Request for Additional Information
Model No. Traveller
Docket No. 71-9297

By application dated April 1, 2004, Westinghouse Electric Company requested a Certificate of Compliance for the Model No. Traveller package. This request identifies additional information needed by the Nuclear Regulatory Commission staff (the staff) in connection with its review of the safety analysis report (SAR). The requested information is listed by chapter number and title in the SAR. NUREG-1609, "Standard Review Plan for Transportation Packages for Radioactive Material," was used for this review. This request describes information needed by the staff for it to complete its review of the SAR and to determine whether the applicant has demonstrated compliance with regulatory requirements.

Chapter 1 General Information

1-1_ Revise drawings to adequately depict design features so that there is a sufficient basis for safety evaluation of the package. The information must include details, such as materials of construction, assembly of key components and their locations with other package features. For example:

Drawing No. 10004E58, Rev. 1, Sheet 1

- BOM Items 34, 82, 83, 85 - impact limiter cover/back plate sizes.
- BOM Items 48, 84 - impact limiter foam densities.

Drawing No. 10004E58, Rev. 1, Sheet 2

- Design features of the top and lower impact limiters, including dimensions and attachment details with respect to the Outerpack.
- Design features of Clamshell components, including the axial clamp assembly, reaction pad, and top and lower plates fastening details.
- Locations and associated construction features of the top stiffener flanges, bumpers, and outer shell pack bracing bars.
- The Outerpack “layout,” which provides general arrangement of package components, are illegible in that design features important to safety are hard to read. Design drawings for major package components, such as the Clamshell and upper and lower Outerpack shells, should be individually prepared with appropriate pointers to engineering details.

Drawing No. 10004E58, Rev. 1, Sheet 3

- Location, material specification, and installation features of rubber shock mounts.
- Design features of the Clamshell top door assembly, including engagement details between the lipped and the grooved plates.

Drawing No. 10004E58, Rev. 1, Sheet 4

- Shock mount-to-lower Outerpack attachment design features.

- Location, number, and design feature of the weld stud/nut (Items 53, 54) as fuel assembly restraints.

This information is being requested in accordance with the provisions of 10 CFR 71.33 which requires an application to include a description in sufficient detail to identify the package accurately and provide sufficient basis for evaluation of the package.

Westinghouse Response:

Changes were made to the License Drawings.

1-2 Clarify the statement provided in Section 1.2.1.2, first sentence of the second paragraph, "[a]t each end of the package are thick impact limiters consisting of two sections of foam at different densities sandwiched between three layers of sheet metal." Contrary to the SAR statement, Engineering Drawing No.10004E58, Rev. 1, indicates that the impact limiters are each made of single-block polyurethane foam at the density of 10 pcf and 6 pcf for the top and lower impact limiters, respectively.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

Second paragraph of Section 1.2.1.2 will be revised to read:

> The outerpack is comprised of independent impact limiters at the top end and lower end. Each end impact limiter is a system containing a pillow sub-assembly adjacent to 20 pcf polyurethane foam. The 20 pcf foam is encased by the package outerpack stainless steel skins. The top pillow sub-assembly consists of 6 pcf foam encased between two stainless steel plates to allow mating with the upper outerpack. A detail of the top pillow assembly is shown on 10004E58, sheet 6. The lower pillow assembly consists of 6 pcf foam encased in a stainless steel circular housing which allows mating with the lower outerpack. A detail of the lower pillow assembly is also shown on 10004E58, sheet 6.

1-3 Revise Section 1.2.1.4 to include a description of the placement of the rod box or rod container in the Traveller packaging. The current information is not clear as to how the rod box or rod container is retained in the packaging for transportation operation.

This information is being requested in accordance with the provisions of 10 CFR 71.33 which requires an application to include a description in sufficient detail to identify the package accurately and provide sufficient basis for evaluation of the package.

Westinghouse Response:

The following text has been added to Section 1.2.1.4:

> The fuel assembly, rod box and rod pipe are all held in place by the clamshell restraining devices. Axial restraint is provided by the axial clamp assembly shown on Sheet 7 of 8 of drawing 10004E58. The axial clamp arm is bolted into the top shear lip and the contact to the fuel

assembly, box or pipe is performed by an adjustable jack screw. Lateral and vertical restraint is accomplished through the use of removal rubber pads located inside the clamshell door lip in conjunction with the latch assemblies on the clamshell doors. The rubber pads are of varying thickness to accommodate the different fuel designs and loose rod shipping boxes/pipes. The maximum loaded weight of the pipe or box is 660 pounds.

1-4 Revise the applicable drawings to indicate the following information:

- The minimum effective ^{10}B areal density for the BORAL and borated aluminum neutron absorber plates. The values indicated in the notes appear to be incorrect.
- Remove reference to boron plate and replace with BORAL.
- Remove reference to the phrase “approved equivalent” and replace it with the welding code(s) that will be used to fabricate the package.

Guidance is provided in NUREG/CR-5502, Engineering Drawings for 10 CFR Part 71 Package Approvals.

This information is required in accordance with 10 CFR Part 71.33 which states that applications must include a description in sufficient detail to identify the package accurately and provide a sufficient basis for evaluation of the package.

Westinghouse Response:

Changes were made to the License Drawings.

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Chapter 2 Structural Evaluation

2-1 Page 2-1. Supplement the discussion provided in Section 2.1.1, first paragraph, to include justification for the bolt performance criteria. The current discussion states, "[p]ositive closure of the Outerpack is accomplished by means of high strength stainless bolts. ... [b]oth are below the bolt's ultimate strength." It is not clear from this information as to how the ultimate strength was considered when analyzing the closure function of the Outerpack.
This information is required in accordance with 10 CFR Part 71.33 which states that applications must include a description in sufficient detail to identify the package accurately and provide a sufficient basis for evaluation of the package.

Westinghouse Response:

The following text has been added to Section 2.1.1:

> The design loadings for both packages are below the ultimate design loads for the Outerpack bolts. The worst case forces for the package are presented in Section 2.12.3.2.2, Horizontal Side Drops, and a discussion regarding the design allowable is presented in Section 2.12.3.7, Evaluation, Analysis and Detailed Calculations, and Section 2.12.3.9, Bolt Factor of Safety Calculation. Further evidence of the adequacy of the Outerpack bolts is demonstrated through 9m drop testing whereby only one (1) Outerpack bolt failed in a total of nine (9) 9m drop tests. The single bolt that failed did so as a result of direct impact with the drop pad.

2-2 Clarify the apparent discrepancy related to the number of hex head bolts required to fasten together the top and bottom Outerpack halves. Item 1, Bill of Materials, Drawing No. 10004E58, Rev. 1, specifies 48 bolts, which is twice as many as that discussed in Section 2.1.1.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

The following text has been added to Section 2.1.1:

> There are 48 bolts ¾-inch bolts in the Outerpack, 24 attaching the hinge sections to the lower Outerpack and 24 attaching the upper Outerpack to the hinge sections. To remove the upper Outerpack, the 24 bolts must be removed. In the preferred approach, the Outerpack is opened when it is in a vertical orientation by removing the 12 bolts attaching the upper Outerpack to the hinges on one side. This allows the upper Outerpack to be opened on the other hinge sections, like a door.

2-3 Revise Section 2.6.5 to include an evaluation of vibration frequencies of the Clamshell-shock mount system to ensure that no resonant vibration conditions could occur yet result in damage to the Clamshell and its contents during normal conditions of transport.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.71(c)(5).

Westinghouse Response:

The following text and figure have been added to Section 2.6.5:

> There are several natural frequencies of the shock mount system depending on direction of movement. The dominant frequency is for vertical movement. This frequency is between 5.9 and 6.7 Hz (for Traveller XL) depending on the weight of the fuel assembly being transported. The fore and aft pitch frequency is slightly higher (6.9-7.9 Hz) but has a lower amplitude. Road tests have been performed with the suspension system to measure amplitudes during shipping. Figure 2-1A is characteristic of the results seen. When the truck travels over a bump, the clamshell initially sees relatively large accelerations (2-3 g's) but this oscillation quickly damps out to accelerations less than 1g. This 300 mi trip involved approximately five and a half hours on the road with 1.4×10^5 total cycles.

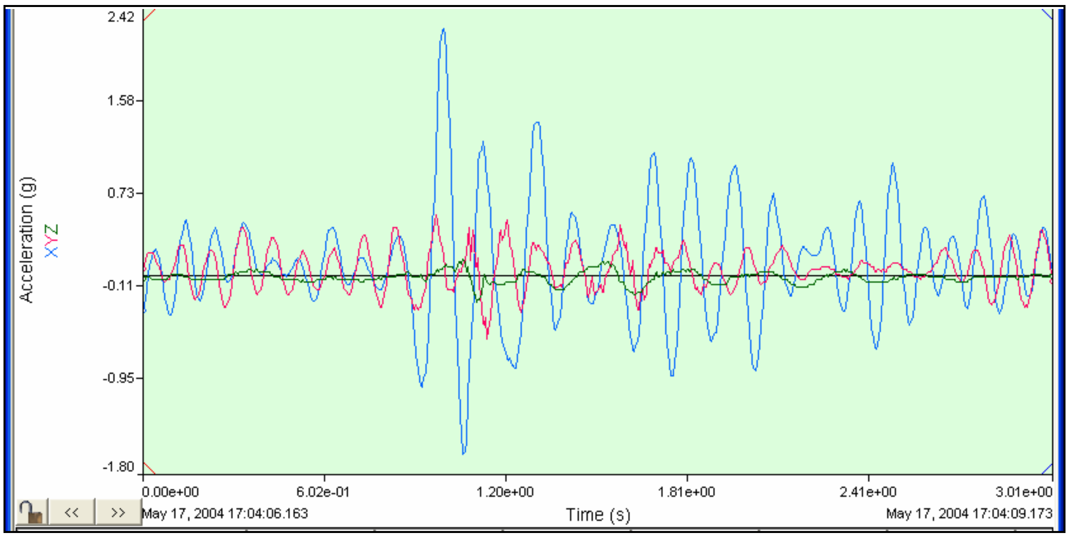

Figure 2-1A Sample of Clamshell Accelerations Measured During Road Test (May 11, 2004)

2-4 Provide design drawing details for the polyethylene moderator block, including the 26-gage stainless steel sheet covering and its attachment features to the Outerpack. Proper sheathing is noted as a means to prevent ignition of the polyethylene blocks during a fire accident (Table 2-5, Page 2-19). As such, design features of the polyethylene moderator blocks, including their attachment to the inner Outerpack, should be properly documented in the application.

This information is being requested in accordance with the provisions of 10 CFR 71.33 which requires an application to include a description in sufficient detail to identify the package accurately and provide sufficient basis for evaluation of the package.

Westinghouse Response:

The license drawing has been revised to show the requested details for the polyethylene moderator block and cover.

2-5 Provide drawing details for the design changes introduced to the Certification Test Unit drop tests to improve performance of the package, including welding of the impact limiter pillow to the Outerpack liner plate and modification of the quick release pin. Changes to the packaging features that are important to safety should properly be presented in design drawings (Table 2-5, Page 2-22).

This information is being requested in accordance with the provisions of 10 CFR 71.33 which requires an application to include a description in sufficient detail to identify the package accurately and provide sufficient basis for evaluation of the package.

Westinghouse Response:

The following text and figures have been added to Table 2-5:

> The figure below (Figure 2-1B) shows the impact limiter, or Pillow, assembly (shown without insulation). This assembly is shown installed in the Traveller package bottom (the configurations are the same for STD and XL packages) in Figure 2-1C. The weld between the bottom plate (yellow) and the puncture plate (red) is also shown. During testing this weld failed as expected, however, it did not completely allow the components to separate. This design change weakens the bottom plate by reducing its thickness to a nominal 0.025" thickness, as shown in Figures 2-1D and 2-1E. A .25 inch wide channel was added to weaken the part.

