GR     INFHOM
'URANIUM METAL
U          1 0.00253829 294.0 92235 100.0 END
POLYETHYLENE    1 0.99746 294.0  END
'GRAPHITE   1 0.100 294.0  END
'INTERSPERSED MODERATOR
H2O          2 1.0  294.0  END
'PACKAGE STEEL
CARBONSTEEL  3 1.0  294.0  END
'REFLECTOR
H2O          4 1.0   294.0  END
'INSULATION
H2O          5 0.0001 294.0 END
END COMP
READ PARM  NUB=YES GEN=600 NPG=1000 NSK=5
END PARM
READ GEOMETRY

UNIT  10
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  11
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE  100  ORIGIN X=6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  20
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  21
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  30
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
```

```
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  31
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  40
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  41
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT 50
HEXPRISM  10  26.9081  43.4768 -41.9307
MEDIA  4  1  10
BOUNDARY  10

UNIT 51
HEXPRISM  10  26.9081  41.9307 -43.4768
MEDIA  4  1  10
BOUNDARY  10

UNIT  100
SPHERE  1  12.00
MEDIA  1  1  1
BOUNDARY  1

GLOBAL
UNIT  1000
CUBOID  10  457.5  0.00  380.1  0.00  854.075  0.00
ARRAY  1  10  PLACE 5 2 1  26.9081  26.9081
43.4768
CUBOID  20  487.91  -30.48  410.53  -30.48  884.555
-30.48
MEDIA  4  10  20  -10
BOUNDARY  20
END GEOMETRY
READ ARRAY
GBL=1 ARA=1 TYP=TRIANGULAR NUX=13  NUY=10  NUZ=10
    FILL 51 51 51 51 51 51 51 51 51 51 51 51 51
        51 51 51 51 11 21 31 11 21 31 11 21 51
       51 51 51 51 31 11 21 31 11 21 31 11 51
      51 51 51 11 21 31 11 21 31 11 21 51 51
     51 51 51 31 11 21 31 11 21 31 11 51 51
    51 51 11 21 31 11 21 31 11 21 51 51 51
   51 51 31 11 21 31 11 21 31 11 51 51 51
  51 11 21 31 11 21 31 11 21 51 51 51 51
 51 31 11 21 31 11 21 31 11 51 51 51 51
51 51 51 51 51 51 51 51 51 51 51 51 51
         50 50 50 50 50 50 50 50 50 50 50 50 50
        50 50 50 50 10 20 30 10 20 30 10 20 50
       50 50 50 50 30 10 20 30 10 20 30 10 50
      50 50 50 10 20 30 10 20 30 10 20 50 50
     50 50 50 30 10 20 30 10 20 30 10 50 50
    50 50 10 20 30 10 20 30 10 20 50 50 50
   50 50 30 10 20 30 10 20 30 10 50 50 50
  50 10 20 30 10 20 30 10 20 50 50 50 50
 50 30 10 20 30 10 20 30 10 50 50 50 50
```

```
50 50 50 50 50 50 50 50 50 50 50 50 50
4Q260  END FILL
END ARRAY
READ BOUNDS
ALL=VACUUM
END BOUNDS
END DATA
END
```

Input Case: VERSA_HAC_FINH_12S_1X324 (MOD0 Array Configuration)
HAC Case Finite In-Homogeneous Hexagonal Lattice 12-cm Spheres 18X18X1 Packages

```
=CSAS26     PARM='SIZE=00900000'
CENTURY INDUSTRIES VERSA-PAK
44GR     INFHOM
'URANIUM METAL
U          1 0.00253829 294.0 92235 100.0 END
POLYETHYLENE    1  DEN=0.98  0.99746 294.0  END
'PARAFFIN      1  0.99746 294.0  END
'GRAPHITE   1 0.100 294.0  END
'INTERSPERSED MODERATOR
H2O          2 1.0  294.0  END
'PACKAGE STEEL
CARBONSTEEL  3 1.0  294.0  END
'REFLECTOR
H2O          4 1.0   294.0  END
'INSULATION
H2O          5 0.0001 294.0 END
END COMP
READ PARM  NUB=YES GEN=600 NPG=1000 NSK=5
END PARM
READ GEOMETRY

UNIT  10
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  11
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE  100  ORIGIN X=6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  20
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE  100  ORIGIN  X=-6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  21
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  30
CYLINDER  1  19.2088 34.5281 -34.5281
```

```
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  31
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  40
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  41
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT 50
HEXPRISM  10  26.9081  43.4768 -41.9307
MEDIA  4  1  10
BOUNDARY  10

UNIT 51
HEXPRISM  10  26.9081  41.9307 -43.4768
MEDIA  4  1  10
BOUNDARY  10

UNIT  100
SPHERE  1  12.00
MEDIA  1  1  1
BOUNDARY  1

GLOBAL
UNIT  1000
CUBOID  10  995.5997  0.00  846.1215  0.00  85.4075
0.00
ARRAY  1  10  PLACE 10 2 1  26.9081  26.9081
43.4768
CUBOID  20  1026.0797  -30.48  876.6015 -30.48
115.8875  -30.48
MEDIA  4  10  20  -10
BOUNDARY  20
END GEOMETRY
READ ARRAY
GBL=1 ARA=1 TYP=TRIANGULAR NUX=28  NUY=20  NUZ=1
FILL
                   51 51 51 51 51 51 51 51 51 51 51
51 51 51 51 51 51 51 51
51 51 51 51 51 51 51 51 51
                  51 51 51 51 51 51 51 51 51 11 21
31 11 21 31 11 21 31 11
21 31 11 21 31 11 21 31 51
                 51 51 51 51 51 51 51 51 51 31 11
21 31 11 21 31 11 21 31
11 21 31 11 21 31 11 21 51
```

```
                51 51 51 51 51 51 51 51 11 21 31 11
21 31 11 21 31 11 21
31 11 21 31 11 21 31 51 51
               51 51 51 51 51 51 51 51 31 11 21 31
11 21 31 11 21 31 11
21 31 11 21 31 11 21 51 51
              51 51 51 51 51 51 51 11 21 31 11 21
31 11 21 31 11 21 31
11 21 31 11 21 31 51 51 51
             51 51 51 51 51 51 51 31 11 21 31 11 21
31 11 21 31 11 21
31 11 21 31 11 21 51 51 51
            51 51 51 51 51 51 11 21 31 11 21 31 11
21 31 11 21 31 11
21 31 11 21 31 51 51 51 51
           51 51 51 51 51 51 31 11 21 31 11 21 31
11 21 31 11 21 31
11 21 31 11 21 51 51 51 51
          51 51 51 51 51 11 21 31 11 21 31 11 21 31
11 21 31 11 21
31 11 21 31 51 51 51 51 51
         51 51 51 51 51 31 11 21 31 11 21 31 11 21
31 11 21 31 11
21 31 11 21 51 51 51 51 51
        51 51 51 51 11 21 31 11 21 31 11 21 31 11
21 31 11 21 31
11 21 31 51 51 51 51 51 51
       51 51 51 51 31 11 21 31 11 21 31 11 21 31 11
21 31 11 21
31 11 21 51 51 51 51 51 51
      51 51 51 11 21 31 11 21 31 11 21 31 11 21 31
11 21 31 11
21 31 51 51 51 51 51 51 51
     51 51 51 31 11 21 31 11 21 31 11 21 31 11 21
31 11 21 31
11 21 51 51 51 51 51 51 51
    51 51 11 21 31 11 21 31 11 21 31 11 21 31 11 21
31 11 21
31 51 51 51 51 51 51 51 51
   51 51 31 11 21 31 11 21 31 11 21 31 11 21 31 11
21 31 11
21 51 51 51 51 51 51 51 51
  51 11 21 31 11 21 31 11 21 31 11 21 31 11 21 31
11 21 31
51 51 51 51 51 51 51 51 51
 51 31 11 21 31 11 21 31 11 21 31 11 21 31 11 21 31
11 21
51 51 51 51 51 51 51 51 51
51 51 51 51 51 51 51 51 51 51 51 51 51 51 51 51 51
51 51
51 51 51 51 51 51 51 51 51  END FILL
END ARRAY
READ BOUNDS
ALL=VACUUM
END BOUNDS
END DATA
END
```

Input Case: VERSA_HAC_FINH_12S_2X338 (MOD0 Array Configuration)
HAC Case Finite In-Homogeneous Hexagonal Lattice 12-cm Spheres 13X13X2 Packages

```
=CSAS26     PARM='SIZE=00900000'
CENTURY INDUSTRIES VERSA-PAK
44GR     INFHOM
'URANIUM METAL
U          1 0.00253829 294.0 92235 100.0 END
POLYETHYLENE    1  DEN=0.98  0.99746 294.0  END
'PARAFFIN       1  0.99746 294.0  END
'GRAPHITE   1 0.100 294.0  END
'INTERSPERSED MODERATOR
H2O          2 1.0  294.0  END
'PACKAGE STEEL
CARBONSTEEL  3 1.0  294.0  END
'REFLECTOR
H2O          4 1.0   294.0  END
'INSULATION
H2O          5 0.0001 294.0 END
END COMP
READ PARM  NUB=YES GEN=600 NPG=1000 NSK=5
END PARM
READ GEOMETRY

UNIT  10
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  11
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE  100  ORIGIN X=6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  20
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
```

```
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  21
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  30
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  31
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  40
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  41
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
```

```
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT 50
HEXPRISM  10  26.9081  43.4768 -41.9307
MEDIA  4  1  10
BOUNDARY  10

UNIT 51
HEXPRISM  10  26.9081  41.9307 -43.4768
MEDIA  4  1  10
BOUNDARY  10

UNIT  100
SPHERE  1  12.00
MEDIA  1  1  1
BOUNDARY  1

GLOBAL
UNIT  1000
CUBOID  10  726.5187  0.00  613.5706  0.00
170.8150  0.00
ARRAY  1  10  PLACE 8 2 1  26.9081  26.9081
43.4768
CUBOID  20  756.9987  -30.48  643.5706 -30.48
201.2950  -30.48
MEDIA  4  10  20  -10
BOUNDARY  20
END GEOMETRY
READ ARRAY
GBL=1 ARA=1 TYP=TRIANGULAR NUX=21  NUY=15  NUZ=2
FILL
               51 51 51 51 51 51 51 51 51 51 51 51
51 51 51 51 51 51 51 51 51
              51 51 51 51 51 51 51 11 21 31 11 21
31 11 21 31 11 21 31 11 51
             51 51 51 51 51 51 51 31 11 21 31 11 21
31 11 21 31 11 21 31 51
            51 51 51 51 51 51 11 21 31 11 21 31 11
21 31 11 21 31 11 51 51
           51 51 51 51 51 51 31 11 21 31 11 21 31
11 21 31 11 21 31 51 51
          51 51 51 51 51 11 21 31 11 21 31 11 21 31
11 21 31 11 51 51 51
         51 51 51 51 51 31 11 21 31 11 21 31 11 21
31 11 21 31 51 51 51
        51 51 51 51 11 21 31 11 21 31 11 21 31 11
21 31 11 51 51 51 51
       51 51 51 51 31 11 21 31 11 21 31 11 21 31 11
21 31 51 51 51 51
      51 51 51 11 21 31 11 21 31 11 21 31 11 21 31
11 51 51 11 51 51
     51 51 51 31 11 21 31 11 21 31 11 21 31 11 21
31 51 21 31 11 51
    51 51 11 21 31 11 21 31 11 21 31 11 21 31 11 51
51 51 51 51 51
   51 51 31 11 21 31 11 21 31 11 21 31 11 21 31 51
51 51 51 51 51
  51 11 21 31 11 21 31 11 21 31 11 21 31 11 51 51
51 51 51 51 51
 51 51 51 51 51 51 51 51 51 51 51 51 51 51 51 51 51
51 51 51 51
               50 50 50 50 50 50 50 50 50 50 50 50
50 50 50 50 50 50 50 50 50
              50 50 50 50 50 50 50 10 20 30 10 20
30 10 20 30 10 20 30 10 50
             50 50 50 50 50 50 50 30 10 20 30 10 20
30 10 20 30 10 20 30 50
            50 50 50 50 50 50 10 20 30 10 20 30 10
20 30 10 20 30 10 50 50
           50 50 50 50 50 50 30 10 20 30 10 20 30
10 20 30 10 20 30 50 50
          50 50 50 50 50 10 20 30 10 20 30 10 20 30
10 20 30 10 50 50 50
         50 50 50 50 50 30 10 20 30 10 20 30 10 20
30 10 20 30 50 50 50
        50 50 50 50 10 20 30 10 20 30 10 20 30 10
20 30 10 50 50 50 50
       50 50 50 50 30 10 20 30 10 20 30 10 20 30 10
20 30 50 50 50 50
      50 50 50 10 20 30 10 20 30 10 20 30 10 20 30
10 50 50 50 50 50
     50 50 50 30 10 20 30 10 20 30 10 20 30 10 20
30 50 50 50 50 50
    50 50 10 20 30 10 20 30 10 20 30 10 20 30 10 50
50 50 50 50 50
   50 50 30 10 20 30 10 20 30 10 20 30 10 20 30 50
50 50 50 50 50
  50 10 20 30 10 20 30 10 20 30 10 20 30 10 50 50
50 50 50 50 50
 50 50 50 50 50 50 50 50 50 50 50 50 50 50 50 50 50
50 50 50 50
END FILL
END ARRAY
READ BOUNDS
ALL=VACUUM
END BOUNDS
END DATA
END
```

Input Case: VERSA_HAC_FINH_12S_3X300 (MOD0 Array Configuration)
HAC Case Finite In-Homogeneous Hexagonal Lattice 12-cm Spheres 10X10X3 Packages

```
=CSAS26      PARM='SIZE=00900000'
CENTURY INDUSTRIES VERSA-PAK
44GR     INFHOM
'URANIUM METAL
U          1 0.00253829 294.0 92235 100.0 END
POLYETHYLENE    1  DEN=0.98  0.99746 294.0   END
'PARAFFIN       1  0.99746 294.0  END
'GRAPHITE   1 0.100 294.0  END
'INTERSPERSED MODERATOR
H2O          2 1.0   294.0  END
'PACKAGE STEEL
CARBONSTEEL  3 1.0   294.0  END
'REFLECTOR
H2O          4 1.0    294.0  END
'INSULATION
H2O          5 0.0001 294.0 END
END COMP
READ PARM  NUB=YES GEN=600 NPG=1000 NSK=5
END PARM
READ GEOMETRY

UNIT  10
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
```

```
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  11
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE  100  ORIGIN X=6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  20
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  21
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  30
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  31
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12
```

```
UNIT  40
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  41
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT 50
HEXPRISM  10  26.9081  43.4768 -41.9307
MEDIA  4  1  10
BOUNDARY  10

UNIT 51
HEXPRISM  10  26.9081  41.9307 -43.4768
MEDIA  4  1  10
BOUNDARY  10

UNIT  100
SPHERE  1  12.00
MEDIA  1  1  1
BOUNDARY  1

GLOBAL
UNIT  1000
CUBOID  10  565.0701  0.00  473.2720  0.00
256.2225  0.00
ARRAY  1  10  PLACE 6 2 1  26.9081  26.9081
43.4768
CUBOID  20  595.5501  -30.48  503.7520 -30.48
286.7025  -30.48
MEDIA  4  10  20  -10
BOUNDARY  20
END GEOMETRY
READ ARRAY
GBL=1 ARA=1 TYP=TRIANGULAR NUX=16  NUY=12  NUZ=3
FILL
            51 51 51 51 51 51 51 51 51 51 51 51 51
51 51 51
           51 51 51 51 51 11 21 31 11 21 31 11 21
31 11 51
          51 51 51 51 51 31 11 21 31 11 21 31 11 21
31 51
         51 51 51 51 11 21 31 11 21 31 11 21 31 11
51 51
        51 51 51 51 31 11 21 31 11 21 31 11 21 31
51 51
       51 51 51 11 21 31 11 21 31 11 21 31 11 51 51
51
      51 51 51 31 11 21 31 11 21 31 11 21 31 51 51
51
     51 51 11 21 31 11 21 31 11 21 31 11 51 51 51
51
    51 51 31 11 21 31 11 21 31 11 21 31 51 51 51 51
   51 11 21 31 11 21 31 11 21 31 11 51 51 51 51 51
  51 31 11 21 31 11 21 31 11 21 31 51 51 51 51 51
 51 51 51 51 51 51 51 51 51 51 51 51 51 51 51 51
            50 50 50 50 50 50 50 50 50 50 50 50 50
50 50 50
           50 50 50 50 50 10 20 30 10 20 30 10 20
30 10 50
          50 50 50 50 50 30 10 20 30 10 20 30 10 20
30 50
         50 50 50 50 10 20 30 10 20 30 10 20 30 10
50 50
        50 50 50 50 30 10 20 30 10 20 30 10 20 30
50 50
       50 50 50 10 20 30 10 20 30 10 20 30 10 50 50
50
      50 50 50 30 10 20 30 10 20 30 10 20 30 50 50
50
     50 50 10 20 30 10 20 30 10 20 30 10 50 50 50
50
    50 50 30 10 20 30 10 20 30 10 20 30 50 50 50 50
   50 10 20 30 10 20 30 10 20 30 10 50 50 50 50 50
  50 30 10 20 30 10 20 30 10 20 30 50 50 50 50 50
 50 50 50 50 50 50 50 50 50 50 50 50 50 50 50 50
1Q192
END FILL
END ARRAY
READ BOUNDS
ALL=VACUUM
END BOUNDS
END DATA
END
```

Input Case: VERSA_HAC_FINH_12S_4X272 (MOD1 Array Configuration)
HAC Case Finite In-Homogeneous Hexagonal Lattice 12-cm Spheres 8/7X9X4 Packages

```
=CSAS26     PARM='SIZE=00900000'
CENTURY INDUSTRIES VERSA-PAK
44GR     INFHOM
'URANIUM METAL
U          1 0.00253829 294.0 92235 100.0 END
POLYETHYLENE    1  DEN=0.98  0.99746 294.0  END
'PARAFFIN       1  0.99746 294.0  END
'GRAPHITE   1 0.100 294.0  END
'INTERSPERSED MODERATOR
H2O          2 1.0  294.0  END
'PACKAGE STEEL
CARBONSTEEL  3 1.0  294.0  END
'REFLECTOR
```

```
H2O          4 1.0   294.0  END
'INSULATION
H2O          5 0.0001 294.0 END
END COMP
READ PARM  NUB=YES GEN=600 NPG=1000 NSK=5
END PARM
READ GEOMETRY

UNIT  10
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  11
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE  100  ORIGIN X=6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  20
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  21
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  30
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
```

```
BOUNDARY  12

UNIT  31
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  40
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  41
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT 50
HEXPRISM  10  26.9081  43.4768 -41.9307
MEDIA  4  1  10
BOUNDARY  10

UNIT 51
HEXPRISM  10  26.9081  41.9307 -43.4768
MEDIA  4  1  10
BOUNDARY  10

UNIT  100
SPHERE  1  12.00
MEDIA  1  1  1
BOUNDARY  1

GLOBAL
UNIT  1000
CUBOID  10  511.2639  0.00  426.6658  0.00
341.6300  0.00
ARRAY  1  10  PLACE 6 2 1  26.9081  26.9081
43.4768
CUBOID  20  541.7339  -30.48  457.1458 -30.48
372.1100  -30.48
MEDIA  4  10  20  -10
BOUNDARY  20
END GEOMETRY
READ ARRAY
GBL=1 ARA=1 TYP=TRIANGULAR NUX=15  NUY=11  NUZ=4
FILL
           51 51 51 51 51 51 51 51 51 51 51 51 51
51 51
          51 51 51 51 51 11 21 31 11 21 31 11 21 51
51
         51 51 51 51 51 31 11 21 31 11 21 31 51 51
51
        51 51 51 51 11 21 31 11 21 31 11 21 51 51
51
       51 51 51 51 31 11 21 31 11 21 31 51 51 51 51
      51 51 51 11 21 31 11 21 31 11 21 51 51 51 51
     51 51 51 31 11 21 31 11 21 31 51 51 51 51 51
    51 51 11 21 31 11 21 31 11 21 51 51 51 51 51
   51 51 31 11 21 31 11 21 31 51 51 51 51 51 51
  51 11 21 31 11 21 31 11 21 51 51 51 51 51 51
 51 51 51 51 51 51 51 51 51 51 51 51 51 51 51
1Q165
           50 50 50 50 50 50 50 50 50 50 50 50 50
50 50
          50 50 50 50 50 10 20 30 10 20 30 10 20 50
50
         50 50 50 50 50 30 10 20 30 10 20 30 50 50
50
        50 50 50 50 10 20 30 10 20 30 10 20 50 50
50
       50 50 50 50 30 10 20 30 10 20 30 50 50 50 50
      50 50 50 10 20 30 10 20 30 10 20 50 50 50 50
     50 50 50 30 10 20 30 10 20 30 50 50 50 50 50
    50 50 10 20 30 10 20 30 10 20 50 50 50 50 50
   50 50 30 10 20 30 10 20 30 50 50 50 50 50 50
  50 10 20 30 10 20 30 10 20 50 50 50 50 50 50
 50 50 50 50 50 50 50 50 50 50 50 50 50 50 50
1Q165
END FILL
END ARRAY
READ BOUNDS
```

```
ALL=VACUUM
END BOUNDS
END DATA
END
```

Input Case: VERSA_HAC_FINH_12S_5X280 (MOD1 Array Configuration)
HAC Case Finite In-Homogeneous Hexagonal Lattice 12-cm Spheres 7X8X5 Packages

```
=CSAS26     PARM='SIZE=00900000'
CENTURY INDUSTRIES VERSA-PAK
44GR     INFHOM
'URANIUM METAL
U          1 0.00253829 294.0 92235 100.0 END
POLYETHYLENE    1  DEN=0.98  0.99746 294.0  END
'PARAFFIN      1  0.99746 294.0  END
'GRAPHITE   1 0.100 294.0  END
'INTERSPERSED MODERATOR
H2O         2 1.0  294.0  END
'PACKAGE STEEL
CARBONSTEEL  3 1.0  294.0  END
'REFLECTOR
H2O         4 1.0   294.0  END
'INSULATION
H2O         5 0.0001 294.0 END
END COMP
READ PARM  NUB=YES GEN=600 NPG=1000 NSK=5
END PARM
READ GEOMETRY

UNIT  10
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  11
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE  100  ORIGIN X=6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  20
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  21
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  30
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
```

```
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  31
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  40
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  41
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE  100  ORIGIN  X=-6.24  Y=-3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT 50
HEXPRISM  10  26.9081  43.4768 -41.9307
MEDIA  4  1  10
BOUNDARY  10

UNIT 51
HEXPRISM  10  26.9081  41.9307 -43.4768
MEDIA  4  1  10
BOUNDARY  10

UNIT  100
SPHERE  1  12.00
MEDIA  1  1  1
BOUNDARY  1

GLOBAL
UNIT  1000
CUBOID  10  457.4377  0.00  380.0596  0.00
427.0375  0.00
ARRAY  1  10  PLACE 5 2 1  26.9081  26.9081
43.4768
CUBOID  20  487.9177  -30.48  410.5396 -30.48
457.5175  -30.48
MEDIA  4  10  20  -10
BOUNDARY  20
END GEOMETRY
READ ARRAY
GBL=1 ARA=1 TYP=TRIANGULAR NUX=13  NUY=10  NUZ=5
FILL
          51 51 51 51 51 51 51 51 51 51 51 51 51
         51 51 51 51 11 21 31 11 21 31 11 51 51
        51 51 51 51 31 11 21 31 11 21 31 51 51
       51 51 51 11 21 31 11 21 31 11 51 51 51
      51 51 51 31 11 21 31 11 21 31 51 51 51
     51 51 11 21 31 11 21 31 11 51 51 51 51
    51 51 31 11 21 31 11 21 31 51 51 51 51
   51 11 21 31 11 21 31 11 51 51 51 51 51
  51 31 11 21 31 11 21 31 51 51 51 51 51
 51 51 51 51 51 51 51 51 51 51 51 51 51
2Q130
          50 50 50 50 50 50 50 50 50 50 50 50 50
```

```
         50 50 50 50 10 20 30 10 20 30 10 50 50
        50 50 50 50 30 10 20 30 10 20 30 50 50
       50 50 50 10 20 30 10 20 30 10 50 50 50
      50 50 50 30 10 20 30 10 20 30 50 50 50
     50 50 10 20 30 10 20 30 10 50 50 50 50
    50 50 30 10 20 30 10 20 30 50 50 50 50
   50 10 20 30 10 20 30 10 50 50 50 50 50
  50 30 10 20 30 10 20 30 50 50 50 50 50
 50 50 50 50 50 50 50 50 50 50 50 50 50
1Q130
END FILL
END ARRAY
READ BOUNDS
ALL=VACUUM
END BOUNDS
END DATA
END
```

Input Case: VERSA_HAC_FINH_12S_6X288 (MOD1 Array Configuration)
HAC Case Finite In-Homogeneous Hexagonal Lattice 12-cm Spheres 6X8X6 Packages

```
=CSAS26     PARM='SIZE=00900000'
CENTURY INDUSTRIES VERSA-PAK
44GR     INFHOM
'URANIUM METAL
U          1 0.00253829 294.0 92235 100.0 END
POLYETHYLENE    1  DEN=0.98  0.99746 294.0  END
PARAFFIN        1  0.99746 294.0  END
'GRAPHITE   1 0.100 294.0  END
'INTERSPERSED MODERATOR
H2O         2 1.0  294.0  END
'PACKAGE STEEL
CARBONSTEEL  3 1.0  294.0  END
'REFLECTOR
H2O          4 1.0   294.0  END
'INSULATION
H2O          5 0.0001 294.0 END
END COMP
READ PARM  NUB=YES GEN=600 NPG=1000 NSK=5
END PARM
READ GEOMETRY

UNIT  10
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  11
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE  100  ORIGIN X=6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  20
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  21
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
```

```
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  30
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  31
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  40
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  41
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT 50
HEXPRISM  10  26.9081  43.4768 -41.9307
MEDIA  4  1  10
BOUNDARY  10

UNIT 51
HEXPRISM  10  26.9081  41.9307 -43.4768
MEDIA  4  1  10
BOUNDARY  10

UNIT  100
SPHERE  1  12.00
MEDIA  1  1  1
BOUNDARY  1

GLOBAL
UNIT  1000
CUBOID  10  457.4377  0.00  380.0596  0.00
512.4450  0.00
ARRAY  1  10  PLACE 5 2 1  26.9081  26.9081
43.4768
CUBOID  20  487.9177  -30.48  410.5396 -30.48
542.9250  -30.48
MEDIA  4  10  20  -10
BOUNDARY  20
END GEOMETRY
READ ARRAY
GBL=1 ARA=1 TYP=TRIANGULAR NUX=13  NUY=10  NUZ=6
FILL
```

```
          51 51 51 51 51 51 51 51 51 51 51 51 51
         51 51 51 51 11 21 31 11 21 31 51 51 51
        51 51 51 51 31 11 21 31 11 21 51 51 51
       51 51 51 11 21 31 11 21 31 51 51 51 51
      51 51 51 31 11 21 31 11 21 51 51 51 51
     51 51 11 21 31 11 21 31 51 51 51 51 51
    51 51 31 11 21 31 11 21 51 51 51 51 51
   51 11 21 31 11 21 31 51 51 51 51 51 51
  51 31 11 21 31 11 21 51 51 51 51 51 51
 51 51 51 51 51 51 51 51 51 51 51 51 51
2Q130
          50 50 50 50 50 50 50 50 50 50 50 50 50
         50 50 50 50 10 20 30 10 20 30 50 50 50
        50 50 50 50 30 10 20 30 10 20 50 50 50
       50 50 50 10 20 30 10 20 30 50 50 50 50
      50 50 50 30 10 20 30 10 20 50 50 50 50
     50 50 10 20 30 10 20 30 50 50 50 50 50
    50 50 30 10 20 30 10 20 50 50 50 50 50
   50 10 20 30 10 20 30 50 50 50 50 50 50
  50 30 10 20 30 10 20 50 50 50 50 50 50
 50 50 50 50 50 50 50 50 50 50 50 50 50
2Q130
END FILL
END ARRAY
READ BOUNDS
ALL=VACUUM
END BOUNDS
END DATA
END
```

Input Case: VERSA_HAC_FINH_12S_7X322 (MOD1 Array Configuration)
HAC Case Finite In-Homogeneous Hexagonal Lattice 12-cm Spheres 7/6X7X7 Packages

```
=CSAS26     PARM='SIZE=00900000'
CENTURY INDUSTRIES VERSA-PAK
44GR     INFHOM
'URANIUM METAL
U          1 0.00253829 294.0 92235 100.0 END
POLYETHYLENE    1  DEN=0.98  0.99746 294.0   END
PARAFFIN        1  0.99746 294.0   END
'GRAPHITE   1 0.100 294.0   END
'INTERSPERSED MODERATOR
H2O          2 1.0   294.0   END
'PACKAGE STEEL
CARBONSTEEL  3 1.0   294.0   END
'REFLECTOR
H2O          4 1.0    294.0   END
'INSULATION
H2O          5 0.0001 294.0 END
END COMP
READ PARM  NUB=YES GEN=600 NPG=1000 NSK=5
END PARM
READ GEOMETRY

UNIT  10
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  11
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE  100  ORIGIN X=6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  20
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  21
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
```

```
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  30
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  31
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  40
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  41
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT 50
HEXPRISM  10  26.9081  43.4768 -41.9307
MEDIA  4  1  10
BOUNDARY  10

UNIT 51
HEXPRISM  10  26.9081  41.9307 -43.4768
MEDIA  4  1  10
BOUNDARY  10

UNIT  100
SPHERE  1  12.00
MEDIA  1  1  1
BOUNDARY  1

GLOBAL
UNIT  1000
```

```
CUBOID  10  403.6215  0.00  333.4534  0.00
597.8525  0.00
ARRAY  1  10  PLACE 5 2 1  26.9081  26.9081
43.4768
CUBOID  20  434.1015  -30.48  363.9334 -30.48
628.3325  -30.48
MEDIA  4  10  20  -10
BOUNDARY  20
END GEOMETRY
READ ARRAY
GBL=1 ARA=1 TYP=TRIANGULAR NUX=12  NUY=9  NUZ=7
FILL
         51 51 51 51 51 51 51 51 51 51 51 51
        51 51 51 51 11 21 31 11 21 31 11 51
       51 51 51 51 31 11 21 31 11 21 51 51
      51 51 51 11 21 31 11 21 31 11 51 51
     51 51 51 31 11 21 31 11 21 51 51 51
    51 51 11 21 31 11 21 31 11 51 51 51
   51 51 31 11 21 31 11 21 51 51 51 51
  51 11 21 31 11 21 31 11 51 51 51 51
 51 51 51 51 51 51 51 51 51 51 51 51
3Q108
         50 50 50 50 50 50 50 50 50 50 50 50
        50 50 50 50 10 20 30 10 20 30 10 50
       50 50 50 50 30 10 20 30 10 20 50 50
      50 50 50 10 20 30 10 20 30 10 50 50
     50 50 50 30 10 20 30 10 20 50 50 50
    50 50 10 20 30 10 20 30 10 50 50 50
   50 50 30 10 20 30 10 20 50 50 50 50
  50 10 20 30 10 20 30 10 50 50 50 50
 50 50 50 50 50 50 50 50 50 50 50 50
2Q108
END FILL
END ARRAY
READ BOUNDS
ALL=VACUUM
END BOUNDS
END DATA
END
```

Input Case: VERSA_HAC_FINH_12S_8X312 (MOD1 Array Configuration)
HAC Case Finite In-Homogeneous Hexagonal Lattice 12-cm Spheres 6/5X7X8 Packages

```
=CSAS26     PARM='SIZE=00900000'
CENTURY INDUSTRIES VERSA-PAK
44GR     INFHOM
'URANIUM METAL
U          1 0.00253829 294.0 92235 100.0 END
POLYETHYLENE    1  DEN=0.98  0.99746 294.0   END
'PARAFFIN       1  0.99746 294.0  END
'GRAPHITE   1 0.100 294.0  END
'INTERSPERSED MODERATOR
H2O          2 1.0   294.0  END
'PACKAGE STEEL
CARBONSTEEL  3 1.0   294.0  END
'REFLECTOR
H2O          4 1.0    294.0  END
'INSULATION
H2O          5 0.0001 294.0 END
END COMP
READ PARM  NUB=YES GEN=600 NPG=1000 NSK=5
END PARM
READ GEOMETRY