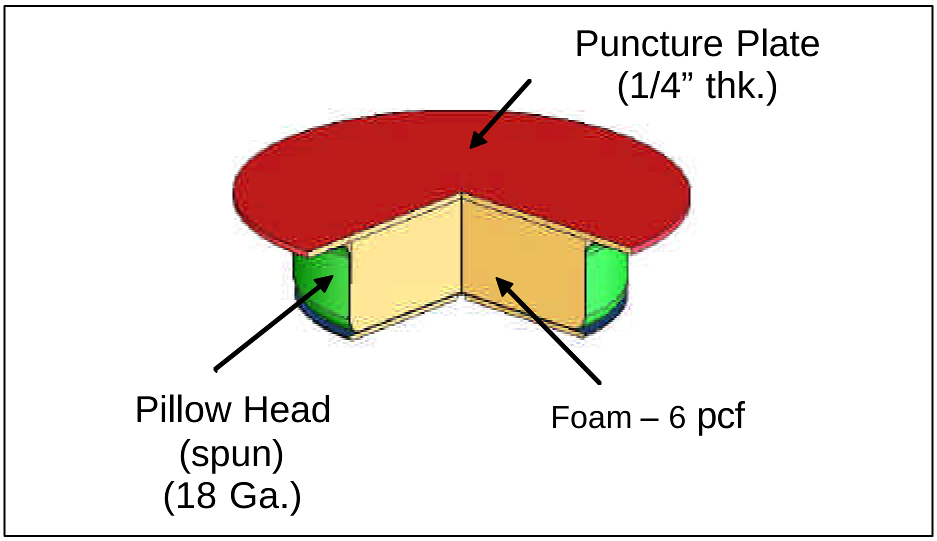

Figure 2-1B Impact Limiter "Pillow" Assembly

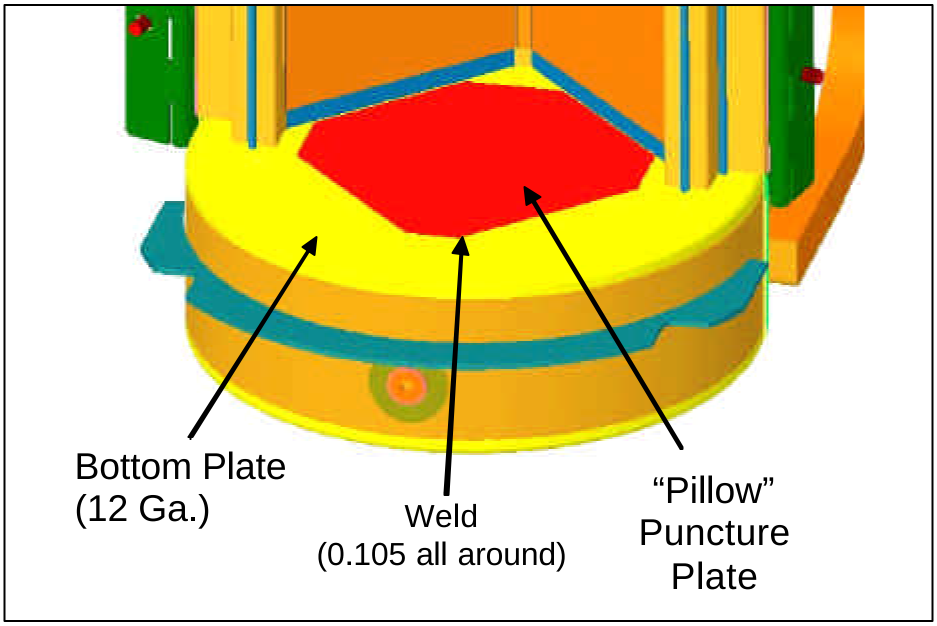

Figure 2-1C Container Bottom End

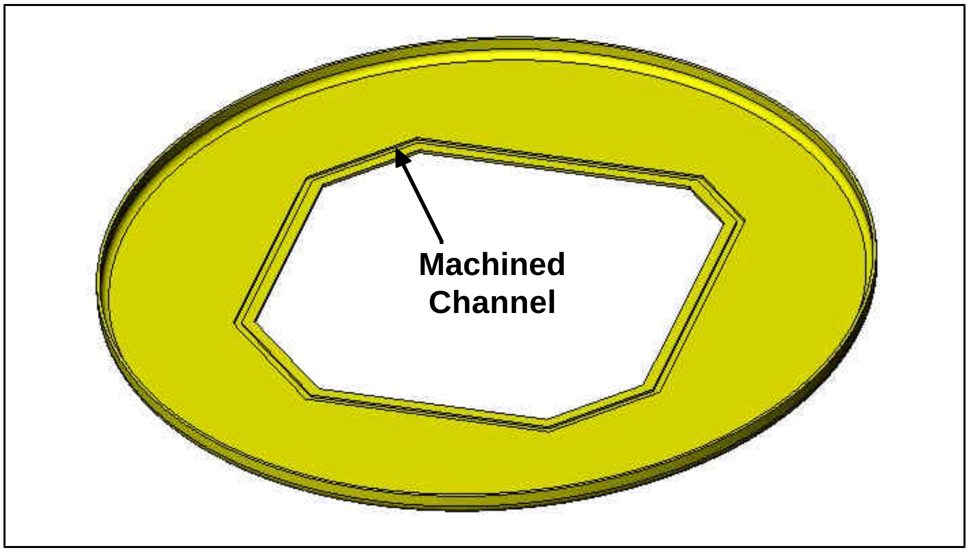

Figure 2-1D Bottom Plate (Viewed from Inside)

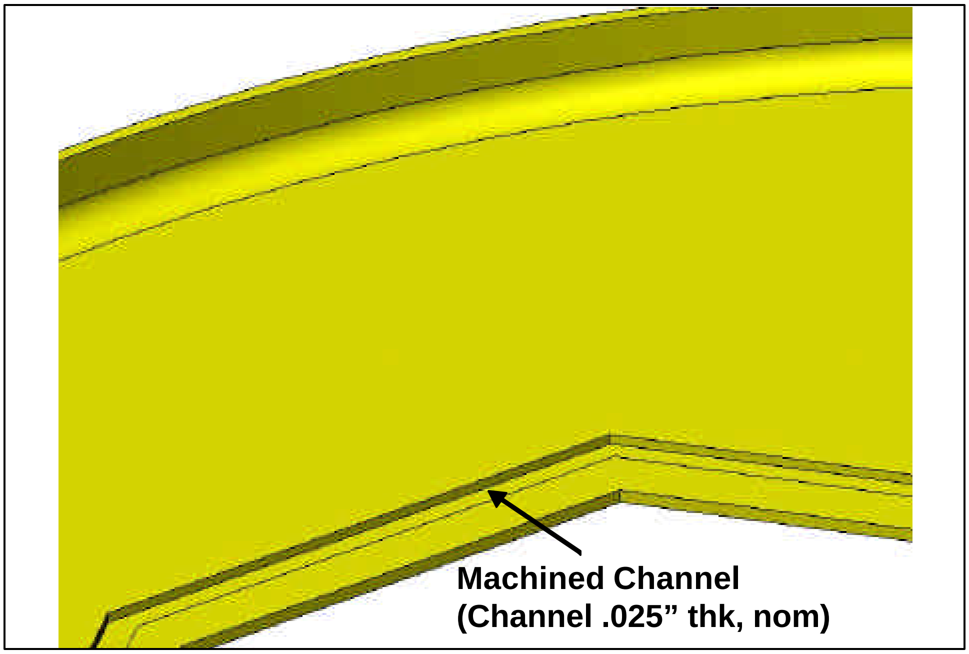

Figure 2-1E Bottom Plate – Viewed from Inside

The CTU design included a pinned connection (2 quick release pins – 0.5" diameter) between Outerpack halves at the bottom end of the package. Quick release pins were designed to help prevent the halves from warping and opening a gap locally during fire testing. Figure 2-1F shows the location of the quick release pins. During drop testing, the pins failed, therefore, they could not be used in the fire testing.

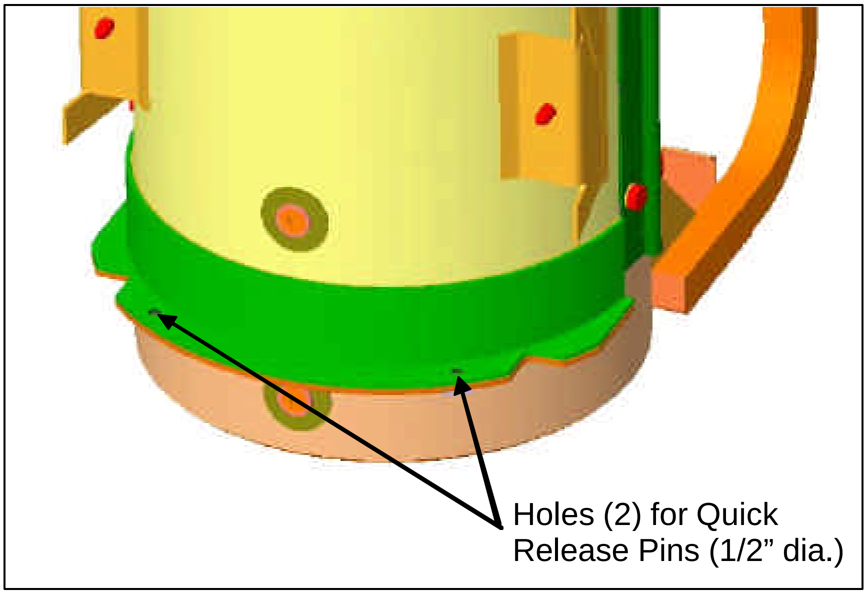

Figure 2-1F CTU Package Bottom End

2-6 Revise stress allowables, as appropriate in Table 2-8 for the structural entities other than lifting attachments and tie-down devices, , to ensure acceptable factors of safety against material yield strengths. Loadings on packaging components other than lifting attachments and tie-down devices are generally not factored up, as required by 10 CFR 71.45, by appropriate load multipliers. As such, contrary to those listed allowable yield stresses, only fractions of material yield strengths can be counted on in a working stress evaluation of structural performance margins.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.45.

Westinghouse Response:

The following text has been added to Section 2.12.2.1:

> The results of the design calculations (where applicable), acceptance criteria, and conditional acceptance are shown in Table 2-8. Based on the results in Table 2-8, the Traveller package is shown to be compliant to mechanical requirements described in 10 CFR 71 and TS-R-1. Where the design features of the Traveller eliminate design concerns (i.e., package tie-downs, internal pressure, etc.) detained stress calculations were not performed.

Table 2-8 has been revised.

2-7 Provide drawing details for the swing bolt block, as identified in Figure 2-9, used for the alternative lifting configuration. The swing bolt block depicted in Figure 2-9 lacks sufficient detail to enable proper evaluation of its structural capacity.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.35.