UNIT  10
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  11
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE  100  ORIGIN X=6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  20
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE  100  ORIGIN  X=-6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  21
```

```
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  30
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  31
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  40
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  41
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT 50
HEXPRISM  10  26.9081  43.4768 -41.9307
MEDIA  4  1  10
BOUNDARY  10

UNIT 51
HEXPRISM  10  26.9081  41.9307 -43.4768
```

```
MEDIA  4  1  10
BOUNDARY  10

UNIT  100
SPHERE  1  12.00
MEDIA  1  1  1
BOUNDARY  1

GLOBAL
UNIT  1000
CUBOID  10  403.6215  0.00  333.4534  0.00
683.2600  0.00
ARRAY  1  10  PLACE 5 2 1  26.9081  26.9081
43.4768
CUBOID  20  434.1015  -30.48  363.9334 -30.48
713.7400  -30.48
MEDIA  4  10  20  -10
BOUNDARY  20
END GEOMETRY
READ ARRAY
GBL=1 ARA=1 TYP=TRIANGULAR NUX=12  NUY=9  NUZ=8
FILL
         51 51 51 51 51 51 51 51 51 51 51 51
        51 51 51 51 11 21 31 11 21 31 51 51
       51 51 51 51 31 11 21 31 11 51 51 51
      51 51 51 11 21 31 11 21 31 51 51 51
     51 51 51 31 11 21 31 11 51 51 51 51
    51 51 11 21 31 11 21 31 51 51 51 51
   51 51 31 11 21 31 11 51 51 51 51 51
  51 11 21 31 11 21 31 51 51 51 51 51
 51 51 51 51 51 51 51 51 51 51 51 51
3Q108
         50 50 50 50 50 50 50 50 50 50 50 50
        50 50 50 50 10 20 30 10 20 30 50 50
       50 50 50 50 30 10 20 30 10 50 50 50
      50 50 50 10 20 30 10 20 30 50 50 50
     50 50 50 30 10 20 30 10 50 50 50 50
    50 50 10 20 30 10 20 30 50 50 50 50
   50 50 30 10 20 30 10 50 50 50 50 50
  50 10 20 30 10 20 30 50 50 50 50 50
 50 50 50 50 50 50 50 50 50 50 50 50
3Q108
END FILL
END ARRAY
READ BOUNDS
ALL=VACUUM
END BOUNDS
END DATA
END
```

Input Case: VERSA_HAC_FINH_12S_9X324 (MOD1 Array Configuration)
HAC Case Finite In-Homogeneous Hexagonal Lattice 12-cm Spheres 6X7X9 Packages

```
=CSAS26     PARM='SIZE=00900000'
CENTURY INDUSTRIES VERSA-PAK
44GR     INFHOM
'URANIUM METAL
U          1 0.00253829 294.0 92235 100.0 END
POLYETHYLENE    1  DEN=0.98  0.99746 294.0  END
'PARAFFIN        1  0.99746 294.0  END
'GRAPHITE   1 0.100 294.0  END
'INTERSPERSED MODERATOR
H2O          2 1.0  294.0  END
'PACKAGE STEEL
CARBONSTEEL  3 1.0  294.0  END
'REFLECTOR
H2O          4 1.0   294.0  END
'INSULATION
H2O          5 0.0001 294.0 END
END COMP
READ PARM  NUB=YES GEN=600 NPG=1000 NSK=5
END PARM
READ GEOMETRY

UNIT  10
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  11
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE  100  ORIGIN X=6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  20
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
```

```
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  21
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  30
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  31
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  40
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  41
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
```

```
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT 50
HEXPRISM  10  26.9081  43.4768 -41.9307
MEDIA  4  1  10
BOUNDARY  10

UNIT 51
HEXPRISM  10  26.9081  41.9307 -43.4768
MEDIA  4  1  10
BOUNDARY  10

UNIT  100
SPHERE  1  12.00
MEDIA  1  1  1
BOUNDARY  1

GLOBAL
UNIT  1000
CUBOID  10  349.8053  0.00  286.8472  0.00
768.6675  0.00
ARRAY  1  10  PLACE 4 2 1  26.9081  26.9081
43.4768
CUBOID  20  380.2853  -30.48  317.8472 -30.48
799.1475  -30.48
MEDIA  4  10  20  -10
BOUNDARY  20
END GEOMETRY
READ ARRAY
GBL=1 ARA=1 TYP=TRIANGULAR NUX=10  NUY=8  NUZ=9
FILL
        51 51 51 51 51 51 51 51 51 51
       51 51 51 11 21 31 11 21 31 51
      51 51 51 31 11 21 31 11 21 51
     51 51 11 21 31 11 21 31 51 51
    51 51 31 11 21 31 11 21 51 51
   51 11 21 31 11 21 31 51 51 51
  51 31 11 21 31 11 21 51 51 51
 51 51 51 51 51 51 51 51 51 51
4Q80
        50 50 50 50 50 50 50 50 50 50
       50 50 50 10 20 30 10 20 30 50
      50 50 50 30 10 20 30 10 20 50
     50 50 10 20 30 10 20 30 50 50
    50 50 30 10 20 30 10 20 50 50
   50 10 20 30 10 20 30 50 50 50
  50 30 10 20 30 10 20 50 50 50
 50 50 50 50 50 50 50 50 50 50
3Q80
END FILL
END ARRAY
READ BOUNDS
ALL=VACUUM
END BOUNDS
END DATA
END
```

Input Case: VERSA_HAC_FINH_12S_10X300 (MOD1 Array Configuration)
HAC Case Finite In-Homogeneous Hexagonal Lattice 12-cm Spheres 5X5X10 Packages

```
=CSAS26     PARM='SIZE=00900000'
CENTURY INDUSTRIES VERSA-PAK
44GR     INFHOM
'URANIUM METAL
U         1 0.00253829 294.0 92235 100.0 END
POLYETHYLENE    1  DEN=0.98  0.99746 294.0  END
PARAFFIN        1  0.99746 294.0  END
'GRAPHITE   1 0.100 294.0  END
'INTERSPERSED MODERATOR
H2O           2 1.0  294.0  END
'PACKAGE STEEL
CARBONSTEEL  3 1.0  294.0  END
'REFLECTOR
H2O          4 1.0   294.0  END
'INSULATION
H2O          5 0.0001 294.0 END
END COMP
READ PARM  NUB=YES GEN=600 NPG=1000 NSK=5
END PARM
READ GEOMETRY

UNIT  10
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  11
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE  100  ORIGIN X=6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  20
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
```

```
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  21
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  30
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  31
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  40
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  41
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
```

```
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT 50
HEXPRISM  10  26.9081  43.4768 -41.9307
MEDIA  4  1  10
BOUNDARY  10

UNIT 51
HEXPRISM  10  26.9081  41.9307 -43.4768
MEDIA  4  1  10
BOUNDARY  10

UNIT  100
SPHERE  1  12.00
MEDIA  1  1  1
BOUNDARY  1

GLOBAL
UNIT  1000
CUBOID  10  349.8053  0.00  286.8472  0.00
854.0750  0.00
ARRAY  1  10  PLACE 4 2 1  26.9081  26.9081
43.4768
CUBOID  20  380.2853  -30.48  317.8472 -30.48
884.5550  -30.48
MEDIA  4  10  20  -10
BOUNDARY  20
END GEOMETRY
READ ARRAY
GBL=1 ARA=1 TYP=TRIANGULAR NUX=10  NUY=8  NUZ=10
FILL
        51 51 51 51 51 51 51 51 51 51
       51 51 51 11 21 31 11 21 51 51
      51 51 51 31 11 21 31 11 51 51
     51 51 11 21 31 11 21 51 51 51
    51 51 31 11 21 31 11 51 51 51
   51 11 21 31 11 21 51 51 51 51
  51 31 11 21 31 11 51 51 51 51
 51 51 51 51 51 51 51 51 51 51
4Q80
        50 50 50 50 50 50 50 50 50 50
       50 50 50 10 20 30 10 20 50 50
      50 50 50 30 10 20 30 10 50 50
     50 50 10 20 30 10 20 50 50 50
    50 50 30 10 20 30 10 50 50 50
   50 10 20 30 10 20 50 50 50 50
  50 30 10 20 30 10 50 50 50 50
 50 50 50 50 50 50 50 50 50 50
4Q80
END FILL
END ARRAY
READ BOUNDS
ALL=VACUUM
END BOUNDS
END DATA
END
```

Input Case: VERSA_HAC_FINH_12S_12X300 (MOD1 Array Configuration)
HAC Case Finite In-Homogeneous Hexagonal Lattice 12-cm Spheres 5X4X12 Packages

```
=CSAS26     PARM='SIZE=00900000'
CENTURY INDUSTRIES VERSA-PAK
44GR     INFHOM
'URANIUM METAL
U          1 0.00253829 294.0 92235 100.0 END
POLYETHYLENE    1  DEN=0.98  0.99746 294.0  END
'PARAFFIN       1  0.99746 294.0  END
'GRAPHITE   1 0.100 294.0  END
'INTERSPERSED MODERATOR
H2O          2 1.0  294.0  END
'PACKAGE STEEL
CARBONSTEEL  3 1.0  294.0  END
'REFLECTOR
H2O          4 1.0   294.0  END
'INSULATION
H2O          5 0.0001 294.0 END
END COMP
READ PARM  NUB=YES GEN=600 NPG=1000 NSK=5
END PARM
READ GEOMETRY

UNIT  10
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  11
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE  100  ORIGIN X=6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  20
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=-22.528
```

```
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  21
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  30
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  31
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  40
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  41
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=-3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  5  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
```

```
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  5  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  5  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  5  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  5  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT 50
HEXPRISM  10  26.9081  43.4768 -41.9307
MEDIA  4  1  10
BOUNDARY  10

UNIT 51
HEXPRISM  10  26.9081  41.9307 -43.4768
MEDIA  4  1  10
BOUNDARY  10

UNIT  100
SPHERE  1  12.00
MEDIA  1  1  1
BOUNDARY  1

GLOBAL
UNIT  1000
CUBOID  10  295.9891  0.00  240.2410  0.00
1024.8900  0.00
ARRAY  1  10  PLACE 4 2 1  26.9081  26.9081
43.4768
CUBOID  20  326.4691  -30.48  270.7210 -30.48
1055.3700  -30.48
MEDIA  4  10  20  -10
BOUNDARY  20
END GEOMETRY
READ ARRAY
GBL=1 ARA=1 TYP=TRIANGULAR NUX=9  NUY=7  NUZ=12
FILL
       51 51 51 51 51 51 51 51 51
      51 51 51 11 21 31 11 21 51
     51 51 51 31 11 21 31 11 51
    51 51 11 21 31 11 21 51 51
   51 51 31 11 21 31 11 51 51
  51 11 21 31 11 21 51 51 51
 51 51 51 51 51 51 51 51 51
5Q63
       50 50 50 50 50 50 50 50 50
      50 50 50 10 20 30 10 20 50
     50 50 50 30 10 20 30 10 50
    50 50 10 20 30 10 20 50 50
   50 50 30 10 20 30 10 50 50
  50 10 20 30 10 20 50 50 50
 50 50 50 50 50 50 50 50 50
5Q63
END FILL
END ARRAY
READ BOUNDS
ALL=VACUUM
END BOUNDS
END DATA
END
```

MULTIREGION Input Case: VERSA_HAC_FINH_12S_4X272_MR (MOD1 Array Configuration)
HAC Case Finite In-Homogeneous Hexagonal Lattice 12-cm Spheres 8/7X9X4 Packages

```
=CSAS26     PARM='SIZE=1000000'
CENTURY INDUSTRIES VERSA-PAK
44GR     INFHOM
'URANIUM METAL
U         1 0.00253829 294.0 92235 100.0 END
'PARAFFIN  1  0.99746  294.0  END
POLYETHYLENE    1  DEN=0.98  0.99746 294.0  END
'GRAPHITE   1 0.100 294.0  END
'INTERSPERSED MODERATOR
H2O           2 1.0   294.0  END
'PACKAGE STEEL
CARBONSTEEL  3 1.0  294.0  END
'REFLECTOR
H2O           4 1.0   294.0  END
'PAYLOAD CAVITY
H2O           5 0.0001 294.0 END
'RADIAL CAVITY
H2O           6 0.0001 294.0 END
'TOP BOTTOM CAVITY
H2O           7 0.0001 294.0 END
'RADIAL INNER OUTER CAVITY
H2O           8 0.0001 294.0 END
'PACKAGE EXTERIOR
H2O           9 0.0001 294.0 END
END COMP
READ PARM  NUB=YES GEN=600 NPG=1000 NSK=5
END PARM
READ GEOMETRY

UNIT  10
CYLINDER  1  19.2088 34.5281 -34.5281
'PAYLOAD
MEDIA  5  1  1
HOLE   100  ORIGIN  X=6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
'PAYLOAD RADIAL INSULATION
MEDIA  6  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
'TOP INSULATION
MEDIA  7  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
'TOP/BOTTOM INSULATION
MEDIA  7  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
'INNER/OUTER RADIAL LINER INSULATION
MEDIA  8  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
'EXTERIOR MODERATION
MEDIA  9  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  11
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE  100  ORIGIN X=6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  6  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  7  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
```

```
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  7  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  8  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  9  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  20
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  6  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  7  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  7  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  8  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  9  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  21
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=-6.24  Y=3.60  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  6  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  7  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  7  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  8  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  9  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  30
CYLINDER  1  19.2088 34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=-22.528
CYLINDER  2  19.5163  34.5281  -34.8357
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.5281  -34.8357
MEDIA  6  1  3  -2  -1
CYLINDER  4  25.8663  35.7727  -34.8357
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  36.8560  -34.8357
MEDIA  7  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  36.9914  -34.8357
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  43.3414  -41.1857
MEDIA  7  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  43.3414  -41.7953
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374  43.3414  -41.7963
MEDIA  8  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727  43.3414  -41.7953
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081  43.4768  -41.9307
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081  43.4768  -41.9307
MEDIA  9  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT  31
CYLINDER  1  19.2088  34.5281 -34.5281
MEDIA  5  1  1
HOLE   100  ORIGIN  X=0.00  Y=-7.208  Z=22.528
CYLINDER  2  19.5163  34.8357  -34.5281
MEDIA  3  1  2  -1
CYLINDER  3  25.8663  34.8357  -34.5281
MEDIA  6  1  3  -2  -1
CYLINDER  4  25.8663  34.8357  -35.7727
MEDIA  3  1  4  -3  -2  -1
CYLINDER  5  25.8663  34.8357  -36.8560
MEDIA  7  1  5  -4  -3  -2  -1
CYLINDER  6  25.8663  34.8357  -36.9914
MEDIA  3  1  6  -5  -4  -3  -2  -1
CYLINDER  7  25.8663  41.1857  -43.3414
MEDIA  7  1  7  -6  -5  -4  -3  -2  -1
CYLINDER  8  26.0017  41.7953  -43.3414
MEDIA  3  1  8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  9  26.6374 41.7963  -43.3414
MEDIA  8  1  9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  10  26.7727 41.7953  -43.3414
MEDIA  3  1  10  -9  -8  -7  -6  -5  -4  -3  -2  -1
CYLINDER  11  26.9081 41.9307  -43.4768
MEDIA  3  1  11 -10  -9  -8  -7  -6  -5  -4  -3  -2
-1
HEXPRISM  12  26.9081 41.9307  -43.4768
MEDIA  9  1  12 -11 -10  -9  -8  -7  -6  -5  -4  -3
-2  -1
BOUNDARY  12