Westinghouse Response:

Figure 2-9 has been revised as follows:

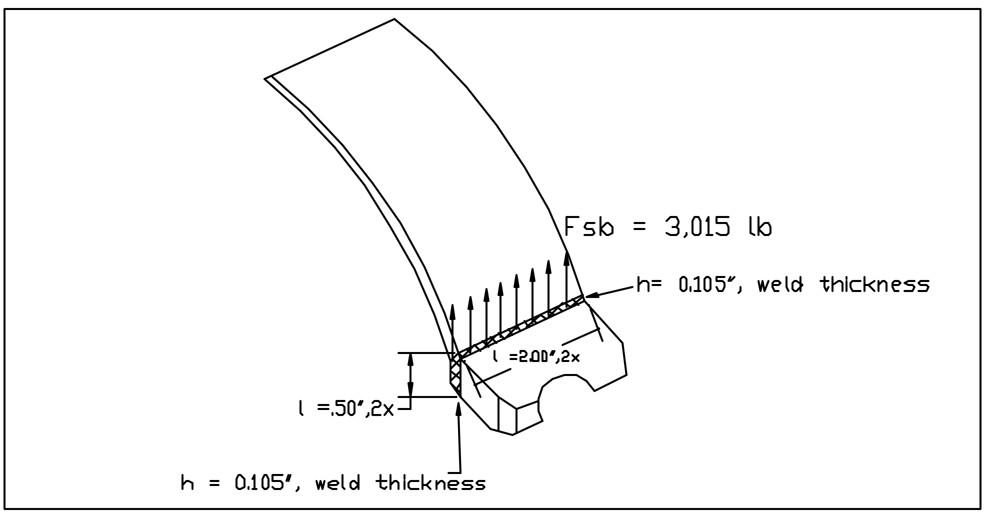

Figure 2-9 Weld Geometry at Swing Bolt Block

2-8 Clarify the apparent discrepancy of polyurethane foam densities between those stated in Section 2.12.2.2.4, "[t]he material of construction of the Traveller Outerpack include...and low density, closed cell polyurethane impact limiter/thermal insulator (10 pcf along the axis as well as 7 and 20 pcf at the end caps)," and those stated in Items 24 and 57, Drawing No. 10004E58, which specify the 20 pcf polyurethane foam for the end caps.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

Section 2.12.2.2.4 has been revised to read as follows:

2.12.2.2.4 Design Temperature Analysis –40°F (-40°C) and 158°F (70°C)

The materials of construction of the Traveller Outerpack include ASTM A240 Type 304 Stainless Steel for the shells and low density, closed cell polyurethane impact limiter/thermal insulator (10 pcf along the axis, 6 pcf inside the top and lower pillows, and 20 pcf between the top and lower pillows). The Clamshell is comprised of ASTM B209/B221 Type 6005-T5 Aluminum. As demonstrated in the below sections, the package is suitable for transport operations over the required design temperature range.

2-9 Provide drawing details for the polyethylene panels installation plan, including dimensions of individual panels and location of bolting studs, to ensure that thermally induced interference stresses or gap expansions are within acceptable limits. The discussion on Differential Thermal Expansion, page 2-56, lacks sufficient design details for evaluating effects of differential thermal expansion on the structural performance of the polyethylene moderator panels which are important to criticality safety.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.33.

Westinghouse Response:

The following text has been added to Section 2.12.2.2.4:

The polyethylene moderator blocks are attached by 0.375 inch diameter weld studs on the inner skin of the on the Outerpack. The weld studs penetrate the moderator blocks through 0.563 inch diameter holes). The blocks are mounted with a nominal gap, block to block, of 0.260 inches. The coefficients of thermal expansions are:

- 304 stainless steel 9.6 µ in/in-F
- UHMW polyethylene 72 – 111 µ in/in-F

Using the worst difference in expansion coefficients, 100 µ in/in-F, the gaps between the blocks will accommodate heat up from 70° to 167°F. In addition, there is an additional 0.094 inch of clearance between the weld studs and each side of the holes in the polyethylene that will allow blocks with less than nominal clearance to slide in a direction to provide uniform clearance along the length of the Traveller.

Because the polyethylene's coefficient of expansion is much greater than stainless steel, interference between moderator blocks is not an issue when temperature drops. Instead, it is the interference between the blocks and the weld studs. Based on nominal clearances and a maximum distance of 17.0 inches from outboard hole-to-outboard hole, the package temperature can drop from 70°F to -41°F before the polyethylene is stressed. Most of the moderator blocks have significantly smaller distances between the outboard holes (6.5 to 12.5 inches) allowing them to accommodate larger temperature changes.
See Licensing drawings for additional details.

2-10 Revise Section 2.12.3, to include illustrations in sufficient detail for the finite element analysis (FEA) models of individual package parts and their interfaces. Also, revise the application to include descriptions of modeling parameters, such as element types, material types and associated state equations, and boundary conditions from which the calculated drop accident responses can be properly evaluated.

The color "solid model" representations of the package parts have not lent themselves to sufficient description of modeling parameters.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.73.

Westinghouse Response:

Two new sections, Sections 2.12.3.5.4 and 2.12.3.5.5 have been added and the title for Section 2.12.3.6 has been corrected as follows:

2.12.3.5.4 Qualification Unit – Outerpack Model Details

The FE model of the outerpack is shown in Figures 2-100 through 2-101A. Key features of the outerpack include the combination circumferential stiffeners/legs, the forklift pockets, the upper and lower outerpack halves, the hinges/latches on the sides, the stacking brackets, and the circumferential stiffeners on the upper outerpack. These features were included in the FE model as described below.

The circumferential stiffeners/legs and forklift pockets (Figure 2-100A) were modeled using 4-node Belytschko-Tsay shell elements (LS-DYNA elform = 2). These elements were integrated at three locations through the thickness using Gaussian quadrature. 1,008 of these elements were used to model the forklift pockets and 4,436 were used modeling the legs.

Both the circumferential stiffeners/legs and forklift pockets are welded to the lower overpack outer casing. In the model, these parts were attached to one another using a penalty based tied contact algorithm (LS-DYNA's TIED_NODES_TO_SURFACE_OFFSET contact algorithm).

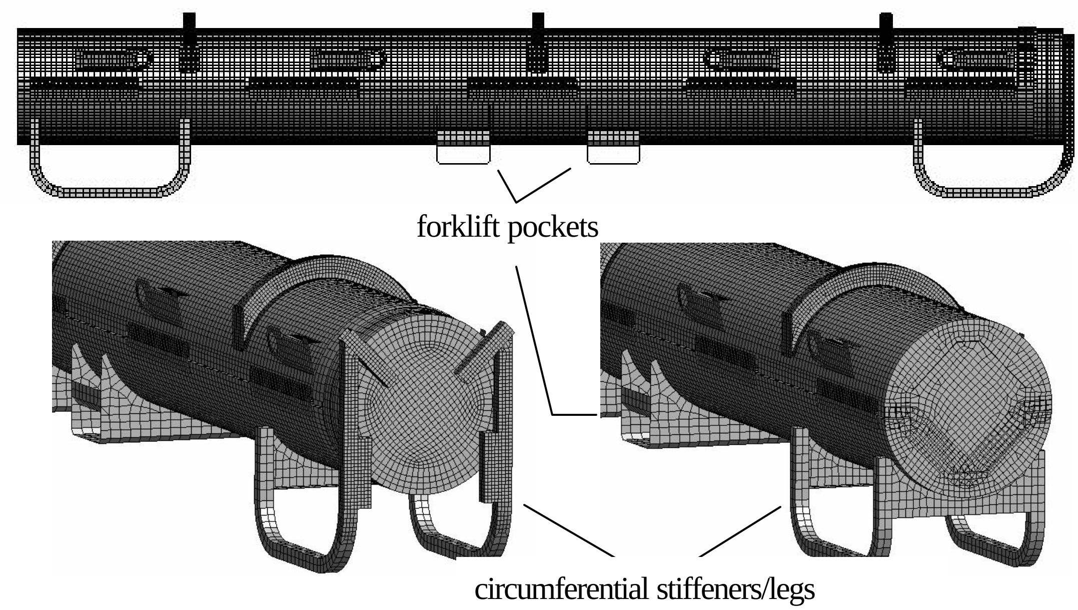

Figure 2-100 Outerpack Mesh in Qualification Unit Model

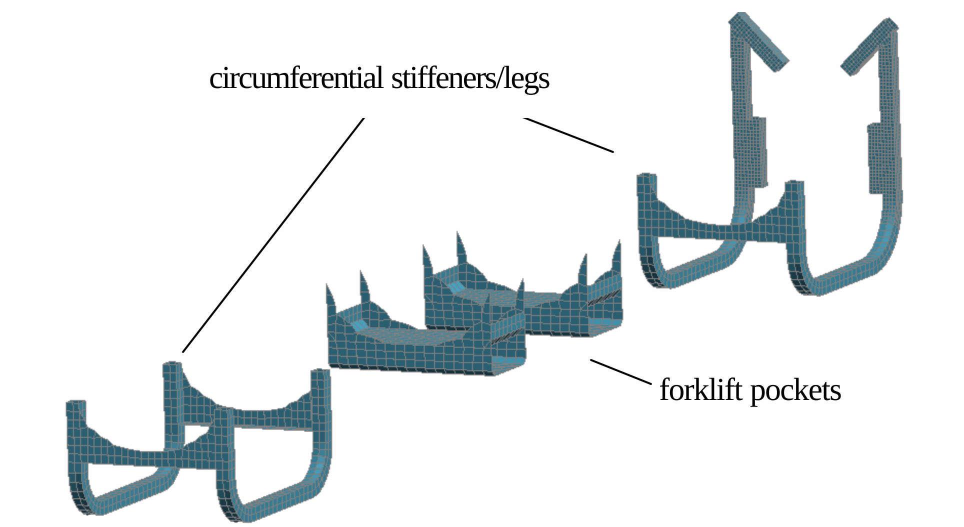

Figure 2-100A FE Meshes of Outerpack Legs and Forklift Pockets

The FE model of the QTU lower outerpack is depicted in Figures 2-100B and 2-100C. In addition to the previously mentioned circumferential stiffeners/legs, the lower outerpack is comprised of a long thick-walled "half-barrel" body and an impact limiter attached to one end (Figure 2-100A). The "half barrel" body is a sandwich construct of 10 pcf foam encased in 0.105 inch thick 304 stainless steel (Figure 2-100C). The outer steel casing was modeled using the same element formulation and integration scheme used for the circumferential stiffeners/legs. 19,516 elements were required. The 10 pcf foam was modeled using 8 node selectively reduced fully integrated solid elements (LS-DYNA elform = 2) in conjunction with a material formulation developed especially for crushable foam (LS-DYNA material type = 63). Modeling the 10 pcf foam in the lower outerpack required 36,617 elements. Since this foam was poured-in-place, it is adhered to the stainless steel casing. This was modeled by enforcing tied contact between the outer nodes of the foam and the casing. The moderator blocks in the lower outerpack were modeled using 26,368 constant stress solid elements (LS-DYNA elform =1). Linear elastic material properties were used. The moderator blocks were attached to the lower outerpack using four bolts each for the full length moderator sections and two bolts each for the half-length moderator sections at the ends. These bolts were modeled using beam elements (LS-DYNA elform = 9) with a "spot weld" material formulation (LS-DYNA material type = 100.) Contacts between the moderator blocks, the lower outerpack, and the clamshell were defined using a penalty-based contact algorithm that accounts for shell thicknesses and for self contact as well as contact between different parts (LS-DYNA's AUTOMATIC_SINGLE_SURFACE contact algorithm). Contact stiffness was found by dividing the nodal mass by the square of the time step size with a scale factor to ensure stability (LS-DYNA's SOFT=1 contact option.) This approach was used because the foam has stiffness that is one or more orders of magnitude less than the metal parts. (Contact would possibly have broken down with other approaches that basically use the minimum stiffness of the two contact surfaces.)

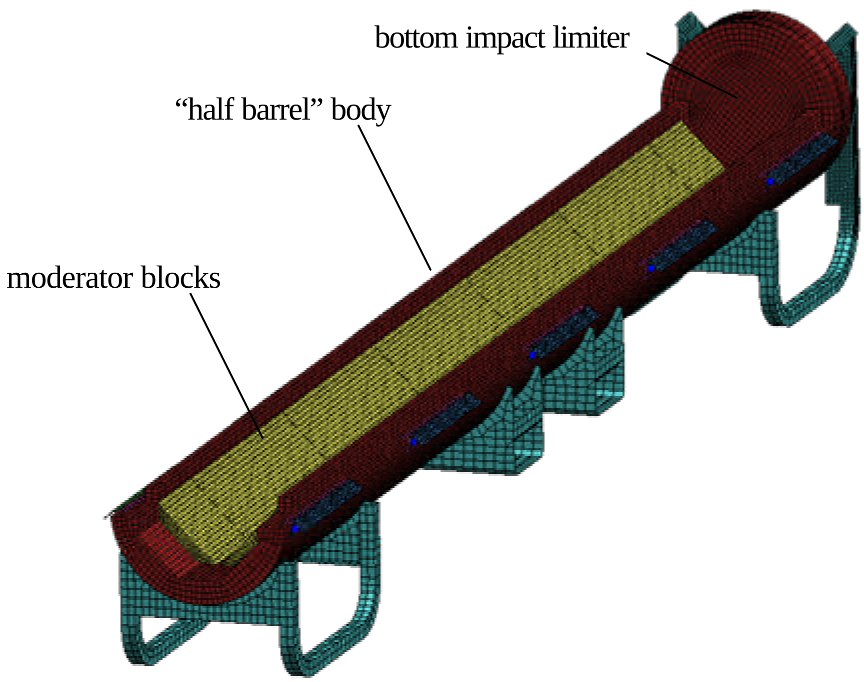

Figure 2-100B Lower Outerpack Mesh for Qualification Unit Model

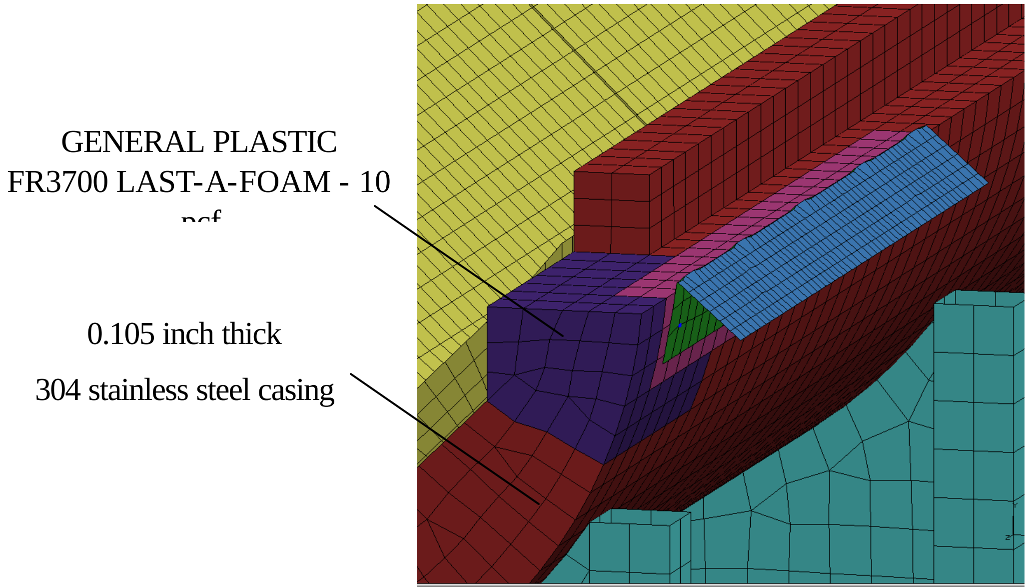

Figure 2-100C Qualification Unit Model Mesh Detail

The FE model of the QTU upper outerpack is depicted in Figure 2-100D. It primarily consists of a long thick-walled “half-barrel” body and an impact limiter attached to one end (Figure 2-100D). The “half barrel” body is a sandwich construct of 10 pcf foam encased in 0.105 inch thick 304 stainless steel. The outer steel casing was modeled using the same element formulation and integration scheme used for the circumferential stiffeners/legs and lower outerpack casing. 18,634 elements were required. The 10 pcf foam was modeled using 8 node selectively reduced fully integrated solid elements (LS-DYNA elform = 2) in conjunction with a material formulation developed especially for crushable foam (LS-DYNA material type = 63). Modeling the 10 pcf foam in the lower outerpack required 36,094 elements. Since this foam was poured-in-place, it is adhered to the stainless steel casing. This was modeled by enforcing tied contact between the outer nodes of the foam and the casing. The moderator blocks in the upper outerpack were modeled using 26,368 constant stress solid elements (LS-DYNA elform = 1). Linear elastic material properties were used. The moderator blocks were attached to the upper outerpack using four bolts each for the full length moderator sections and two bolts each for the half-length moderator sections at the ends. These bolts were modeled using beam elements (LS-DYNA elform = 9) with a “spot weld” material formulation (LS-DYNA material type = 100). Contacts between the moderator blocks, the upper outerpack, and the clamshell were defined using a penalty-based contact algorithm as described for the lower outerpack.

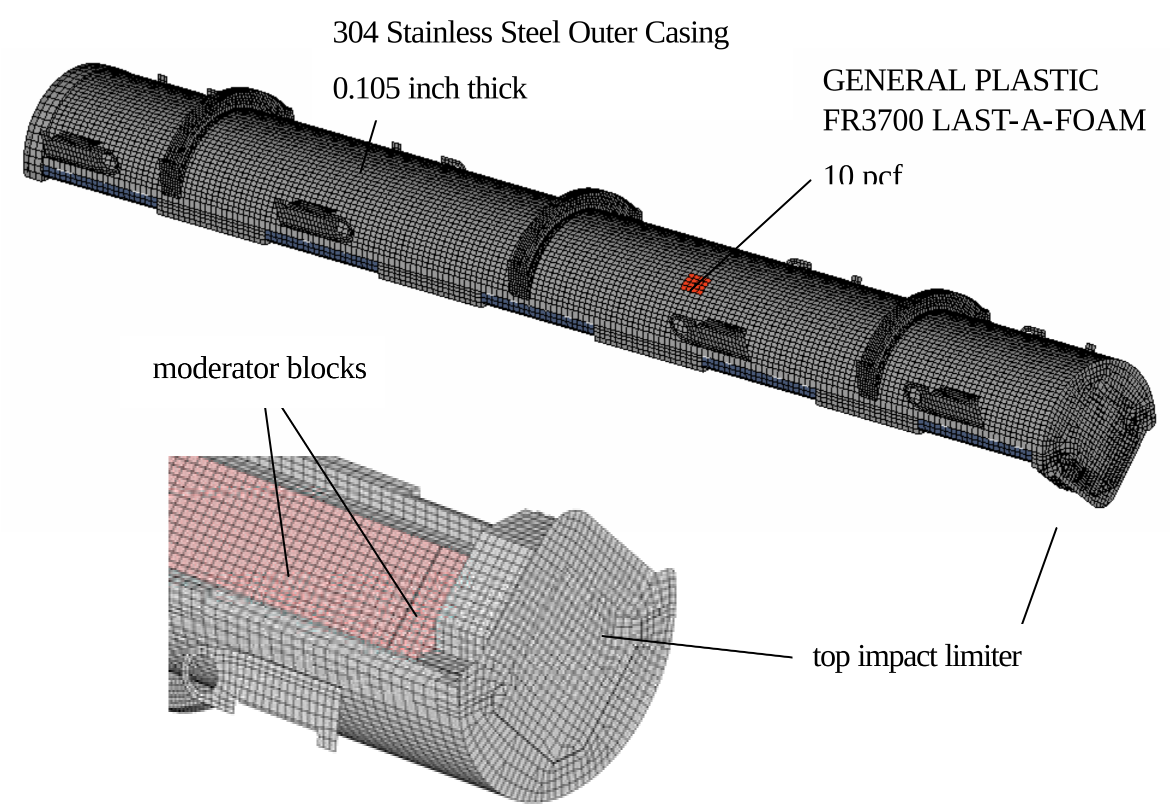

Figure 2-100D Upper Outerpack Mesh for Qualification Unit Model

Model details of the impact limiters are shown in Figure 2-101. Both consisted of two separate foam pieces: a 7 pcf foam block was placed inboard nearest the clamshell and 14 pcf foam covered both ends of the overpacks. These foam pieces were separated and covered by stainless steel. The foams were modeled using the same element formulation and material model as described for the 10 pcf foam in the overpack “barrels” except that each foam density had its own stress-strain curve. The 7 pcf foam in the bottom impact limiter was modeled with 2112 solid elements; the 14 pcf foam was modeled with 4480. The 7 pcf foam in the top impact limiter was modeled with 5248 elements; the 14 pcf foam was modeled with 1755 elements. Because these foams were “cut-to-fit,” they were not bonded to the steel cases. Thus, contact between the steel casings and the foam was defined using LS-DYNA’s AUTOMATIC_SINGLE_SURFACE contact algorithm as previously described (for contact between the lower outerpack, moderator blocks and clamshell).

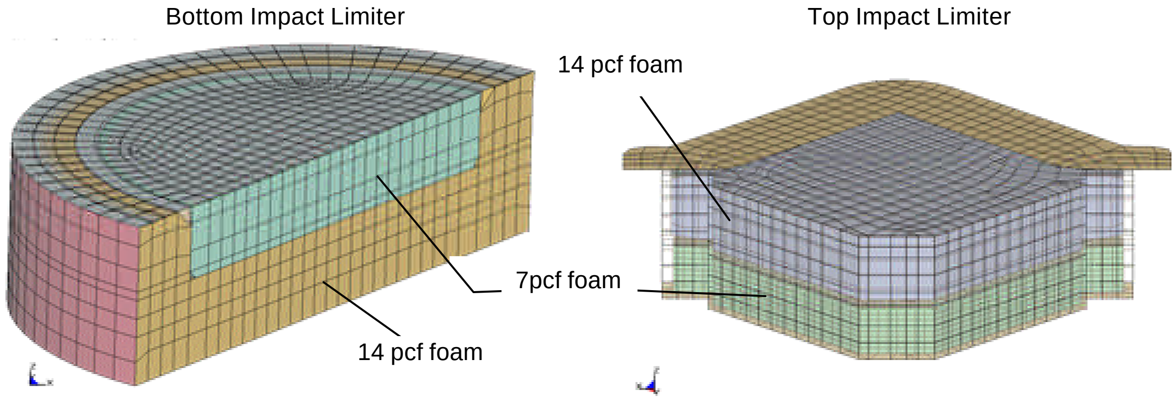

Figure 2-101 Impact Limiter Meshes in Qualification Unit Model

The stacking brackets and circumferential stiffeners on the upper overpack (Figure 2-100D) were modeled using the same element formulation and integration scheme used for the circumferential stiffeners/legs and outerpack casings. 4,404 of these elements were used to model the stiffeners and 1,376 were used modeling the stacking brackets. Both the stiffeners and brackets were secured to the upper outerpack casing using a tied contact algorithm as described for the circumferential stiffeners/forklift pockets and lower overpack casing.

The bolts which secure the outerpack hinges/latches are all that prevent the upper and lower outerpacks from separating upon impact. This was simulated in the model by replication of each physical part of the hinge/latch assemblies. In particular, hinge/latch assemblies including mounting blocks, hinge leaves, and the bolts were modeled (see Figure 2-98 and associated description in Section 2.12.3.5). These assemblies were attached to the upper and lower overpacks via tied (penalty-based) constraints. This methodology permitted relative rotations between the upper and lower outerpacks along the axes of the hinges/latches while resisting any relative translations. Thus, the model forced the overpack latch bolts to prevent the displacement shown in Figure 2-101A. This allowed predicted deformations at the outerpack seam to be realistic (e.g., Figures 2-30B and 2-74.)