UNIT 50
HEXPRISM  10  26.9081  43.4768 -41.9307
MEDIA  4  1  10
BOUNDARY  10

UNIT 51
HEXPRISM  10  26.9081  41.9307 -43.4768
MEDIA  4  1  10
BOUNDARY  10

UNIT  100
SPHERE  1  12.00
MEDIA  1  1  1
BOUNDARY  1

GLOBAL
UNIT  1000
CUBOID  10  511.2639  0.00  426.6658  0.00
341.6300  0.00
```

```
ARRAY  1  10  PLACE 6 2 1  26.9081  26.9081
43.4768
CUBOID  20  541.7339  -30.48  457.1458 -30.48
372.1100  -30.48
MEDIA  4  10  20  -10
BOUNDARY  20
END GEOMETRY
READ ARRAY
GBL=1 ARA=1 TYP=TRIANGULAR NUX=15  NUY=11  NUZ=4
FILL
           51 51 51 51 51 51 51 51 51 51 51 51 51
51 51
          51 51 51 51 51 11 21 31 11 21 31 11 21 51
51
         51 51 51 51 51 31 11 21 31 11 21 31 51 51
51
        51 51 51 51 11 21 31 11 21 31 11 21 51 51
51
       51 51 51 51 31 11 21 31 11 21 31 51 51 51 51
      51 51 51 11 21 31 11 21 31 11 21 51 51 51 51
     51 51 51 31 11 21 31 11 21 31 51 51 51 51 51
    51 51 11 21 31 11 21 31 11 21 51 51 51 51 51
   51 51 31 11 21 31 11 21 31 51 51 51 51 51 51
  51 11 21 31 11 21 31 11 21 51 51 51 51 51 51
 51 51 51 51 51 51 51 51 51 51 51 51 51 51 51
1Q165
           50 50 50 50 50 50 50 50 50 50 50 50 50
50 50
          50 50 50 50 50 10 20 30 10 20 30 10 20 50
50
         50 50 50 50 50 30 10 20 30 10 20 30 50 50
50
        50 50 50 50 10 20 30 10 20 30 10 20 50 50
50
       50 50 50 50 30 10 20 30 10 20 30 50 50 50 50
      50 50 50 10 20 30 10 20 30 10 20 50 50 50 50
     50 50 50 30 10 20 30 10 20 30 50 50 50 50 50
    50 50 10 20 30 10 20 30 10 20 50 50 50 50 50
   50 50 30 10 20 30 10 20 30 50 50 50 50 50 50
  50 10 20 30 10 20 30 10 20 50 50 50 50 50 50
 50 50 50 50 50 50 50 50 50 50 50 50 50 50 50
1Q165
END FILL
END ARRAY
READ BOUNDS
ALL=VACUUM
END BOUNDS
END DATA
END
```

6.10.2 Appendix 6.10.2: Validation of SCALE4.4a-PC for High Enriched Uranium Systems

Montgomery Engineering and Technical Services (METS-424 Rev 1), June 2009

Issued under separate cover letter

6.10.3 Appendix 6.10.3: Enrichment Loading Table

6.10.3.1 INTRODUCTION

This analysis provides justification for adding the following contents to the Versa-Pac:

- Increased uranium mass limits for U-235 enrichments less than or equal to 5wt.%, 10wt.%, and 20wt.%, and
- Natural thorium in any form.

Table 6-15 shows the uranium mass limits for the current approved 100wt.% and for the three additional enrichment levels.

Table 6-15 Uranium Mass Limits for Uranium Enrichment Levels

U-235 wt-%	Mass U-235 (g)	Mass Uranium (g)
100	350	350
20	410	2,050
10	470	4,700
5	580	11,600

6.10.3.2 METHOD OF ANALYSIS

This analysis used as starting points the most reactive single package and package array cases from Section 6. The package array case input deck is VERSAPAK_HAC_FINH_12S_4x272P from Table 6-1. The single package case input deck is VERSAPAK_HAC_SIN_12S_A from Table 6-6.

The analysis first used the package array case and followed an iterative process to determine the optimum sphere radius and maximum mass for each enrichment level. The mass limits from the package array analysis were then modeled in the single package case.

Step 1 of the iterative process involved selecting a sphere radius and an amount of uranium at a specified enrichment. Step 2 consisted of keeping the radius constant and increasing the uranium amount until peak reactivity was reached. If the k_{eff} was above the upper subcritical limit (USL), the radius was too large. If k_{eff} was below the USL, the radius was too small. Step 3, then, consisted of adjusting the sphere radius accordingly, while maintaining the uranium mass and only changing the polyethylene moderation in the fissile mass, and then repeating from step 2 optimizing moderation in the fissile mass. This process was continued until k_{eff} plus two sigma was optimized to the USL. Only the results from the final iteration showing the optimum k_{eff} are included in this calculation.

Once a mass limit was obtained using the package array case, it was inserted into the single package case and held constant while the sphere radius was varied, to ensure that the k_{eff} plus two sigma values were below the USL. See Section 6.10.5.5.

Sensitivity analyses were also conducted to determine the effect of natural thorium on k_{eff} in single packages and arrays for all four uranium enrichment levels. This analysis examined the addition of 50 through 400 grams of thorium to the spherical mass. The amounts of uranium and polyethylene from the most limiting case for each enrichment level were held constant. Therefore, as natural thorium was added, only the size of the sphere changed to allow for nominal densities and masses for all three materials. All natural thorium was added to the fissile mass in a homogeneous manner.

Finally, a moderator density study was conducted using the U(20) model to evaluate both interspersed moderation and intra-package moderation, similar to the analyses defined in Section 6.6.2.2.3 and 6.6.2.2.9 for the U(100) model. The discussion is found in the package array discussion, Section 6.10.3.6.4.

SCALE 6.1.3 was used to complete the criticality analysis for this calculation note [6]. SCALE is a comprehensive modeling and simulation suite for nuclear safety analysis and design developed and maintained by Oak Ridge National Laboratory under contract with the U.S. Nuclear Regulatory Commission, U.S. Department of Energy, and the National Nuclear Security Administration to perform reactor physics, criticality safety, radiation shielding, and spent fuel characterization for nuclear facilities and transportation/storage package designs. Microsoft Excel was used to create the mixtures necessary for the SCALE input decks.

6.10.3.3 DESIGN INPUT

6.10.3.3.1 Material Input Calculation

Material amounts for uranium and polyethylene were hand calculated during the iteration process by calculating the proper volume fractions of the two components in the homogeneous fissile mass mixture as follows:

(1) Calculate the volume of uranium in the mixture by dividing the desired mass of uranium by its theoretical density.

(2) Calculate the volume fraction of uranium by dividing the volume of uranium by the volume of the desired sphere.

(3) Calculate the volume fraction of the polyethylene by subtracting the volume fraction of uranium from unity.

The following example illustrates the process. Volume fractions here are calculated for uranium at 100 wt.% enrichment and polyethylene in a 12-cm radius sphere. To create the volume fractions for other cases, the variables $m_{U\text{-}235}$, $w_{U\text{-}235}$, and r_{sph} were modified accordingly. For weight percentages less than 100 wt% U-235, the remaining uranium material is modeled solely as U-238.

The specific input deck for the variables below is VERSAPAK_HAC_SIN_100WT_12S_A.

Volume fraction of U (VF_U)= V_U / V_{sph} = 0.002538

Volume fraction of polyethylene = $1 - VF_U$ = 0.997462

Where

Uranium volume	V_U =	m_U / ρ_U	18.3727 cm^3
Mixture volume	V_{sph} =	$(4/3)\ \pi\ r_{sph}^3$	7238.23 cm^3
Mass of uranium	m_U =	$m_{U\text{-}235} / w_{U\text{-}235}$	350 g
Mass of U-235	$m_{U\text{-}235}$		350 g
Weight fraction of U-235	$w_{U\text{-}235}$		1.0
Density of uranium	ρ_U		19.05 g / cm^3
Radius of fuel sphere	r_{sph}		12 cm

6.10.3.3.2 Determining Sphere Radius with Natural Thorium Addition

To determine the radius of a sphere with natural thorium added, the volumes of uranium and polyethylene from the most limiting case for each enrichment level were held constant and the size of the sphere was increased to accommodate the natural thorium.

The following example illustrates how the 12-cm radius sphere was increased to include 50 grams of thorium. First, the volumes of uranium and polyethylene are found as described above. The volume of thorium is calculated by dividing the mass by its theoretical density. The new total volume of the sphere is equal to the sum of the component volumes. New volume fractions are found by dividing the component volumes by the new total volume of the sphere. The new radius is found using the equation for volume of a sphere.

The specific input deck for the variables below is VERSAPAK_HAC_SIN_100WT_12S_A_50T.

New radius of sphere = $\sqrt[3]{\frac{3}{4\pi} V_{tot}}$ = 12.0024 cm

Where

Beginning sphere radius	r_{sph}		12.0 cm
Beginning total sphere volume	V_{sph} =	$(4/3)\ \pi\ r_{sph}^3$	7238.23 cm^3
Volume of uranium	V_U =	m_U / ρ_U	18.3727 cm^3
Volume of Polyethylene	V_{poly} =	$V_{sph} - V_U$	7219.86 cm^3
Mass of thorium	m_{Th}		50 g
Density of thorium	ρ_{Th}		11.7 g / cm^3
Volume of thorium	V_{Th} =	m_{Th} / ρ_{Th}	4.27350 cm^3

New total volume of sphere	$V_{tot} = V_U + V_{Poly} + V_{Th}$	7242.51 cm^3
New volume fraction of U	$VF_U = V_U / V_{tot}$	0.002537
New volume fraction of poly	$VF_{poly} = V_{poly} / V_{tot}$	0.996873
Volume fraction of thorium	$VF_{Th} = V_{Th} / V_{tot}$	0.000590

6.10.3.4 Material Properties

See Section 6.3.2 for the materials utilized in this calculation and their respective densities as modeled. All polyethylene moderation in this analysis is modeled as high-density polyethylene (HDPE). HDPE bounds all hydrogen-containing materials with a hydrogen density less than or equal to 0.141 g/cc, which includes light water, low-density polyethylene, and paraffin.

All thorium modeled in this analysis is modeled as natural, elemental thorium, which consists of only thorium-232, the only isotope of thorium that exists in any significant quantity in nature [7]. The natural thorium density provided in the SCALE input libraries, 11.7 g/cc, is used in order to bound all compounds and forms of natural thorium.

6.10.3.5 Model Conservatisms

The model used in this analysis is described in Section 6.3.1 and repeated here. :

- Dimensions of the package, except the containment, modeled at reduced tolerances
- Conservative representation of HAC damage
  - 0.125 inch (0.3176 cm) increase in inner containment diameter
  - 1.313 inch (3.335 cm) decrease in outer drum diameter to bound HAC test reduction of 0.313 inch (0.795 cm)
  - 0.875 inch (2.2224 cm) reduction in outer drum height (including lid) applied only to the bottom of package due to less steel between the outer boundary of the package and the lumped sphere, which bounds HAC test reduction of 0.25 inch (0.635 cm)
- The four vertical members (square tubing), reinforcing angles, and bottom plate ring constructed from carbon steel have been neglected, resulting in modeling less than 50% of the package carbon steel
- All insulation products are modeled as optimum interspersed water moderation

6.10.3.6 Package Array Evaluation

6.10.3.6.1 Configuration

Three uranium enrichment levels (U(20), U(10), and U(5)) were examined. The fissile material configurations for these levels were varied in both mass and physical dimensions to find the optimum configuration.

Polyethylene at 0.98 g/cc, high-density polyethylene (HDPE), was used as the moderating material for the arrays in this section as HDPE bounds all other hydrogen-containing materials with a hydrogen density of 0.141 g/cc or less.

An interspersed moderator volume fraction of 0.0001 of light water was used for the HAC package array analysis. Sections 6.6.2.2.3 and 6.6.2.2.9 concluded there was no significant difference between interspersed moderator volume fractions of 0.0001, 0.001, and 0.01. When the interspersed moderator was modeled at volume fraction 0.1 or higher, the k_{eff} began to decrease. The value of k_{eff} approached the value for a single package when the interspersed moderator volume fraction reached 1.0.