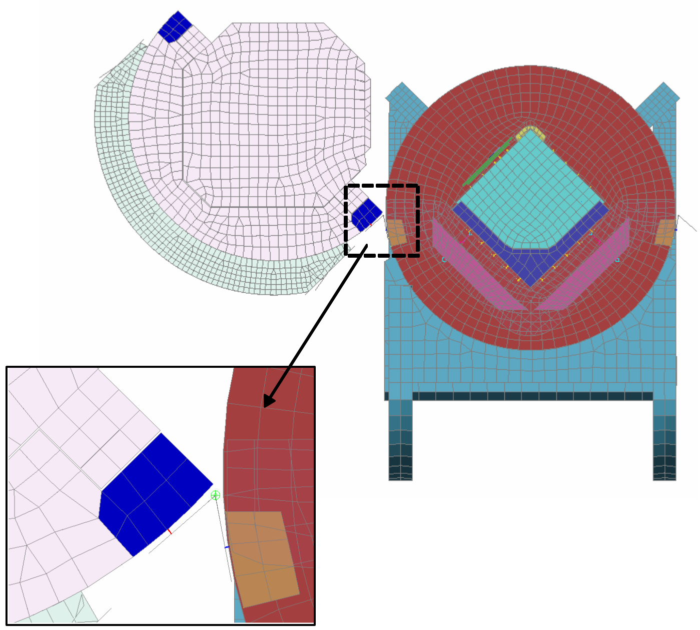

Figure 2-101A Hinge/Latch Feature in Qualification Unit Model

2.12.3.5.5 Qualification Unit – Clamshell Model Details

The FE model of the clamshell is shown in Figures 2-102 through 2-102C. Key features of the clamshell include: the clamshell top assembly, the V-shaped extrusion, the two doors including the hinges, middle latch and locks, and the bottom plate. These features were included in the FE model as described below.

The clamshell top assembly has two major features. First it can swivel from either side to allow access to the top portion of the fuel assembly. This is shown in Figure 2-102A where the CS head is swiveling about its right side. This feature was built into the FE model using the LS-DYNA revolute joint elements. (This is very similar to what was done for the overpack hinges/latches.)

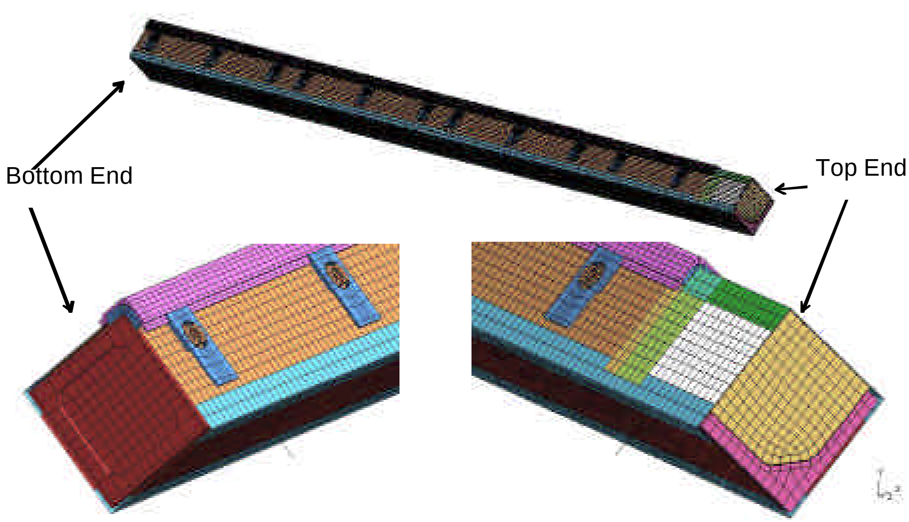

Figure 2-102 Clamshell Mesh in Qualification Unit Model

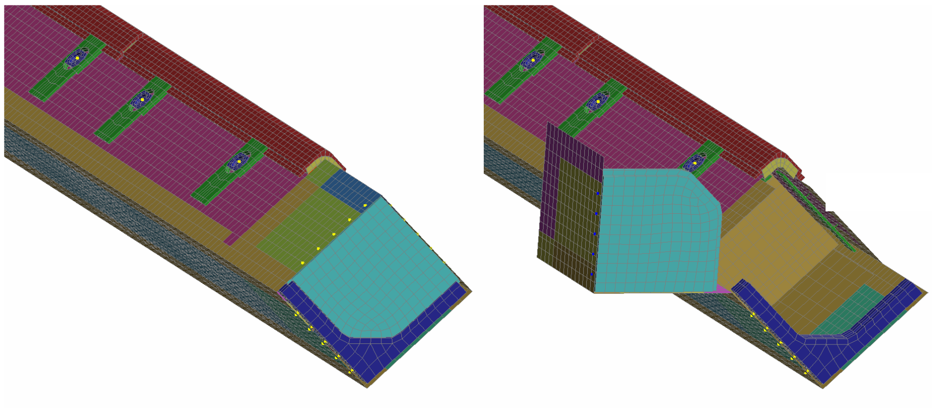

Figure 2-102A Clamshell Top Head in Qualification Unit Model

The second major feature was the top nozzle hold-down bars as shown in Figure 2-102B. Although this hardware has length adjustments to accommodate different fuel assembly heights, the hold-down bar was modeled for the height of an XL fuel assembly. If other fuels were to be modeled, the hold-down bars would need to be scaled in the z-direction. The hold-down bars were modeled with 8 node solid elements and contact between the top nozzle and other fuel and clamshell parts in the near vicinity was defined using LS-DYNA's AUTOMATIC_SINGLE_SURFACE contact algorithm.

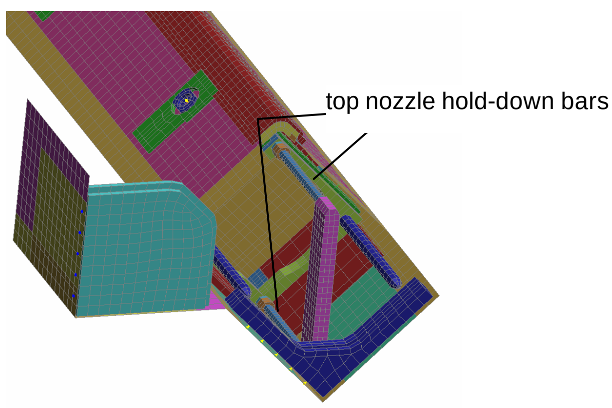

Figure 2-102B Clamshell Top Nozzle Hold-down Bars in Qualification Unit Model

The model of the clamshell latch and hinges allow the doors to rotate about the hinge centerlines as depicted in Figure 2-102C. These features were added using the LS-DYNA revolute joint element as already described.

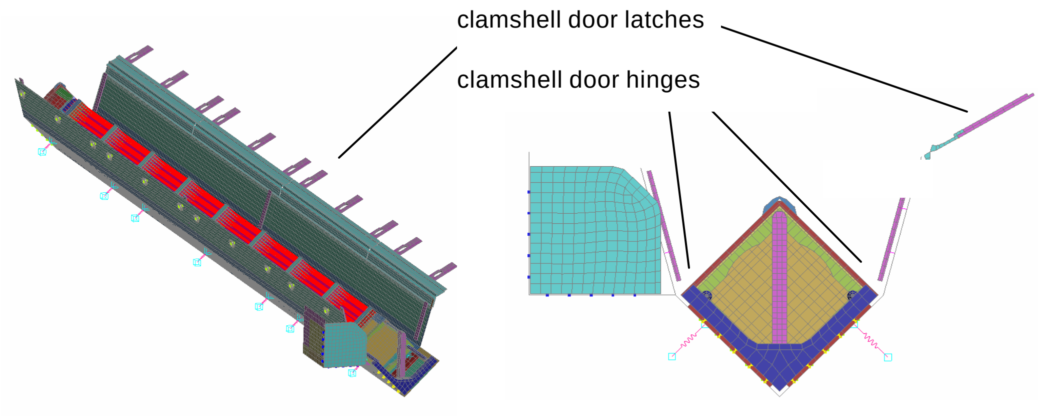

Figure 2-102C Clamshell Hinges and Latches in Qualification Unit Model

2.12.3.6 Model Input

2-11 Provide a description of the attributes of and corresponding assumptions for the finite element models for the lipped/grooved interfaces between the Clamshell end plates themselves, at the top end, and between the Clamshell doors and the plate at the bottom end. The application (pages 2-75, 2-84, 2-96) notes that the Clamshell cross-sectional shape is predicted to stay essentially unchanged during the horizontal drops. Because the predicted deformation of the interlocked end joints will depend primarily on the assumptions made for the finite element model, sufficient modeling details, including gap size, and contact stiffness, if any, must be presented for evaluating the analysis results.

This information is being requested in accordance with the provisions of 10 CFR 71.33 which requires an application to include a description in sufficient detail to identify the package accurately and provide sufficient basis for evaluation of the package.

Westinghouse Response:

No changes required to the SAR. The following is provided for clarification:

The lipped/grooved interface between the clamshell top end plates is shown in Figure 2-11.1 and the interface between the bottom clamshell plate and doors is shown in Figure 2-11.2.

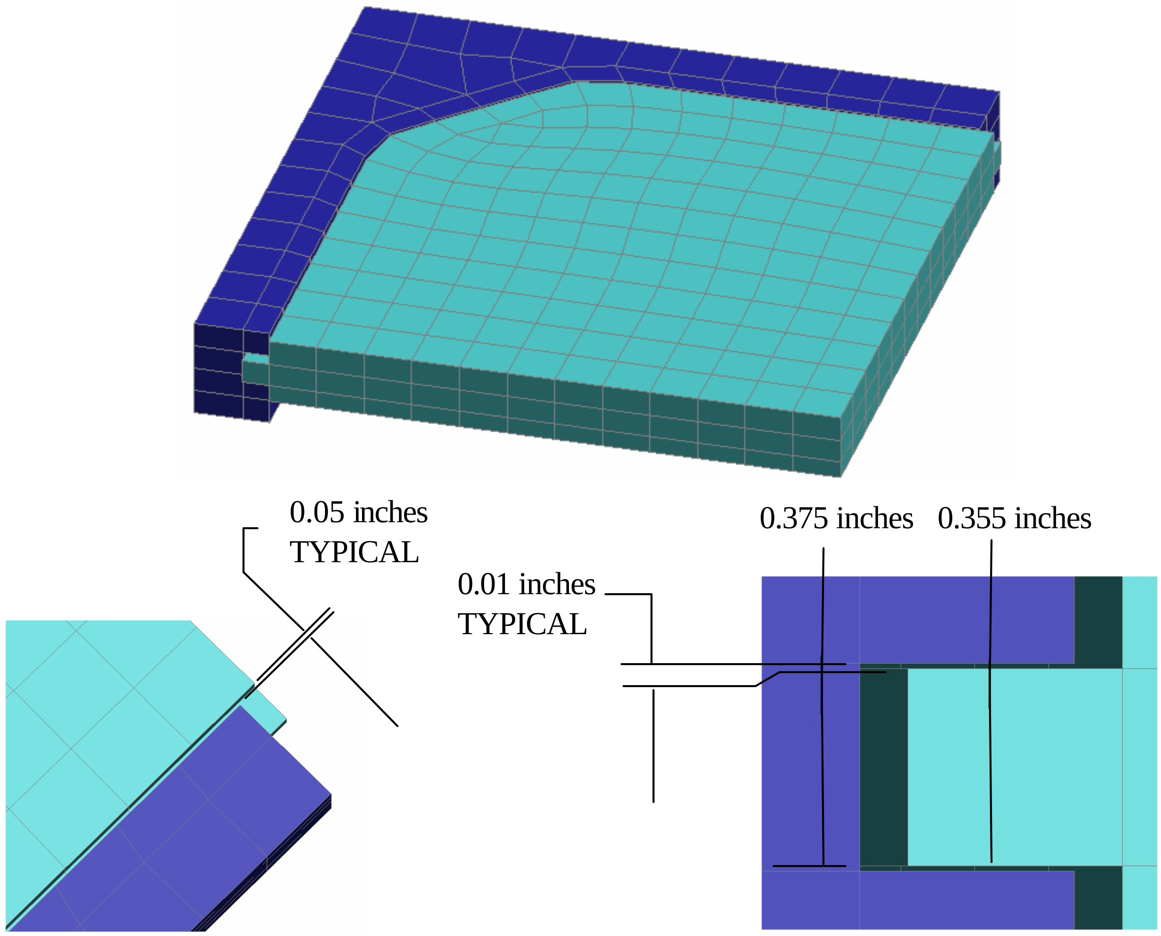

Figure 2-11.1 Clamshell Top Plates

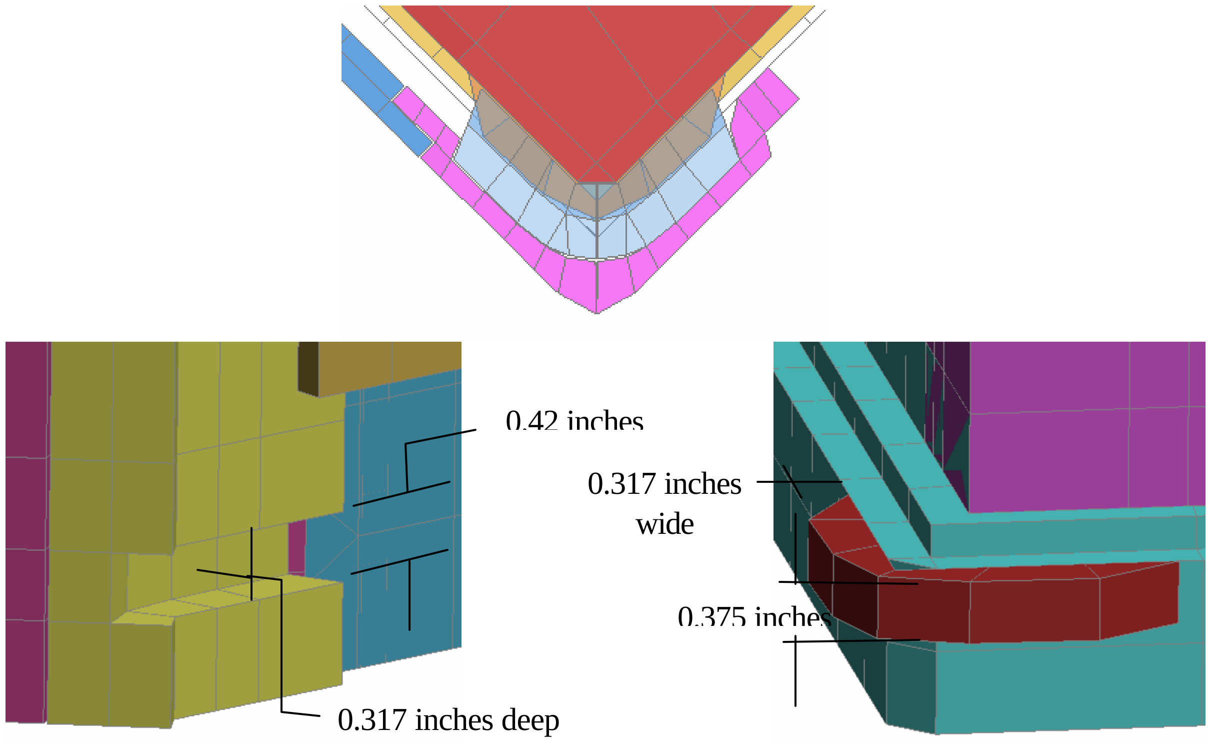

Figure 2-11.2 Clamshell Bottom Plate

For the top plates, the 0.355 inch thick lip is positioned within a 0.375 inch thick groove, leaving an axial clearance on either side of approximately 0.010 inches. The clearance in the plane of the plates is 0.050 inches. The axial clearance between the lip on the bottom plate and the groove in the latch is 0.0225 inches on both sides (0.42 – 0.375 inches). In the plane of these plates, there is line to line contact since locking the clamshell door involves rotating the latch until the vertical wall in the latch groove contacts the vertical side of the lip extending from the clamshell bottom plate. Contacts were defined using a penalty-based contact algorithm; contact stiffness was found by dividing the nodal mass by the square of the time step size with a scale factor to ensure stability (LS-DYNA's SOFT=1 contact option). Although there is only metal contacting metal in these two situations, this approach was used because the foam has stiffness that is one or more orders of magnitude less than the metal parts. Further, the stiffness of these parts is of similar magnitude and it is most likely the SOFT=1 option did not influence the contact stiffness determined for these parts.

Finally, it should be noted that the proximity of the clamshell walls to the moderator blocks helps the clamshell maintain its cross-sectional shape during the horizontal drops. This is shown in Figures 2-40 and 2-42.

2-12 Provide a discussion, with respect to Figure 2-47, explaining the process of implementing a puncture drop analysis with the puncture pin hitting the Outerpack top that was damaged in a previous finite element simulation analysis of an angled drop onto the top nozzle end of the package.

It is not clear from the information provided how the damaged and, thus, deformed packaging finite element model from the drop test was reinitiated in a follow-up puncture drop analysis.

10 CFR 71.73(c)(3) requires that the puncture test be performed on the specimen that has undergone free drop tests, in a position to cause maximum damage to the package.

<u>Westinghouse Response</u>:

The damage incurred in the 9 meter angled drop preceding the pin puncture drop was included in the puncture analysis. The methodology was to use the predicted final package shape and stresses for the 9 meter angled drop as the initial shape and stress state of the package undergoing a pin puncture test. Indeed, Figure 2-47 shows the package as it is *initially* contacting the pin. None of the deformation in Figure 2-47 is from the pin puncture test. Rather, the deformation shown is from the preceding 9 meter angled drop (corresponding to Figure 2-45). The methodology for including the deformation and stresses from the preceding 9 meter test involved defining the nodal coordinates in the pin puncture model as the deformed nodal positions of the previous analysis plus a rigid-body-rotation to locate the "model with previous damage" to the proper position/orientation for the pin puncture test. The element stresses were extracted from the first analysis and included as initial stresses in the second analysis.

The following text has been added to Section 2.12.3.2.3:

> The FEA of the pin drop incorporated package deformations and stresses calculated to result from the 9m drop. The methodology for including the deformation and stresses involved defining the nodal coordinates in the pin puncture model as the deformed nodal positions of the previous analysis plus a rigid-body-rotation to locate the "model with previous damage" to the proper position/orientation for the pin puncture test. The element stresses were extracted from the first analysis and included as initial stresses in the second analysis.

2-13 Provide a discussion clarifying the apparent discrepancy between the statement on page 2-98, "...the fuel rod and associated fuel assembly structures, except for the top and bottom nozzles, were converted into a rigid part...[t]his prevented the fuel rods from buckling...," and Figure 2-83 where fuel rods are shown buckled. It is not clear from the information provided how the rigid fuel assembly were modeled to allow fuel rod to buckle, which is only characteristic of the deformable fuel rods.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.35.

<u>Westinghouse Response</u>:

No changes required to the SAR. The following is provided for clarification:

The fuel rods were NOT modeled to allow fuel rod buckling. However, the emphasis of this analysis was not on whether the fuel rods would or would not buckle. Rather, the model was used to determine the worst case drop orientations for the fuel assembly and for the package. As discussed in Section 2.12.3.2.4, the most damaging orientation for the fuel assembly was ascertained from which one imparted the highest accelerations to the fuel rods. Indeed, we concluded the vertical drop onto the bottom end of the package was the worst orientation for the fuel assembly because it subjects the fuel assembly (as a rigid body) to a predicted maximum acceleration of 126 g's (Figure 2-57.) This was the highest predicted fuel assembly acceleration for any drop orientation.

It should be noted that although the fuel rods and guide thimbles were held rigid, the fuel assembly end fittings (the top and bottom nozzles) were deformable as was the top nozzle hold-down fixture. This is evident in Figures 2-58 through 2-61.

2-14 Correct the following apparent underscored typographical errors, as appropriate:

- Page 2-99, third line from the bottom of the page: "Figure 2-50"
- Page 2-103, fourth line from the top of the page: "Figure 2-41"
- Page 2-104, twelfth line from the bottom of the page: "Figure 2-64"
- Page 2-104,. ninth line from the bottom of the page: "Figure 2-82"
- Page 2-104,. third line from the bottom of the page: "Figure 2-83"
- Page 2-106, third line from the top of the page: "Figure 2-44"
- Page 2-159, Table 2-32, Item 2.1: "1.2-m NAC drop"
- Page 2-177, Figure 2-135: "Test 2.3"
- Page 2-177, Figure 2-135: "Test 2.4"

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

The following typographical errors have been corrected:

- Page 2-99, third line from the bottom of the page: "Figure 2-49"
- Page 2-103, fourth line from the top of the page: "Figure 2-61"
- Page 2-104, twelfth line from the bottom of the page: "Figure 2-44"
- Page 2-104,. ninth line from the bottom of the page: "Figure 2-62"
- Page 2-104,. third line from the bottom of the page: "Figure 2-63"
- Page 2-106, third line from the top of the page: "Figure 2-64"
- Page 2-159, Table 2-32, Item 2.1: "1.2-m NAC drop" (No correction needed) (Added reference for Table 2-32 to page 2-158)
- Page 2-177, Figure 2-135: "Test 2.3" (Replaced Figure 2-135)
- Page 2-177, Figure 2-135: "Test 2.4" (Replaced Figure 2-135)

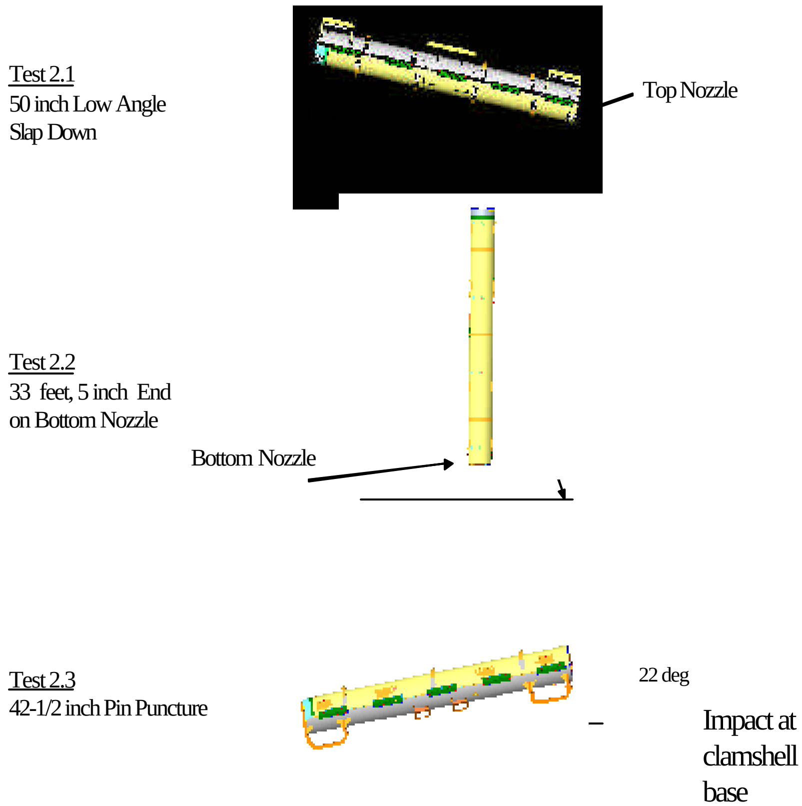

Figure 2-135 QTU Test Series 2 Drop Orientations

2-15 Provide a description of relevant model attributes, including use of sketches, to clarify the statement made on page 2-102, "[t]he vertical load developed by shock mounts is negligible and was ignored." It is not clear from the information provided how the Clamshell loads and accelerations are defined with respect to the Clamshell shock mounts layout.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.35.