The limiting package array size of 272 packages as defined by the U(100) analysis is applied to the reduced enrichment levels as to maintain a single CSI as described in Section 6.1.3.

6.10.3.6.2 Results

Summary results are shown in Table 6-41.

For the U(20) enrichment, a fully polyethylene-moderated sphere with a radius of 13 cm was the most reactive, resulting in a limit of 410 g of U-235. For the U(10) enrichment, a fully polyethylene-moderated sphere with a radius of 13.5 cm was most reactive, resulting in a limit of 470 g of U-235. For the U(5) enrichment, a fully polyethylene-moderated sphere of 14.5 cm was the most reactive, resulting in a limit of 580 g of U-235.

6.10.3.6.3 100-wt% U-235 Enriched Uranium Results

For the U(100) package array analysis, the natural thorium addition sensitivity analysis was the only analysis examined because this enrichment level was already examined in Section 6.6.

As shown in Table 6-16, the addition of natural thorium decreases k_{eff} as the amount of thorium increased. Therefore, it is concluded that the addition of natural thorium has no effect on increasing k_{eff} for U(100) package arrays. The thorium addition sensitivity results for package arrays are shown in Figure 6-23.

Table 6-16 Natural Thorium Addition Sensitivity, Package Array – U(100)

	Thorium mass (g)	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_FINH_100WT_12S_4x272P [a]	0	0.9352	0.0011	0.9374
VERSAPAK_HAC_FINH_100WT_12S_4x272P_50T	50	0.93526	0.0008	0.9369
VERSAPAK_HAC_FINH_100WT_12S_4x272P_100T	100	0.93216	0.00077	0.9337
VERSAPAK_HAC_FINH_100WT_12S_4x272P_200T	200	0.92797	0.00094	0.9299
VERSAPAK_HAC_FINH_100WT_12S_4x272P_300T	300	0.92515	0.00074	0.9266
VERSAPAK_HAC_FINH_100WT_12S_4x272P_400T	400	0.92137	0.0009	0.9232

NOTE: [a] model rerun with SCALE 6.1.3 for sensitivity study comparison

6.10.3.6.4 20-wt% U-235 Enriched Uranium

Using the method outlined in Section 6.10.3.2, the following sphere radius sensitivity and fissile mass sensitivity analyses confirm that a maximum amount of 410 g U-235 at 20wt% enrichment (2,050 gram uranium) and a sphere radius of 13 cm form the limiting configuration for U(20).

In the first analysis, the mass was held constant and the sphere radius was varied by both a 1-cm decrease and a 1-cm increase. By holding the mass constant while varying the radius, the only variable that changed was the mass of polyethylene, thereby varying the H/U-235 ratio. As shown in Table 6-17, optimum moderation is for a 13-cm radius sphere, which produced higher values of k_{eff} + 2 sigma than the 12-cm and 14-cm radius spheres. Note that the limiting case is highlighted. The sphere radius sensitivity results for package arrays are shown in Figure 6-24.

Case VERSAPAK_HAC_FINH_20WT_x_1x324P is a case that models a finite, hexagonal-pitch (FINH) array of Versa-Pacs under Hypothetical Accident Conditions (HAC) with 20-wt% U-235 enriched uranium (20WT). The “x” is a placeholder for the radius of the sphere and 1x324P signifies a one-package tall array with 324 total packages. P signifies polyethylene moderation.

Table 6-17 Sphere radius sensitivity, package array - U(20)

	12-cm Radius			13-cm Radius			14-cm Radius		
	k_{eff}	sigma	k_{eff} + 2 sigma	k_{eff}	sigma	k_{eff} + 2 sigma	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_FINH_20WT_x_1x324P	0.848	0.0012	0.8504	0.8578	0.001	0.8598	0.8515	0.0011	0.8537
VERSAPAK_HAC_FINH_20WT_x_2x338P	0.9082	0.0011	0.9104	0.915	0.0011	0.9172	0.9069	0.0011	0.9091
VERSAPAK_HAC_FINH_20WT_x_3x300P	0.9249	0.0012	0.9273	0.9319	0.001	0.9339	0.9202	0.0011	0.9224
VERSAPAK_HAC_FINH_20WT_x_4x272P	0.9301	0.0011	0.9323	0.9351	0.0012	0.9375	0.9225	0.001	0.9245
VERSAPAK_HAC_FINH_20WT_x_4x288P	0.9329	0.0013	0.9355	0.9364	0.0012	0.9388	0.9256	0.0011	0.9278
VERSAPAK_HAC_FINH_20WT_x_4x308P	0.9337	0.0011	0.9359	0.9379	0.001	0.9399	0.9279	0.0011	0.9301
VERSAPAK_HAC_FINH_20WT_x_5x280P	0.9268	0.001	0.9288	0.934	0.0011	0.9362	0.9208	0.0012	0.9232
VERSAPAK_HAC_FINH_20WT_x_6x288P	0.9243	0.0011	0.9265	0.9314	0.0011	0.9336	0.9192	0.0011	0.9214
VERSAPAK_HAC_FINH_20WT_x_6x312P	0.9306	0.0011	0.9328	0.9345	0.001	0.9365	0.9235	0.0011	0.9257
VERSAPAK_HAC_FINH_20WT_x_7x322P	0.9251	0.001	0.9271	0.9313	0.001	0.9333	0.9197	0.001	0.9217
VERSAPAK_HAC_FINH_20WT_x_8x312P	0.9202	0.001	0.9222	0.922	0.0012	0.9244	0.9136	0.0011	0.9158
VERSAPAK_HAC_FINH_20WT_x_9x324P	0.9159	0.0013	0.9185	0.9212	0.0012	0.9236	0.9133	0.001	0.9153
VERSAPAK_HAC_FINH_20WT_x_10x300P	0.905	0.001	0.907	0.9123	0.0011	0.9145	0.9028	0.001	0.9048
VERSAPAK_HAC_FINH_20WT_x_12x300P	0.8946	0.0011	0.8968	0.9024	0.0013	0.9050	0.8961	0.0012	0.8985

Table 6-18 Sphere Radius Sensitivity, Package Array – U(20)

	12-cm Radius			13-cm Radius			14-cm Radius		
	k_{eff}	sigma	k_{eff} + 2 sigma	k_{eff}	sigma	k_{eff} + 2 sigma	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_FINH_20WT_x_1x324P	0.848	0.0012	0.8504	0.8578	0.001	0.8598	0.8515	0.0011	0.8537
VERSAPAK_HAC_FINH_20WT_x_2x338P	0.9082	0.0011	0.9104	0.915	0.0011	0.9172	0.9069	0.0011	0.9091
VERSAPAK_HAC_FINH_20WT_x_3x300P	0.9249	0.0012	0.9273	0.9319	0.001	0.9339	0.9202	0.0011	0.9224
VERSAPAK_HAC_FINH_20WT_x_4x272P	0.9301	0.0011	0.9323	0.9351	0.0012	0.9375	0.9225	0.001	0.9245
VERSAPAK_HAC_FINH_20WT_x_4x288P	0.9329	0.0013	0.9355	0.9364	0.0012	0.9388	0.9256	0.0011	0.9278
VERSAPAK_HAC_FINH_20WT_x_4x308P	0.9337	0.0011	0.9359	0.9379	0.001	0.9399	0.9279	0.0011	0.9301
VERSAPAK_HAC_FINH_20WT_x_5x280P	0.9268	0.001	0.9288	0.934	0.0011	0.9362	0.9208	0.0012	0.9232
VERSAPAK_HAC_FINH_20WT_x_6x288P	0.9243	0.0011	0.9265	0.9314	0.0011	0.9336	0.9192	0.0011	0.9214
VERSAPAK_HAC_FINH_20WT_x_6x312P	0.9306	0.0011	0.9328	0.9345	0.001	0.9365	0.9235	0.0011	0.9257
VERSAPAK_HAC_FINH_20WT_x_7x322P	0.9251	0.001	0.9271	0.9313	0.001	0.9333	0.9197	0.001	0.9217
VERSAPAK_HAC_FINH_20WT_x_8x312P	0.9202	0.001	0.9222	0.922	0.0012	0.9244	0.9136	0.0011	0.9158
VERSAPAK_HAC_FINH_20WT_x_9x324P	0.9159	0.0013	0.9185	0.9212	0.0012	0.9236	0.9133	0.001	0.9153
VERSAPAK_HAC_FINH_20WT_x_10x300P	0.905	0.001	0.907	0.9123	0.0011	0.9145	0.9028	0.001	0.9048
VERSAPAK_HAC_FINH_20WT_x_12x300P	0.8946	0.0011	0.8968	0.9024	0.0013	0.9050	0.8961	0.0012	0.8985

In the second analysis, the radius of the sphere was held constant at 13 cm and the uranium mass was increased and decreased by 25 g. This was done to verify that k_{eff} decreases as the mass decreases, which would demonstrate that the evaluated mass limit is optimally moderated and any decrease in mass would decrease the criticality of the package. If it were not optimally moderated, a similar or larger value of k_{eff} would be expected for a smaller mass. As shown in Table 6-19, the data shows that k_{eff} did reduce as expected when the amount of fissile material was reduced. A mass evaluated above the defined fissile mass limit produced higher values of k_{eff} + 2 sigma above the USL. Note that the U(100)-defined limiting package array size is highlighted.

Table 6-19 U-235 Mass Sensitivity, Package Array – U(20)

	385 g U-235			410 g U-235			435 g U-235		
	k_{eff}	sigma	k_{eff} + 2 sigma	k_{eff}	sigma	k_{eff} + 2 sigma	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_FINH_20WT_13S_1x324P	0.8426	0.001	0.8446	0.8578	0.001	0.8598	0.8719	0.0011	0.8741
VERSAPAK_HAC_FINH_20WT_13S_2x338P	0.8971	0.001	0.8991	0.915	0.0011	0.9172	0.9322	0.0011	0.9344
VERSAPAK_HAC_FINH_20WT_13S_3x300P	0.9123	0.0011	0.9145	0.9319	0.001	0.9339	0.944	0.0011	0.9462
VERSAPAK_HAC_FINH_20WT_13S_4x272P	0.916	0.0012	0.9184	0.9351	0.0012	0.9375	0.9499	0.0012	0.9523
VERSAPAK_HAC_FINH_20WT_13S_4x288P	0.9181	0.0012	0.9205	0.9364	0.0012	0.9388	0.9523	0.001	0.9543
VERSAPAK_HAC_FINH_20WT_13S_4x308P	0.9214	0.0015	0.9244	0.9379	0.001	0.9399	0.9528	0.0011	0.955
VERSAPAK_HAC_FINH_20WT_13S_5x280P	0.9158	0.001	0.9178	0.934	0.0011	0.9362	0.9488	0.0013	0.9514
VERSAPAK_HAC_FINH_20WT_13S_6x288P	0.9134	0.00099	0.9154	0.9314	0.0011	0.9336	0.9463	0.0011	0.9485
VERSAPAK_HAC_FINH_20WT_13S_6x312P	0.9175	0.001	0.9195	0.9345	0.001	0.9365	0.9506	0.0013	0.9532
VERSAPAK_HAC_FINH_20WT_13S_7x322P	0.9148	0.0012	0.9172	0.9313	0.001	0.9333	0.9493	0.001	0.9513
VERSAPAK_HAC_FINH_20WT_13S_8x312P	0.9081	0.0011	0.9103	0.922	0.0012	0.9244	0.9382	0.0014	0.9410
VERSAPAK_HAC_FINH_20WT_13S_9x324P	0.9059	0.001	0.9079	0.9212	0.0012	0.9236	0.9406	0.0011	0.9428
VERSAPAK_HAC_FINH_20WT_13S_10x300P	0.8945	0.0011	0.8967	0.9123	0.0011	0.9145	0.9291	0.0011	0.9313
VERSAPAK_HAC_FINH_20WT_13S_12x300P	0.8868	0.001	0.8888	0.9024	0.0013	0.9050	0.9189	0.0011	0.9211

In the third analysis, natural thorium addition sensitivity was analyzed for U(20) package arrays. As shown in Table 6-20, the addition of thorium caused a decrease in k_{eff}. Therefore, it is concluded that the addition of thorium has no effect on increasing k_{eff} for U(20) package arrays. The thorium addition sensitivity results for package arrays are shown in Figure 6-23.

Table 6-20 Natural thorium addition sensitivity, package array – U(20)

	Thorium mass (g)	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_FINH_20WT_13S_4x272P	0	0.9351	0.0012	0.9375
VERSAPAK_HAC_FINH_20WT_13S_4x272P_50T	50	0.93207	0.00077	0.93361

	Thorium mass (g)	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_FINH_20WT_13S_4x272P_100T	100	0.93047	0.00077	0.93201
VERSAPAK_HAC_FINH_20WT_13S_4x272P_200T	200	0.92636	0.00077	0.9279
VERSAPAK_HAC_FINH_20WT_13S_4x272P_300T	300	0.92429	0.00075	0.92579
VERSAPAK_HAC_FINH_20WT_13S_4x272P_400T	400	0.92231	0.0008	0.92391

As mentioned in Section 6.10.3.2, a sensitivity study examining interspersed moderation, package moderation, and the combination of both was done using the U(20) model to verify that a moderation volume fraction greater than zero was indeed more reactive than an array with no reduced moderation. A water moderator volume fraction of 0.0001, modeled both between packages and inside packages, was selected for the U(100) package array analysis, as defined by results of Section 6.6.2.2.3 and 6.6.2.2.9.

Interspersed moderation volume fractions of 0, 0.0001, 0.001, 0.01, 0.1, and 1.0 were evaluated first. Table 6-21 shows the results. For this study the interior of the packages was dry. As shown, the values of k_{eff} + 2 sigma for moderation volume fractions of 0 through 0.01 are all within 2 sigma of each other. This signifies that modeling no moderator between packages is not more reactive than the selected moderator volume fraction value of 0.0001 chosen for this calculation.

Table 6-21 Interspersed moderation sensitivity

	Moderator Volume Fraction	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_FINH_20WT_13S_4x272P_im0	0	0.93271	0.00078	0.93427
VERSAPAK_HAC_FINH_20WT_13S_4x272P_im1	0.0001	0.93315	0.0007	0.93455
VERSAPAK_HAC_FINH_20WT_13S_4x272P_im2	0.001	0.9337	0.00076	0.93522
VERSAPAK_HAC_FINH_20WT_13S_4x272P_im3	0.01	0.93305	0.00083	0.93471
VERSAPAK_HAC_FINH_20WT_13S_4x272P_im4	0.1	0.92566	0.00078	0.92722
VERSAPAK_HAC_FINH_20WT_13S_4x272P_im5	1	0.86668	0.00094	0.86856

Table 6-22 shows the results of the package moderation sensitivity analysis. In this study, only moderation inside packages was modeled; the region between and outside of packages was dry. As shown, the values of k_{eff} + 2 sigma for moderation volume fractions of 0 through 0.001

are all within 2 sigma of each other. This signifies that modeling no moderator between packages is not more reactive than the selected moderator volume fraction value of 0.0001 chosen for this calculation.