Westinghouse Response:

Statement was removed from the SAR on page 2-101. The following is provided for clarification:

The quoted statement in the SAR is incorrect on two counts. First, the loads exerted on the clamshell by the shock mounts are not negligible. Secondly, they were not neglected. Rather the clamshell accelerations stated for the vertical drops 605 and 843 kN (Section 2.12.3.2.5 and Figure 2-57) loads are actually lower due to the loads exerted on the clamshell by the shock mounts. This is explained below.

The clamshell is supported in the lower overpack by 14 shock mounts positioned between the inner shell of the lower overpack and the "V" extrusion of the clamshell as shown in Figures 2-15.1 and 2-15.2. The stiffness of the shock mounts was modeled with elastic spring elements. The mass of the shock mounts was included by lumping ½ of the shock mount mass to each end of these discrete spring elements. The spring nodes were tied to the inner shell of the lower overpack and to the clamshell "V" extrusion using a penalty-based contact algorithm (LS-DYNA's tied nodes to surface contact option.)

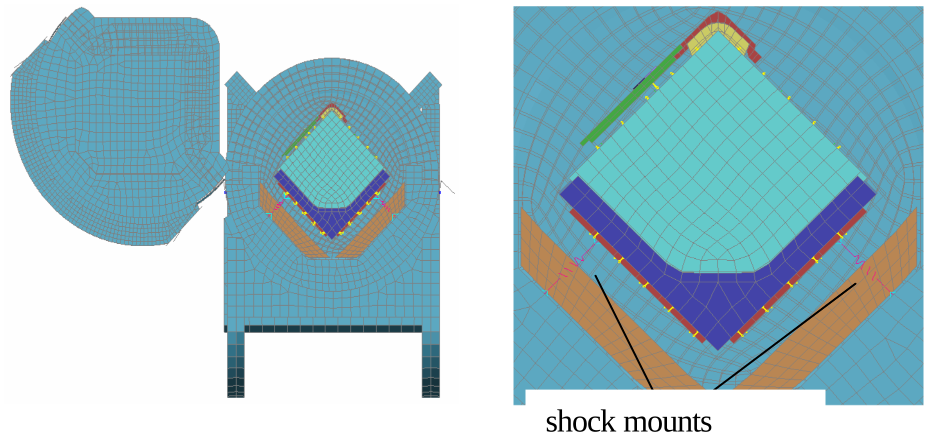

Figure 2-15.1 Shock Mounts in Qualification Unit Model

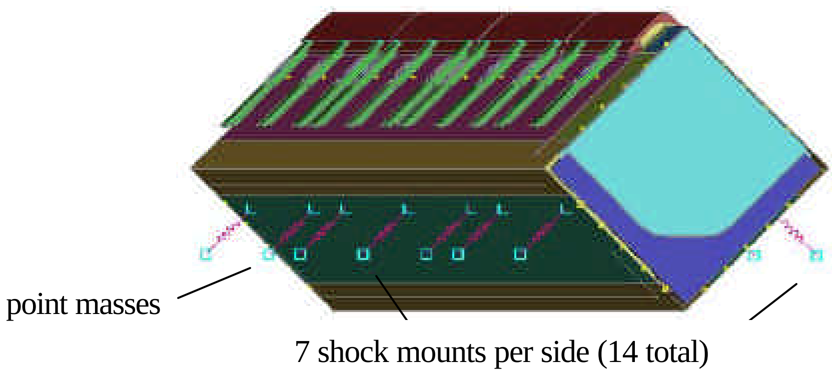

Figure 2-15.2 Shock Mounts in Qualification Unit Model

For vertical drops onto the bottom end of the package, the clamshell loads and accelerations are defined by the contact forces between the clamshell bottom plate and the bottom impact limiter inner cover plate. Similarly, the contact forces between the top clamshell plates (the grooved plate and the lipped plate) and the top impact limiter inner cover plate were used to determine clamshell loads and accelerations for the vertical (and near vertical) drops onto the top nozzle end of the package. This is illustrated in Figure 2-15.3 for a vertical drop onto the bottom nozzle end of the package.

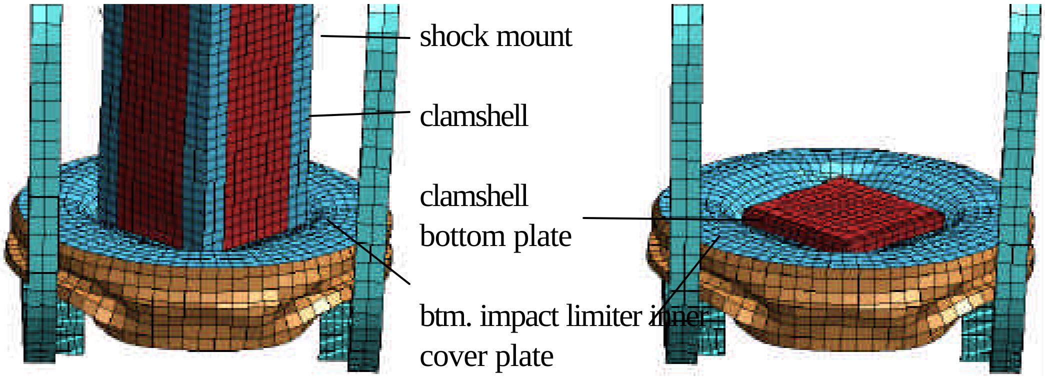

Figure 2-15.3 Contact Between Clamshell Bottom Plate and the Inner Cover of the Bottom Impact Limiter

The loads on the clamshell due to the shock mount extension are calculated using *F*=*k*?. For the vertical case, the spring constant, *k*, is 42.3 N/mm. Further, the shock mount extension, ?, is the difference in the z deflection of the end nodes of the shock mounts (Figure 2-15.4). Finally, the total vertical force on the clamshell from the 14 shock mounts is summed from the 14 individual contributions. Thus, the maximum z-direction force exerted on the clamshell by the 14 shock mounts was approximately 85.4 kN (6.1 kN x 14). Further this load level was maintained from 0.016 to 0.033 seconds after initial impact.

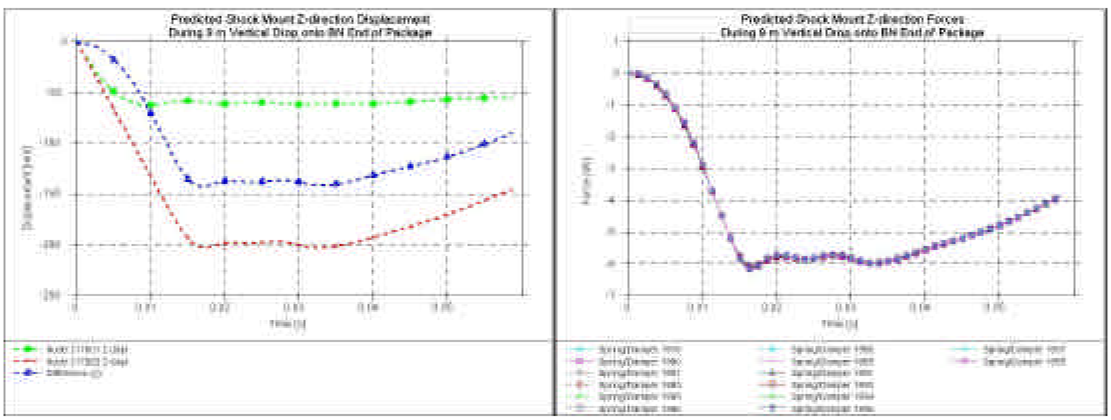

Figure 2-15.4 Z-direction Extension of a Typical Shock Mount; Individual Z-forces for the 14 Shock Mounts

This load is considered in the 843 kN vertical clamshell force predicted for the vertical drop onto the bottom nozzle end of the package. (A similar load is considered in the predicted 605 kN clamshell load for the vertical drop onto the top nozzle end of the package.)

2-16 Revise Section 2.12.3.2.6 to include a reevaluation of effects of temperature and foam density change on the drop test performance of the Traveller package, considering a 9-meter bottom-end down drop test.

The application evaluated temperature and foam density effects on structural package performance by considering the 9-meter CG-forward-of-corner drops onto the top nozzle end of the package. The staff notes that this drop orientation with an initial point contact with the ground is much less stiff and, therefore, less sensitive to the foam density variation, than the flat bottom-end down drop where the impact footprint covers an entire end plate of the Outerpack. The present evaluation has not been shown applicable to the most damaging bottom-end down drop test for the temperature of -29°C (-20°F) in accordance with the requirements of 10 CFR 71.73(b).

<u>Westinghouse Response</u>:

The following text has been added to Section 2.12.3.2.6 after Figure 2-63:

> In addition, the 9 meter vertical bottom-end down drop was analyzed using material properties for -40°C (-40°F) with foam density at the upper end of the tolerance band and 71°C (160°F) with foam density at the lower end of the tolerance band. The predicted results were compared with each other and with those at 24°C (75°F) and nominal foam density previously reported in Section 2.12.3.2.5. The results support the conclusions obtained from analysis of the 9 meter CG-forward-of-corner drops: temperature and variation in foam density due to manufacturing tolerances have only a minor effect on the drop performance of the Traveller package.
>
> Temperature/foam tolerance effects for the 9 meter vertical drop onto the bottom nozzle end of the package were evaluated for the three previously noted conditions. Both predicted outerpack/drop pad force histories and fuel assembly accelerations were compared as shown in Figures 2-63A and 2-63B.

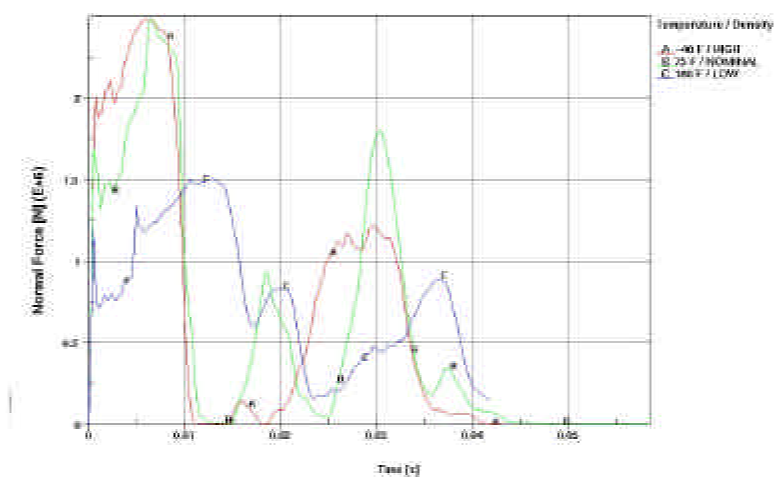

Figure 2-63A Predicted Temperature and Foam Density Effect on Outerpack/Drop Pad Interface Forces (9m Vertical Drop onto the Bottom End of the Package)

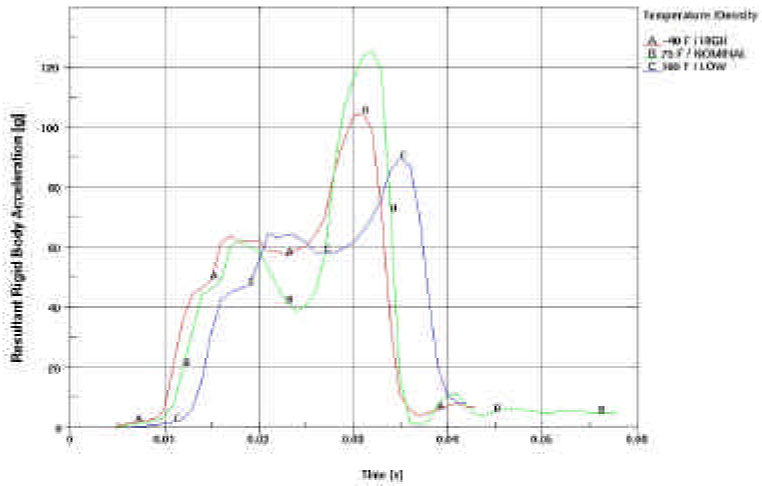

Figure 2-63B Predicted Temperature and Foam Density Effect on Fuel Assembly Acceleration (9m Vertical Drop onto the Bottom End of the Package)

Both of these figures predict that the highest forces occur when the package is 24°C (75°F) with the package having nominal foam density. (This does not necessarily mean that a package dropped at 24°C/75°F having foam densities at either the high or low end of the tolerance band would have had lower outerpack/drop pad forces and lower FA accelerations since that was not investigated.) In particular, the predicted maximum outerpack load for the 75°F (24°C)/nominal foam density scenario was 2.5E6 N. This was equal to that predicted for -40°C (-40°F) with foam density at the upper end of the tolerance band and about 67% greater than the 1.5E6 N load predicted for 71°C (160°F) with foam density at the lower end of the tolerance band. Moreover, a maximum FA acceleration of 126 g's was predicted for drops at 24°C (75°F) with the package having nominal foam density. This was approximately 20% higher than the 105 g's predicted for the -40°C (-40°F) with foam density at the upper end of the tolerance band scenario and approximately 40% higher than the 90.1 g's predicted for 71°C (160°F) with foam density at the lower end of the tolerance band case.