Table 6-22 Package moderation sensitivity

	Moderator Volume Fraction	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_FINH_20WT_13S_4x272P_pm0	0	0.93271	0.00078	0.93427
VERSAPAK_HAC_FINH_20WT_13S_4x272P_pm1	0.0001	0.93303	0.00084	0.93471
VERSAPAK_HAC_FINH_20WT_13S_4x272P_pm2	0.001	0.93224	0.00074	0.93372
VERSAPAK_HAC_FINH_20WT_13S_4x272P_pm3	0.01	0.92755	0.00082	0.92919
VERSAPAK_HAC_FINH_20WT_13S_4x272P_pm4	0.1	0.88266	0.00079	0.88424
VERSAPAK_HAC_FINH_20WT_13S_4x272P_pm5	1	0.89064	0.00074	0.89212

Table 6-23 shows the results of the combined interspersed and package moderation sensitivity study. In this study, moderation was modeled both inside of packages and between packages. As shown, the values of k_{eff} + 2 sigma for moderation volume fractions of 0 through 0.001 are all within 2 sigma of each other. This signifies that modeling no moderator between packages is not more reactive than the selected moderator volume fraction value of 0.0001 chosen for this calculation.

Table 6-23 Combined interspersed and package moderation sensitivity

	Moderator Volume Fraction	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_FINH_20WT_13S_4x272P_b0	0	0.93271	0.00078	0.93427
VERSAPAK_HAC_FINH_20WT_13S_4x272P_b1	0.0001	0.9332	0.00083	0.93486
VERSAPAK_HAC_FINH_20WT_13S_4x272P_b2	0.001	0.93351	0.00083	0.93517
VERSAPAK_HAC_FINH_20WT_13S_4x272P_b3	0.01	0.92643	0.0009	0.92823
VERSAPAK_HAC_FINH_20WT_13S_4x272P_b4	0.1	0.88158	0.00079	0.88316
VERSAPAK_HAC_FINH_20WT_13S_4x272P_b5	1	0.88931	0.00078	0.89087

6.10.3.6.5 10-wt% U-235 Enriched Uranium

Using the method outlined in Section 6.10.3.2, a U-235 mass limit of 470 g at 10wt% enrichment (4700 g uranium) in a 13.5-cm radius sphere was determined to be the most limiting configuration for U(10). Table 6-24 shows the results that the optimally moderated sphere for U(10) is at a 13.5-cm radius. The sphere radius sensitivity results for package arrays are shown in Figure 6-24.

Table 6-24 Sphere radius sensitivity, package array – U(10)

	12.5-cm Radius			13.5-cm Radius			14.5-cm Radius		
	k_{eff}	sigma	k_{eff} + 2 sigma	k_{eff}	sigma	k_{eff} + 2 sigma	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_FINH_10WT_x_1x324P	0.8521	0.0012	0.8545	0.8615	0.0011	0.8637	0.856	0.0011	0.8582
VERSAPAK_HAC_FINH_10WT_x_2x338P	0.9118	0.0012	0.9142	0.9181	0.001	0.9201	0.9107	0.001	0.9127
VERSAPAK_HAC_FINH_10WT_x_3x300P	0.9248	0.0011	0.927	0.9323	0.0011	0.9345	0.9263	0.00097	0.92824
VERSAPAK_HAC_FINH_10WT_x_4x272P	0.9304	0.0012	0.9328	0.9357	0.001	0.9377	0.9272	0.0011	0.9294
VERSAPAK_HAC_FINH_10WT_x_4x288P	0.9306	0.0012	0.933	0.9388	0.0011	0.941	0.9296	0.0011	0.9318
VERSAPAK_HAC_FINH_10WT_x_4x308P	0.9344	0.0012	0.9368	0.9421	0.001	0.9441	0.9317	0.0011	0.9339
VERSAPAK_HAC_FINH_10WT_x_5x280P	0.9263	0.0011	0.9285	0.9342	0.0012	0.9366	0.9262	0.0011	0.9284
VERSAPAK_HAC_FINH_10WT_x_6x288P	0.9268	0.0012	0.9292	0.9323	0.0011	0.9345	0.9248	0.001	0.9268
VERSAPAK_HAC_FINH_10WT_x_6x312P	0.9304	0.0013	0.933	0.9366	0.0011	0.9388	0.9295	0.001	0.9315
VERSAPAK_HAC_FINH_10WT_x_7x322P	0.9279	0.0012	0.9303	0.9305	0.0011	0.9327	0.9259	0.0011	0.9281
VERSAPAK_HAC_FINH_10WT_x_8x312P	0.9167	0.0011	0.9189	0.9273	0.001	0.9293	0.9191	0.0012	0.9215
VERSAPAK_HAC_FINH_10WT_x_9x324P	0.9182	0.0012	0.9206	0.9277	0.001	0.9297	0.9181	0.001	0.9201
VERSAPAK_HAC_FINH_10WT_x_10x300P	0.9084	0.001	0.9104	0.9162	0.0016	0.9194	0.9066	0.001	0.9086
VERSAPAK_HAC_FINH_10WT_x_12x300P	0.899	0.0012	0.9014	0.9064	0.001	0.9084	0.9012	0.0014	0.904

For the second analysis, the radius was held constant at 13.5 cm and the mass was increased and decreased by 25 g from the limit determined in the sphere radius sensitivity analysis. This was done to verify that the radius corresponds to optimum moderation. Table 6-25 gives the results.

Table 6-25 Uranium mass sensitivity, package array - U(10)

	445 g U-235			470 g U-235			495 g U-235		
	k_{eff}	sigma	k_{eff} + 2 sigma	k_{eff}	sigma	k_{eff} + 2 sigma	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_FINH_10WT_13.5S_1x324P	0.8484	0.0012	0.8508	0.8615	0.0011	0.8637	0.8713	0.0012	0.8737
VERSAPAK_HAC_FINH_10WT_13.5S_2x338P	0.9044	0.0012	0.9068	0.9181	0.001	0.9201	0.9325	0.0011	0.9347
VERSAPAK_HAC_FINH_10WT_13.5S_3x300P	0.9187	0.0012	0.9211	0.9323	0.0011	0.9345	0.9462	0.0011	0.9484
VERSAPAK_HAC_FINH_10WT_13.5S_4x272P	0.9227	0.001	0.9247	0.9357	0.001	0.9377	0.9487	0.0012	0.9511
VERSAPAK_HAC_FINH_10WT_13.5S_4x288P	0.9246	0.0011	0.9268	0.9388	0.0011	0.941	0.9513	0.001	0.9533
VERSAPAK_HAC_FINH_10WT_13.5S_4x308P	0.9247	0.001	0.9267	0.9421	0.001	0.9441	0.9545	0.0013	0.9571
VERSAPAK_HAC_FINH_10WT_13.5S_5x280P	0.9204	0.0012	0.9228	0.9342	0.0012	0.9366	0.9486	0.001	0.9506
VERSAPAK_HAC_FINH_10WT_13.5S_6x288P	0.9208	0.0012	0.9232	0.9323	0.0011	0.9345	0.9477	0.0012	0.9501
VERSAPAK_HAC_FINH_10WT_13.5S_6x312P	0.9244	0.001	0.9264	0.9366	0.0011	0.9388	0.9504	0.0011	0.9526
VERSAPAK_HAC_FINH_10WT_13.5S_7x322P	0.9191	0.0011	0.9213	0.9305	0.0011	0.9327	0.9442	0.0012	0.9466
VERSAPAK_HAC_FINH_10WT_13.5S_8x312P	0.9142	0.0011	0.9164	0.9273	0.001	0.9293	0.9388	0.0011	0.941
VERSAPAK_HAC_FINH_10WT_13.5S_9x324P	0.9104	0.0011	0.9126	0.9277	0.001	0.9297	0.9357	0.0011	0.9379
VERSAPAK_HAC_FINH_10WT_13.5S_10x300P	0.904	0.0012	0.9064	0.9162	0.0016	0.9194	0.9278	0.0013	0.9304
VERSAPAK_HAC_FINH_10WT_13.5S_12x300P	0.8931	0.001	0.8951	0.9064	0.001	0.9084	0.9206	0.0012	0.923

Finally, the thorium addition sensitivity study was performed. As shown in Table 6-26, the addition of thorium caused a decrease in k_{eff}. Therefore, it is concluded that the addition of thorium has no effect on increasing k_{eff} for U(10) package arrays. The thorium addition sensitivity results for package arrays are shown in Figure 6-23.

Table 6-26 Natural thorium addition sensitivity, package array – U(10)

	Thorium mass (g)	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_FINH_10WT_13.5S_4x272P	0	0.9357	0.001	0.9377
VERSAPAK_HAC_FINH_10WT_13.5S_4x272P_50T	50	0.93489	0.00077	0.93643

	Thorium mass (g)	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_FINH_10WT_13.5S_4x272P_100T	100	0.93468	0.00079	0.93626
VERSAPAK_HAC_FINH_10WT_13.5S_4x272P_200T	200	0.92996	0.00087	0.9317
VERSAPAK_HAC_FINH_10WT_13.5S_4x272P_300T	300	0.92745	0.00076	0.92897
VERSAPAK_HAC_FINH_10WT_13.5S_4x272P_400T	400	0.926	0.0001	0.9262

6.10.3.6.6 5-wt% U-235 Enriched Uranium

Using the same method outlined in Section 6.10.3.2, a U-235 limit of 580 g at 5wt% enrichment (11,600 g uranium) in a 14.5-cm radius sphere was determined to be the most limiting configuration for U(5). As shown in Table 6-27, 14.5 cm was found to be the optimum sphere radius. The sphere radius sensitivity results for package arrays are shown in Figure 6-24.

Table 6-27 Sphere radius sensitivity, package array – U(5)

	13.5-cm Radius			14.5-cm Radius			15.5-cm Radius		
	k_{eff}	sigma	k_{eff} + 2 sigma	k_{eff}	sigma	k_{eff} + 2 sigma	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_FINH_5WT_x_1x324P	0.8538	0.0011	0.856	0.863	0.0013	0.8656	0.861	0.0011	0.8632
VERSAPAK_HAC_FINH_5WT_x_2x338P	0.912	0.001	0.914	0.9186	0.001	0.9206	0.913	0.0011	0.9152
VERSAPAK_HAC_FINH_5WT_x_3x300P	0.9259	0.0011	0.9281	0.9314	0.0011	0.9336	0.9233	0.0011	0.9255
VERSAPAK_HAC_FINH_5WT_x_4x272P	0.9302	0.0012	0.9326	0.9356	0.001	0.9376	0.9298	0.0012	0.9322
VERSAPAK_HAC_FINH_5WT_x_4x288P	0.9313	0.0011	0.9335	0.9383	0.0011	0.9405	0.928	0.0011	0.9302
VERSAPAK_HAC_FINH_5WT_x_4x308P	0.9324	0.0012	0.9348	0.9374	0.0011	0.9396	0.9299	0.001	0.9319
VERSAPAK_HAC_FINH_5WT_x_5x280P	0.9287	0.0012	0.9311	0.9351	0.001	0.9371	0.9252	0.001	0.9272
VERSAPAK_HAC_FINH_5WT_x_6x288P	0.9261	0.001	0.9281	0.9349	0.0011	0.9371	0.9242	0.0011	0.9264
VERSAPAK_HAC_FINH_5WT_x_6x312P	0.9297	0.0011	0.9319	0.935	0.001	0.937	0.9288	0.0011	0.931
VERSAPAK_HAC_FINH_5WT_x_7x322P	0.9262	0.0011	0.9284	0.9316	0.001	0.9336	0.9248	0.0012	0.9272
VERSAPAK_HAC_FINH_5WT_x_8x312P	0.9186	0.0011	0.9208	0.925	0.0011	0.9272	0.9177	0.0011	0.9199

	13.5-cm Radius			14.5-cm Radius			15.5-cm Radius		
	k_{eff}	sigma	k_{eff} + 2 sigma	k_{eff}	sigma	k_{eff} + 2 sigma	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_FINH_5WT_x_9x324P	0.9156	0.0011	0.9178	0.9232	0.0011	0.9254	0.915	0.001	0.917
VERSAPAK_HAC_FINH_5WT_x_10x300P	0.9071	0.0012	0.9095	0.9153	0.0011	0.9175	0.9082	0.001	0.9102
VERSAPAK_HAC_FINH_5WT_x_12x300P	0.8998	0.0011	0.902	0.9093	0.0012	0.9117	0.9036	0.001	0.9056

Also using the same technique already described for mass sensitivity evaluations, Table 6-28 shows that 580 g U-235 at 5wt% U-235 is optimally moderated, as the decrease in mass decreases k_{eff}.

Table 6-28 Uranium mass sensitivity, package array - U(5)

	555 g U+235			580 g U-235			605 g U-235		
	k_{eff}	sigma	k_{eff} + 2 sigma	k_{eff}	sigma	k_{eff} + 2 sigma	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_FINH_5WT_14.5S_1x324P	0.8546	0.0011	0.8568	0.863	0.0013	0.8656	0.8713	0.001	0.8733
VERSAPAK_HAC_FINH_5WT_14.5S_2x338P	0.9067	0.001	0.9087	0.9186	0.001	0.9206	0.9255	0.001	0.9275
VERSAPAK_HAC_FINH_5WT_14.5S_3x300P	0.9216	0.0011	0.9238	0.9314	0.0011	0.9336	0.942	0.001	0.944
VERSAPAK_HAC_FINH_5WT_14.5S_4x272P	0.9238	0.001	0.9258	0.9356	0.001	0.9376	0.9452	0.0011	0.9474
VERSAPAK_HAC_FINH_5WT_14.5S_4x288P	0.9239	0.0012	0.9263	0.9383	0.0011	0.9405	0.9449	0.001	0.9469
VERSAPAK_HAC_FINH_5WT_14.5S_4x308P	0.9291	0.0011	0.9313	0.9374	0.0011	0.9396	0.9485	0.0012	0.9509
VERSAPAK_HAC_FINH_5WT_14.5S_5x280P	0.9226	0.001	0.9246	0.9351	0.001	0.9371	0.9444	0.001	0.9464
VERSAPAK_HAC_FINH_5WT_14.5S_6x288P	0.92106	0.00097	0.923	0.9349	0.0011	0.9371	0.9417	0.001	0.9437
VERSAPAK_HAC_FINH_5WT_14.5S_6x312P	0.9272	0.001	0.9292	0.935	0.001	0.937	0.9457	0.0011	0.9479
VERSAPAK_HAC_FINH_5WT_14.5S_7x322P	0.9219	0.001	0.9239	0.9316	0.001	0.9336	0.9417	0.0011	0.9439
VERSAPAK_HAC_FINH_5WT_14.5S_8x312P	0.9153	0.0011	0.9175	0.925	0.0011	0.9272	0.9359	0.0011	0.9381
VERSAPAK_HAC_FINH_5WT_14.5S_9x324P	0.913	0.0011	0.9152	0.9232	0.0011	0.9254	0.9328	0.0011	0.935
VERSAPAK_HAC_FINH_5WT_14.5S_10x300P	0.9035	0.0011	0.9057	0.9153	0.0011	0.9175	0.9259	0.0011	0.9281
VERSAPAK_HAC_FINH_5WT_14.5S_12x300P	0.8977	0.0012	0.9001	0.9093	0.0012	0.9117	0.9167	0.0013	0.9193

Finally, the thorium addition sensitivity analysis determined again that the addition of thorium decreased k_{eff}. Therefore, it is concluded that the addition of thorium has no effect on increasing k_{eff} for U(5) package arrays. The thorium addition sensitivity results for package arrays are shown in Figure 6-23.

Table 6-29 Natural thorium addition sensitivity, package array – U(5)

	Thorium mass (g)	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_FINH_5WT_14.5S_4x272P	0	0.9356	0.001	0.9376
VERSAPAK_HAC_FINH_5WT_14.5S_4x272P_50T	50	0.93421	0.00074	0.9357
VERSAPAK_HAC_FINH_5WT_14.5S_4x272P_100T	100	0.93288	0.00069	0.9343
VERSAPAK_HAC_FINH_5WT_14.5S_4x272P_200T	200	0.93024	0.00075	0.9317
VERSAPAK_HAC_FINH_5WT_14.5S_4x272P_300T	300	0.92826	0.00079	0.9298
VERSAPAK_HAC_FINH_5WT_14.5S_4x272P_400T	400	0.92798	0.00078	0.9295

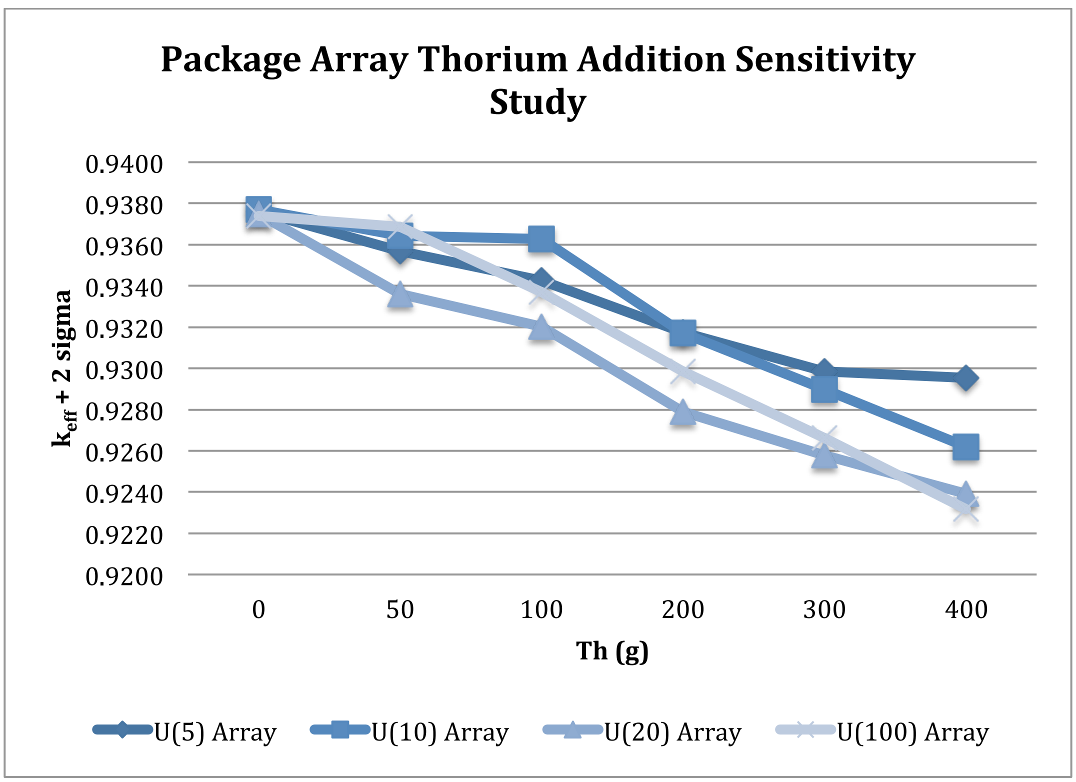

Figure 6-23 Package Array Natural Thorium Addition Sensitivity

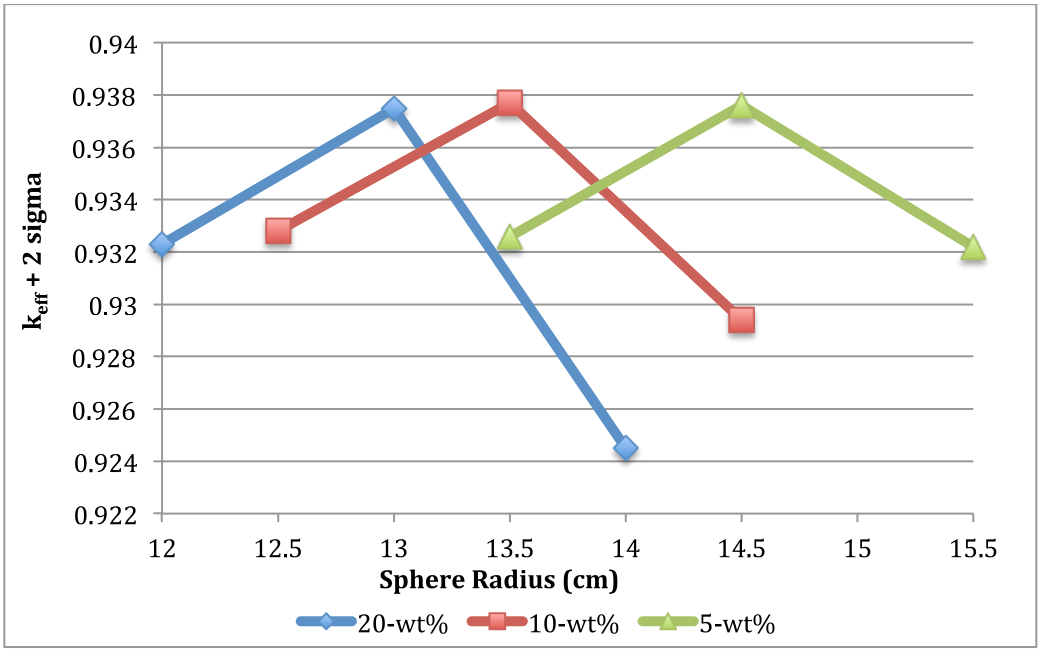

Figure 6-24 Sphere Radius Sensitivity, Package Array

6.10.3.7 Single Package Evaluation

6.10.3.7.1 Configuration

The uranium mass limits used in the single package analyses are taken from the package array analyses of Section 6.10.3.4.6. The single package analysis is performed to verify subcriticality.

Two single package configurations were modeled in this analysis. Configuration #1 was the same configuration used in the original Versa-Pac single package analysis defined in Section 6.4, which consisted of an optimally moderated, homogeneous, spherical fissile mass consisting of just the uranium and polyethylene. The package was modeled as fully flooded and with close full water reflection of 30.48 cm of light water.

Configuration #2 includes of the addition of thorium to the spherical fissile mass of the most reactive case for each enrichment level configuration to examine the effect of thorium added to the contents. Thorium was added in the 50 g, 100 g, 200 g, 300 g, and 400 g increments, and was identified in the input deck filename as 50T, 100T, 200T, 300T, and 400T.

Because the fissile mass might not be restrained from movement under hypothetical accident conditions (HAC), cases were run with the spherical mass in six different locations inside the containment system to determine which position was most reactive. These included top, center, and bottom along the z-axis, and then center and edge along the x- or y- axis. These analyses were performed during the study with the 20 wt.% material. The locations are designated TS, TM, MS, MM, and BS, and BM. It was determined that the centroid of the containment (MM) was the most reactive location, as shown below.

The percentage of polyethylene moderation was also examined to determine its effect on k_{eff}. The polyethylene moderation was first examined at 100%, denoted by a suffix of A in the case name, decreasing by 10 percent per case until polyethylene modeled at 50% nominal density was examined, denoted by a suffix of F in the case name.

6.10.3.7.2 100-wt% U-235 Enriched Uranium Results

The Configuration #1 analysis for 100-wt% U-235 was addressed in Section 6.4. The configuration #2 analysis is found below.

The most limiting case for the U(100) single package analysis was used to determine the thorium sensitivity, which consisted of a 12-cm radius lumped sphere with 350 g of U-235. Thorium was added as described above. As can be seen in Table 6-30, the addition of natural thorium reduced reactivity. The thorium addition sensitivity results are shown in Figure 6-25.

Note that case VERSAPAK_HAC_SIN_100WT_12S_A in Table 6-30 gives higher results than VERSAPAK_HAC_SIN_12S_A in Table 6-6. The two models are not identical. They differ in that the model used in this analysis uses high-density polyethylene as the moderator, includes the packaging, and is analyzed using SCALE 6.1.3.

Table 6-30 Thorium Addition to Single Package Sensitivity – U(100)

	Thorium mass (g)	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_SIN_100WT_12S_A [a]	0	0.9042	0.0012	0.9066
VERSAPAK_HAC_SIN_100WT_12S_A_50T	50	0.90113	0.00076	0.9027
VERSAPAK_HAC_SIN_100WT_12S_A_100T	100	0.90036	0.00079	0.9020
VERSAPAK_HAC_SIN_100WT_12S_A_200T	200	0.89566	0.00078	0.89722
VERSAPAK_HAC_SIN_100WT_12S_A_300T	300	0.89319	0.00076	0.89471
VERSAPAK_HAC_SIN_100WT_12S_A_400T	400	0.88994	0.00085	0.89164

NOTE: [a] model rerun with SCALE 6.1.3 for sensitivity study comparison

6.10.3.7.3 20-wt% U-235 Enriched Uranium Results

All cases in this section of the analysis were modeled with 410 g of U-235 at 20-wt% enrichment. The first analysis was the sphere size sensitivity as described in Section 6.10.3.2. It was found that the sphere radius for a single package with U(20) was 12 cm. Results of the sensitivity analysis are shown in Table 6-31. A plot of the k_{eff} + 2 sigma vs sphere radius is shown in Figure 6-26.

Table 6-31 Sphere Radius Single Package Sensitivity – U(20)

	Sphere radius (cm)	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_SIN_20WT_10S_A	10	0.8697	0.0011	0.8719
VERSAPAK_HAC_SIN_20WT_11S_A	11	0.888	0.0012	0.8904
VERSAPAK_HAC_SIN_20WT_12S_A	12	0.8974	0.0011	0.8996
VERSAPAK_HAC_SIN_20WT_13S_A	13	0.8899	0.0012	0.8923
VERSAPAK_HAC_SIN_20WT_14S_A	14	0.8761	0.0011	0.8783
VERSAPAK_HAC_SIN_20WT_15S_A	15	0.8464	0.001	0.8484

As mentioned in above, a fissile mass placement sensitivity study was performed with U(20). As shown in Table 6-32, placing the sphere at the centroid of the package resulted in the highest k_{eff} plus 2 sigma of 0.8994.

Table 6-32 Sphere placement sensitivity, single package - U(20)

	Z position	Radial position	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_SIN_20WT_12S_A_BM	Bottom	Middle	0.89598	0.00076	0.8975
VERSAPAK_HAC_SIN_20WT_12S_A_BS	Bottom	Side	0.89292	0.00097	0.89486
VERSAPAK_HAC_SIN_20WT_12S_A_MM[1]	Middle	Middle	0.89776	0.00081	0.89938
VERSAPAK_HAC_SIN_20WT_12S_A_MS	Middle	Side	0.89351	0.00086	0.89523
VERSAPAK_HAC_SIN_20WT_12S_A_TM	Top	Middle	0.89548	0.00077	0.89702
VERSAPAK_HAC_SIN_20WT_12S_A_TS	Top	Side	0.89183	0.00088	0.89359

[1] Note this case is identical to case VERSAPAK_HAC_SIN_20WT_12S_A except for the increase in neutron histories.

The next sensitivity study examined reduction in sphere's polyethylene moderation, reducing polyethylene moderation from 100% to 50% in 10% increments. The results, given in Table 6-33, show a 31% reduction in k_{eff} plus two sigma at 50% polyethylene density. Therefore, it can be concluded that 100% polyethylene moderation is the most reactive percentage of polyethylene moderation for a U(20) single package.

Table 6-33 Reduced polyethylene moderation sensitivity, single package - U(20)

	Poly moderation density (%)	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_SIN_20WT_12S_A	100	0.8974	0.0011	0.8996
VERSAPAK_HAC_SIN_20WT_12S_B	90	0.8558	0.0011	0.8580
VERSAPAK_HAC_SIN_20WT_12S_C	80	0.8078	0.0011	0.8100
VERSAPAK_HAC_SIN_20WT_12S_D	70	0.7536	0.0011	0.7558
VERSAPAK_HAC_SIN_20WT_12S_E	60	0.6904	0.0011	0.6926

	Poly moderation density (%)	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_SIN_20WT_12S_F	50	0.6198	0.001	0.6218

Finally, natural thorium addition was examined for the U(20) configuration. As with the U(100) configuration, thorium lowered k_{eff}, as shown in Table 6-34. The thorium addition sensitivity results are shown in Figure 6-25.

Table 6-34 Thorium Addition to Single Package Sensitivity – U(20)

	Thorium mass (g)	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_SIN_20WT_12S_A	0	0.8974	0.0011	0.8996
VERSAPAK_HAC_SIN_20WT_12S_A_50T	50	0.89711	0.00088	0.8989
VERSAPAK_HAC_SIN_20WT_12S_A_100T	100	0.89269	0.00077	0.8942
VERSAPAK_HAC_SIN_20WT_12S_A_200T	200	0.89094	0.0008	0.8925
VERSAPAK_HAC_SIN_20WT_12S_A_300T	300	0.88892	0.00086	0.8906
VERSAPAK_HAC_SIN_20WT_12S_A_400T	400	0.88325	0.00078	0.8848

6.10.3.7.4 10-wt% U-235 Enriched Uranium Results

All cases in this section were modeled with 470 g of U-235 at 10-wt% enrichment. For the U(10) single package analysis, the sphere radius sensitivity, polyethylene moderation sensitivity, and natural thorium addition sensitivity analyses were performed.

The sphere radius sensitivity analysis determined that a lumped sphere radius of 13 cm was the most reactive for U(10), as shown in Table 6-35. The k_{eff} plus two sigma value of 0.8950 for the 13-cm radius lumped sphere is well below the USL. Note the most reactive case is highlighted. A plot of k_{eff} + 2 sigma vs sphere radius is shown in Figure 6-26.

Table 6-35 Sphere Radius Single Package Sensitivity – U(10)

	Sphere radius (cm)	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_SIN_10WT_11S_A	11	0.8730	0.0012	0.8754
VERSAPAK_HAC_SIN_10WT_12S_A	12	0.8906	0.0012	0.8930
VERSAPAK_HAC_SIN_10WT_12.5S_A	12.5	0.8920	0.0011	0.8942
VERSAPAK_HAC_SIN_10WT_13S_A	13	0.8930	0.001	0.8950
VERSAPAK_HAC_SIN_10WT_14S_A	14	0.8820	0.0011	0.8842
VERSAPAK_HAC_SIN_10WT_15S_A	15	0.8630	0.0011	0.8652

For the polyethylene moderation sensitivity study, the amount of polyethylene moderation was reduced in a manner identical to the method described above. Results showed the F case experiencing a 29% reduction in k_{eff} plus two sigma from the A case, as shown in Table 6-36. Therefore, it can be concluded that 100% polyethylene moderation is the most reactive form of polyethylene moderation for a U(10) single package.

Table 6-36 Reduced Polyethylene Moderation Single Package Sensitivity – U(10)

	Poly moderation density (%)	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_SIN_10WT_13S_A	100	0.8930	0.001	0.8950
VERSAPAK_HAC_SIN_10WT_13S_B	90	0.8561	0.001	0.8581
VERSAPAK_HAC_SIN_10WT_13S_C	80	0.8125	0.0011	0.8147
VERSAPAK_HAC_SIN_10WT_13S_D	70	0.7619	0.001	0.7639
VERSAPAK_HAC_SIN_10WT_13S_E	60	0.7011	0.001	0.7031
VERSAPAK_HAC_SIN_10WT_13S_F	50	0.6336	0.001	0.6356

Natural thorium addition sensitivity was also examined for the U(10) configuration. As with the U(100) and U(20) configurations, thorium addition caused a reduction in k_{eff}, as shown in Table 6-37. The thorium addition sensitivity results are shown in Figure 6-25.

Table 6-37 Thorium Addition to Single Package – U(10)

	Thorium mass (g)	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_SIN_10WT_13S_A	0	0.893	0.001	0.8950
VERSAPAK_HAC_SIN_10WT_13S_A_50T	50	0.89036	0.0008	0.8920
VERSAPAK_HAC_SIN_10WT_13S_A_100T	100	0.88928	0.00076	0.8908
VERSAPAK_HAC_SIN_10WT_13S_A_200T	200	0.88575	0.0008	0.8873
VERSAPAK_HAC_SIN_10WT_13S_A_300T	300	0.88418	0.0007	0.8856
VERSAPAK_HAC_SIN_10WT_13S_A_400T	400	0.87996	0.00094	0.8818

6.10.3.7.5 5-wt% U-235 Enriched Uranium Results

All cases in this section were modeled with 580 g of U-235 at 5-wt% enrichment. For the U(5) single package analysis, the sphere radius sensitivity, polyethylene moderation sensitivity, and natural thorium addition sensitivity analyses were performed.

The sphere radius sensitivity analysis determined that sphere radius of 14 cm was the most reactive for U(5), as shown in Table 6-38. The value of k_{eff} plus two sigma is 0.8840 for the 14-cm radius lumped sphere. Note the most reactive case is highlighted. A plot of k_{eff} + 2 sigma vs sphere radius is shown in Figure 6-26.

Table 6-38 Sphere Radius Single Package Sensitivity – U(5)

	Sphere radius (cm)	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_SIN_5WT_12S_A	12	0.8619	0.0013	0.8645
VERSAPAK_HAC_SIN_5WT_13S_A	13	0.8796	0.0011	0.8818
VERSAPAK_HAC_SIN_5WT_14S_A	14	0.8816	0.0012	0.8840
VERSAPAK_HAC_SIN_5WT_15S_A	15	0.8755	0.001	0.8775
VERSAPAK_HAC_SIN_5WT_16S_A	16	0.8613	0.001	0.8633

The polyethylene moderation sensitivity study showed a 27% reduction in k_{eff} plus two sigma for the F case, as shown in Table 6-39. Therefore, it can be concluded that 100% polyethylene moderation is the most reactive form of polyethylene moderation for a U(5) single package.

Table 6-39 Reduced polyethylene moderation sensitivity, single package – U(5)

	Poly moderation density (%)	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_SIN_5WT_14S_A	100	0.8816	0.0012	0.8840
VERSAPAK_HAC_SIN_5WT_14S_B	90	0.8476	0.0011	0.8498
VERSAPAK_HAC_SIN_5WT_14S_C	80	0.8101	0.0011	0.8123
VERSAPAK_HAC_SIN_5WT_14S_D	70	0.7601	0.001	0.7621
VERSAPAK_HAC_SIN_5WT_14S_E	60	0.7038	0.0012	0.7062
VERSAPAK_HAC_SIN_5WT_14S_F	50	0.64	0.001	0.6420

Natural thorium addition sensitivity was examined for the U(5) configuration. As with the U(100), U(20), and U(10) configurations, the addition of natural thorium reduce k_{eff}, as shown in table 6-41. The thorium addition sensitivity results are shown in Figure 6-25.

Table 6-40 Natural thorium addition sensitivity, single package – U(5)

	Thorium mass (g)	k_{eff}	sigma	k_{eff} + 2 sigma
VERSAPAK_HAC_SIN_5WT_14S_A	0	0.8816	0.0012	0.8840
VERSAPAK_HAC_SIN_5WT_14S_A_50T	50	0.88086	0.00081	0.8825
VERSAPAK_HAC_SIN_5WT_14S_A_100T	100	0.87982	0.00078	0.8814
VERSAPAK_HAC_SIN_5WT_14S_A_200T	200	0.87831	0.00077	0.8799
VERSAPAK_HAC_SIN_5WT_14S_A_300T	300	0.8752	0.0008	0.8768
VERSAPAK_HAC_SIN_5WT_14S_A_400T	400	0.87402	0.00081	0.87564

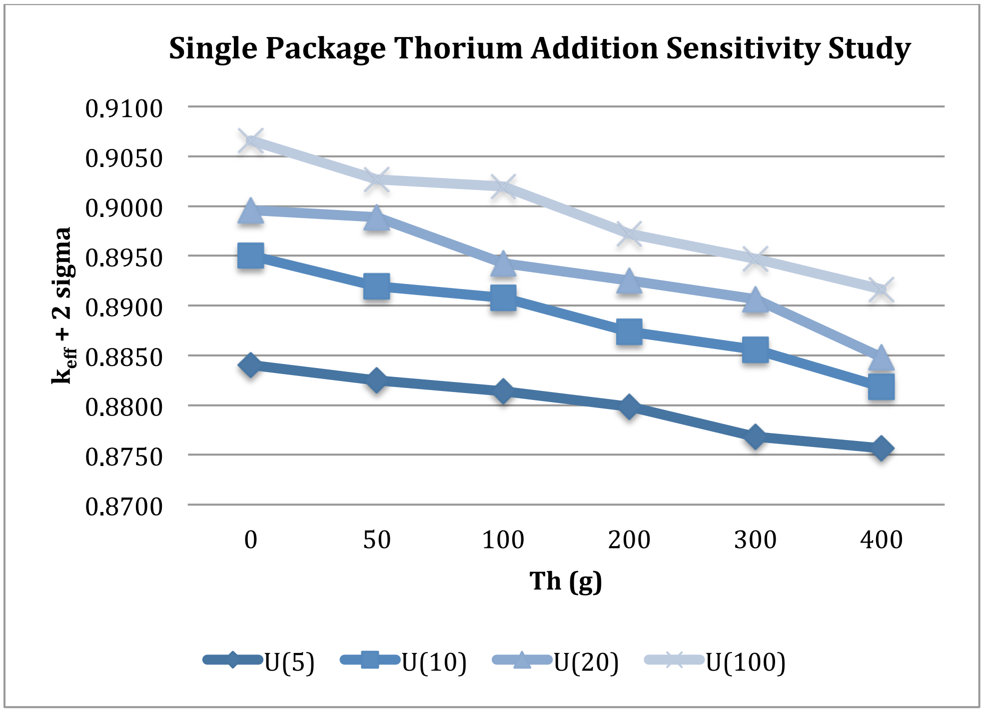

Figure 6-25 Single Package Thorium Addition Sensitivity

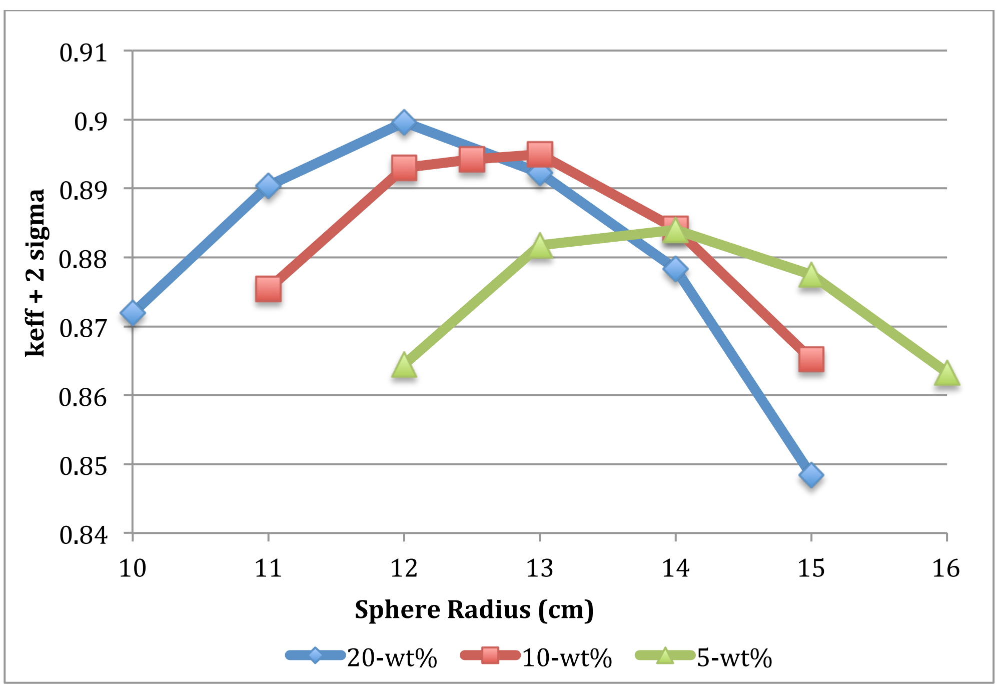

Figure 6-26 Sphere Radius Sensitivity, Single Package

6.10.3.8 Enrichment Loading Summary

Table 6-41.

provides a summary of the criticality evaluations for the addition of the reduced enrichment loadings. The uranium mass limits for each enrichment level examined resulted in k_{eff} plus two sigma values all below the USL for the most limiting cases determined in this analysisTable 6-41.

See 6.10.5 for the benchmark evaluation for SCALE 6.1.3. The most reactive single package case and the most reactive package array case are listed for the additional three enrichment levels examined:

- A mass of 410 g of U-235 at 20wt% enrichment (2,050 g uranium) in a 12-cm radius sphere for a single package and a 13-cm radius sphere for an array were determined to be the most reactive configurations.
- A mass of 470 g of U-235 at 10wt% U-235 enrichment (4,700 g uranium) in a 13-cm radius sphere for a single package and a 13.5-cm radius sphere for an array were determined to be the most reactive configurations.
- A mass of 580 g of U-235 at 5wt% U-235 enrichment (11,600 g uranium) in a 14-cm radius sphere for a single package and a 14.5-cm radius sphere for an array were determined to be the most reactive configurations.

Natural thorium addition was examined for both single packages and package arrays for all enrichment levels. All of the permutations had the same result of no increase in k_{eff}. Rather, each permutation experienced a decrease in k_{eff} as thorium mass increased. Therefore, the addition of natural thorium in any form is authorized for the Versa-Pac. Note these results are not summarized in Table 6-41.

Table 6-41 Summary Table for Enrichment Loading

Case	U-235 Enrichment (wt%)	U-235 Mass (g)	Sphere Radius (cm)	Number of Packages	k_{eff}	sigma	k_{eff} + 2 sigma
HAC Single Packages							
VERSAPAK_HAC_SIN_20WT_12S_A	20	410	12	1	0.8974	0.0011	0.8996
VERSAPAK_HAC_SIN_10WT_13S_A	10	470	13	1	0.8930	0.001	0.8950
VERSAPAK_HAC_SIN_5WT_14S_A	5	580	14	1	0.8816	0.0012	0.8840
HAC Package Arrays							
VERSAPAK_HAC_FINH_20WT_13S_4x272P	20	410	13	272	0.9351	0.0012	0.9375
VERSAPAK_HAC_FINH_10WT_13.5S_4x272P	10	470	13.5	272	0.9357	0.001	0.9377
VERSAPAK_HAC_FINH_5WT_14.5S_4x272P	5	580	14.5	272	0.9356	0.001	0.9376

6.10.4 Appendix 6.10.4: Selected SCALE 6 Input Cases

[Issued separately]

6.10.5 Appendix 6.10.5: SCALE 6.1.3 Benchmark Evaluation

6.10.5.1 BENCHMARK EVALUATIONS

The SCALE 6.1.3 computer code used for the updated criticality calculations of Appendix 6.10.3 and where noted has been benchmarked against applicable criticality experiments.

6.10.5.2 Applicability of Benchmark Experiments

Table 6-42 summarizes the 97 critical benchmark experiments that were deemed applicable to the Versa-Pac. All experiments were homogeneous solutions of uranium compounds and light water in spherical, cylindrical, or parallelepiped metal tanks made of steel or aluminum. Some experiments were bare and some were reflected with light water.

Table 6-42 Summary of Critical Benchmark Experiments

Report [1]	Selected / Total Experiments	Uranium Configuration	U-235 Enrichment (wt%)	Hydrogen Moderation	Reflector	H/U-235 [2]
High-Enriched Uranium						
HEU-SOL-THERM-001	6 / 10	$UO_2(NO_3)_2$	93.17	Water (H_2O)	Bare	68.15 - 499.4
HEU-SOL-THERM-009	4 / 4	UO_2F_2	93.17 - 93.19	Water (H_2O)	Water (H_2O)	35.84 - 126.5
HEU-SOL-THERM-010	4 / 4	UO_2F_2	93.12	Water (H_2O)	Water (H_2O)	239.0 - 270.0
HEU-SOL-THERM-011	2 / 2	UO_2F_2	93.2	Water (H_2O)	Water (H_2O)	523.4 - 533.1
HEU-SOL-THERM-042	8 / 8	$UO_2(NO_3)_2$	93.2	Water (H_2O)	Bare	1634 - 2050
HEU-SOL-THERM-043	3 / 3	UO_2F_2	93.2	Water (H_2O)	Bare	203.5 - 2050
Intermediate-Enriched Uranium						
IEU-SOL-THERM-002	11 / 13	UO_2F_2	30.45	Water (H_2O)	Bare, Water (H_2O)	76.26 - 1611
IEU-SOL-THERM-003	21 / 21	UO_2F_2	30.3	Water (H_2O)	Water (H_2O)	75.40 - 930.8

Report [1]	Selected / Total Experiments	Uranium Configuration	U-235 Enrichment (wt%)	Hydrogen Moderation	Reflector	H/U-235 [2]
Low-Enriched Uranium						
LEU-SOL-THERM-001	1 / 1	UO_2F_2	5	Water (H_2O)	Bare	453.9
LEU-SOL-THERM-002	3 / 3	UO_2F_2	4.9	Water (H_2O)	Water (H_2O)	1001 - 1098
LEU-SOL-THERM-003	9 / 9	$UO_2(NO_3)_2$	10	Water (H_2O)	Bare	770.3 - 1438
LEU-SOL-THERM-004	7 / 7	$UO_2(NO_3)_2$	10	Water (H_2O)	Water (H_2O)	719.0 - 1018
LEU-SOL-THERM-007	5 / 5	$UO_2(NO_3)_2$	10	Water (H_2O)	Bare	709.2 - 942.2
LEU-SOL-THERM-016	7 / 7	$UO_2(NO_3)_2$	10	Water (H_2O)	Water (H_2O)	468.7 - 771.8
LEU-SOL-THERM-017	6 / 6	$UO_2(NO_3)_2$	10	Water (H_2O)	Bare	468.7 - 729.0

NOTES:

[1] All reports taken from the ICSBEP Handbook [8];

[2] As calculated in SCALE 6.1.3

A comparison of the relevant properties between the critical experiments and the Versa-Pac is shown in Table 6-43. The benchmark experiments were grouped by high-, intermediate-, and low-enriched uranium ranges. However, because all of the critical experiment group ranges of EALF and H/U-235 spanned the Versa-Pac's ranges of EALF and H/U-235, the critical experiment groups were analyzed together to produce a single USL for the entire U-235 enrichment range of Versa-Pac.

Table 6-43 Comparison of Parameters Between Selected Critical Experiments and the Versa-Pac

	High Enriched	Intermediate Enriched	Low Enriched	Versa-Pac [2]
Number of Cases	27	32	38	8

	High Enriched	Intermediate Enriched	Low Enriched	Versa-Pac [2]
Fissile Material	Uranium-235	Uranium-235	Uranium-235	Uranium-235
U-235 wt%	93.12 - 93.2	30.3 - 30.45	4.9 - 10	5-100
Fissile Material Configuration	Oxide Solution	Oxide Solution	Oxide Solution	Metal Homogenized with Moderator
Moderation	Water	Water	Water	Polyethylene
Reflector	None, Water	None, Water	None, Water	Water
H/U-235 [1]	35.84 – 2050	75.40 - 1611	453.9 - 1438	571.2 – 728.6
EALF (eV) [1]	3.07E-2 - 5.25E-1	3.20E-2 – 2.95E-1	3.43E-2 - 6.0E-2	3.81E-2 – 4.95E-2

NOTES:

[1] As determined in SCALE 6.1.3;

[2] Parameters from most limiting HAC cases for each enrichment

6.10.5.3 Bias Determination

After a comparison of critical experiments, USLSTATS was used to assist with the statistical analysis of the benchmark experiments. USLSTATS provides two methods of determining a USL as defined in NUREG/CR-6361 [5] . A comparison of these two methods is shown in Figure 6-27.

The first method (USL1), called *Confidence Band with Administrative Margin*, applies a statistical calculation of the bias and its uncertainty, plus an administrative margin, to a linear fit of critical experiment benchmark data.

The second method (USL2), *Single-Sided Uniform Width Closed Interval Approach*, is a single-sided closed interval approach, using a uniform width. The purpose of this method is to determine a uniform tolerance band over a specified closed interval, based on a linear least squares model. The statistical margin calculated for Method 2 is generally less than the administrative margin of 0.05. This difference shows the adequacy of the administrative margin.

For this analysis, Method 1 was applied and Method 2 was used as a verification of Method 1 such that the USL of Method 1 (USL1) must be less than the USL of Method 2 (USL2), which signifies that the administrative margin selected for Method 1 is sufficient.

For the Versa-Pac, EALF and H/U-235 were selected as candidates for the trending parameter. The parameter that results in the highest correlation value, |r|, between the trending parameter and the critical data will be used to determine the value of USL1.

6.10.5.4 Results

The results of the USLSTATS analyses are presented in Table 6-44. This table includes the equations to determine USL1; the applicable trending parameter range; the limiting Versa-Pac trending parameter value; the resultant USL1; the Minimum Margin of Subcriticality, which is the statistically based subcritical margin from the USL2 calculation; and the Correlation Coefficient, r, of the critical data to its respective trending parameter.

Table 6-44 USL1 for the Trending Parameters Analyzed

Trending Parameter	USL Equation (Method 1)	Trending Parameter Range	Limiting X of Versa-Pac	USL_1	C*s(p) - W	Correlation Coefficient (r)
EALF (eV)	0.9402 + (-1.225E-2)*X (X > 0.08644) 0.9391 (X ≤ 0.08644)	0.0307 ≤ X ≤ 0.525	0.0495	0.9391	0.043	-0.248
H/U-235	0.9394 + (1.4531E-6)*X (X < 580.55) 0.9403 (X ≥ 580.55)	35.84 ≤ X ≤ 2050	571.2	0.9402	0.0138	0.19

The administrative margin, Δkm, for these analyses was 0.05, which is greater than the Minimum Margin of Subcriticality (C*s(p)–W), calculated for each trending parameter. Therefore the selected administrative margin is acceptable.

Based on the results of these analyses, the USL1 for the trending parameter EALF as was selected as the USL, because it has a larger Correlation Coefficient, |r| than H/U-235. Inserting the limiting EALF value of the Versa-Pac, USL1 equates to 0.9391, which when rounded down for conservatism, results in a final USL of 0.939.

The following figure plots the EALF trending parameter against k_{eff} of the benchmarks. The first line plots the function $k_c(x)$, the line of fit to the critical data. The second line plots the function $k_c(x) – w(x)$, the line of fit of the critical data with a lower band of 95% confidence margin of the data. The third line plots the function $k_c(x) – W$, the line of best fit of the critical data with the largest band of the 95% confidence margin from the second line, $k_c(x) - w(x)$, applied as a conservatism. The USL_1 and USL_2 plots will plateau at a certain constant value in order to not take credit for any positive biases in $k_c(x) – W$.

The ULSTATS results for EALF as the trending parameter is shown in Figure 6-27. None of the values fell below the lower confidence limit ($k_c(x) – W$) of the calculated critical values. Applying the limiting X value from the Versa-Pac EALF range to the **USL1** equation listed in Table 6-44 resulted in a USL1 value of 0.9391. As the value of EALF increased, the value of k_{eff} decreased, resulting in a negative correlation between EALF and k_{eff}, with a coefficient of r = -0.248.

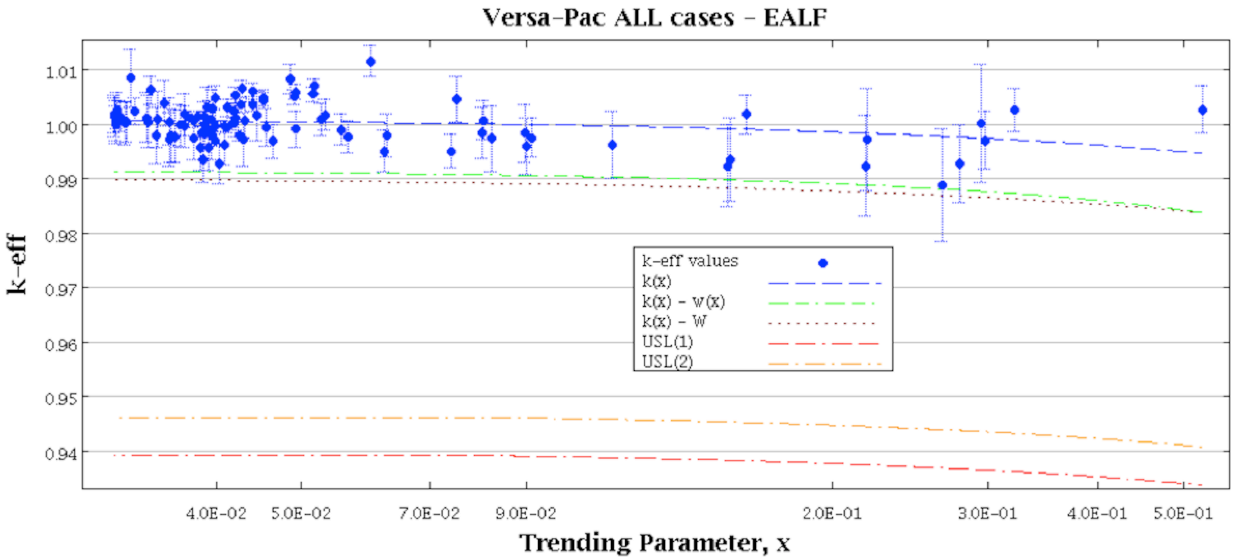

Figure 6-27 USLSTATS Trend Plot of k_{eff} vs. EALF.

6.10.5.5 SCALE 6.1.3 Benchmark Summary

From the trending analysis of k_{eff} vs EALF, the USL that is established for the Versa-Pac supplemental analyses with SCALE 6.1.3 is 0.939. EALF was chosen as the trending parameter because it had a higher correlation with the k_{eff} data than did H/U-235. The USL of 0.939 is deemed acceptable to account for the uncertainties and biases from the models used in SCALE 6.1.3 because the administrative margin, 0.05, used in determining the USL was deemed sufficient, as determined in the USLSTATS analysis through the calculation of a statistical margin.

The generated USL is applicable for an EALF range of 0.0308 through 0.525 eV and for an H/U-235 range of 35.84 through 2050. The Versa-Pac's parameter ranges for EALF and H/U-235 were contained by the parameter ranges of both the entirety of the selected critical benchmark experiments and individually by the high-enriched, intermediate-enriched, and low-enriched uranium critical benchmark experiment subgroups.