2-17 Verify annotation for the measured "Y - Axial g-force" for Figures 2-89 and 2-119. Annotations for the drop response traces are confusing. Throughout the application, the Y coordinate appears to have been assigned to "Vertical," in lieu of "Axial," responses such as that of "Y - Vertical g-force" of Figure 2-118.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

<u>Westinghouse Response</u>:

No change was required to the text of the SAR. Figure 2-91 was replaced.

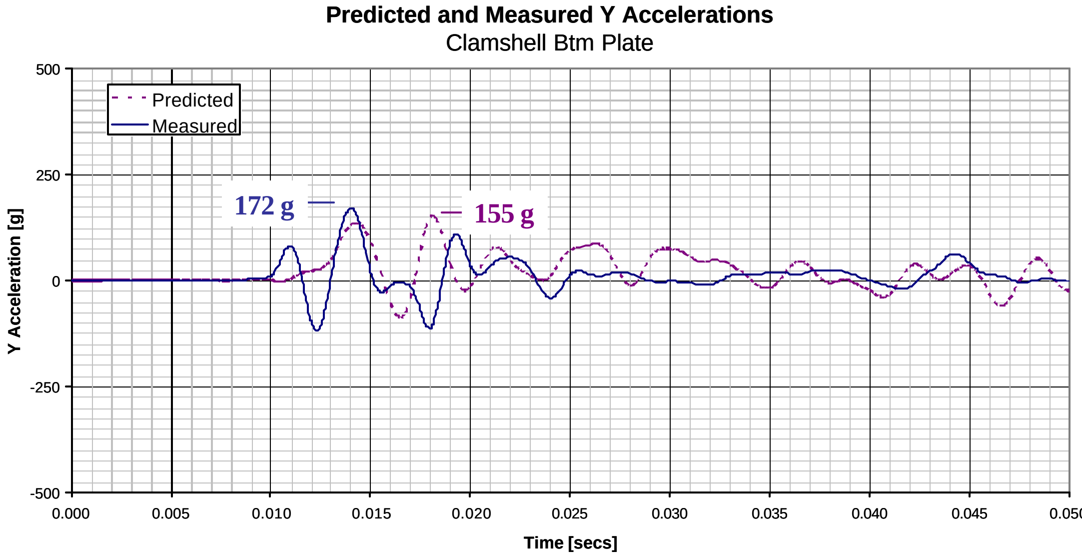

Figure 2-91 Predicted and Measured Y Accelerations

The following is provided for clarification:

The container coordinate axes are defined in Figure 2-103 of the SAR and perhaps better illustrated in Figure 2-23. As shown in these figures, the Z-axis is the axial coordinate and is positively directed going from the BN end to the TN end of the package; the Y-axis is perpendicular to the ground and directed upwards when the package is resting on its legs; and the X-axis, defined by the right-hand rule, goes through the plane of the lower and upper overpack mating surfaces. The accelerometers are fixed to the container and the accelerometer axes were aligned with the container axes.

It should be noted that the orientation of both the container and accelerometer coordinate systems change with respect to the ground depending on drop orientation. Further, the orientation between the coordinate axis and the ground generally changes during testing as the package rotates during the accident. For the case of the low angle slap-down test that was monitored with accelerometers and compared with analytical predictions (Test 1.1), the package was initially oriented at an angle of 14.5 degrees relative to the ground (Figure 2-78) and the first impact occurs with the package so angled. The second impact, however, occurs after the container has become horizontal. Thus, the accelerometer traces shown reflect a change in orientation of approximately 14.5 degrees. The predictions shown in the traces neglect this small change. Rather, the predicted traces are global vertical accelerations (normal to the ground).

2-18 Provide sketches depicting the accelerometer installation plan for the drop tests. The application should include accelerometer locations on the test articles to evaluate correlation between the measured and predicted results.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

The following text and Figure 2-117A have been added to Section 2.12.4:

> The locations of these accelerometers are shown in Figure 2-117A.

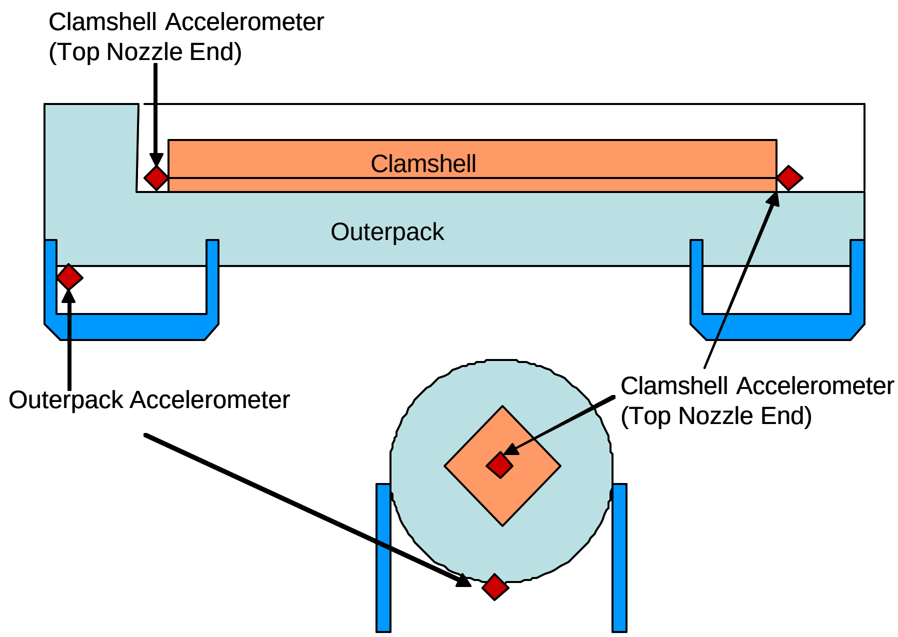

Figure 2-117A Accelerometer Locations on Prototype Drop Test

2-19 Provide a discussion addressing the sources for the discrepancy in weights in statements on pages 2-130 and 2-133:

Predicted model weight for the Prototype units was 2.39 tonnes (5258 lbs). This matched the Prototype unit's 5065 lb. average weight within 3.8%.

Predicted model weight was 2.27 tonnes (4994 lbs). This matched the qualification unit's 4786 lb. average weight within 4.4%.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

The following text has been added to Section 2.12.3.5.2:

> Predicted model weight for the Qualification units was 2.27 tonnes (4994 lbs). This matched the Qualification unit's 4786 lb. average weight within 4.4%.
>
> The Traveller program performed drop tests as input into the design process. As a result, there were changes in the design of the Traveller between the prototypes discussed on page 2-130 and the qualification test units described on page 2-133. The changes resulted in slightly different weights as noted in the descriptions.

2-20 Verify that appropriate finite element Clamshell models were used in the analysis of the Qualification Unit drop test. The staff notes that modeling attributes, including element meshes, are markedly different for the same Qualification Unit Model shown in the two plots, Figures 2-96 and 2-102. It is not clear from the information provided which Clamshell model was used in the analysis.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

<u>Westinghouse Response</u>:

No changes required to the SAR. The following is provided for clarification:

The clamshell design did evolve during its development. The final design is reflected in Figure 2-102 and all analyses reported in the SAR utilized the clamshell model depicted in this figure.

2-21 Verify the temperature-dependence stress-strain curve plots, Figure 2-108, for the Clamshell aluminum at 160^{o} F and -40^{o} F. The stress-strain curves at the two temperatures appear to have been mislabeled.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

<u>Westinghouse Response</u>:

The following figure, Figure 2-108 has been replaced:

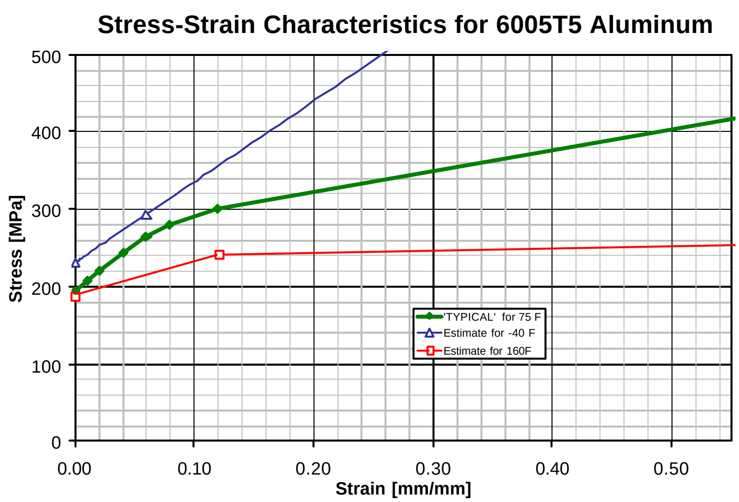

Figure 2-108 Stress-Strain Characteristics of Aluminum in Clamshell

2-22 Revise Figure 2-105, as appropriate, to provide detailed stress-strain data for the strains ranging from zero to ten percent. Also, re-evaluate the bottom end drop to determine effects of cold temperature on package structural performance by using relevant stress-strain data in the finite element analysis. The staff notes that there are no stress-strain data reported for the strain range cited above. By assigning a yield point at the 10-percent strain offset, which had not been substantiated, the result was an assumption on the rate of momentum change of the free dropping package to dictate certain analysis outcomes.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

The following text and figure has been added to Section 2.12.3.6.2:

> The use of a linear elastic material model from 0-10% strain was selected to evaluate the effects of temperature and foam density on drop test reaction forces. From Section 2.12.3.2.6, foam linear data demonstrated that temperature and foam density have a minor effect on the drop test response of the Traveller. The use of true stress-strain data ranging from 0-10% would not impact the conclusions of the comparative analysis.
>
> A typical comparison of foam stress-strain behavior demonstrates that the available strain energy of a linear model is less than that observed with true stress-strain data. The use of true stress-strain data is expected to result in greater foam deflection when compared to linear modeling. Since greater crushing would absorb more kinetic energy, the predicted reaction force of the outerpack using true stress-strain data is expected to be less compared to linear data. It is concluded that the use of linear stress-strain data in the 0-10% range adds additional conservatism to the model.

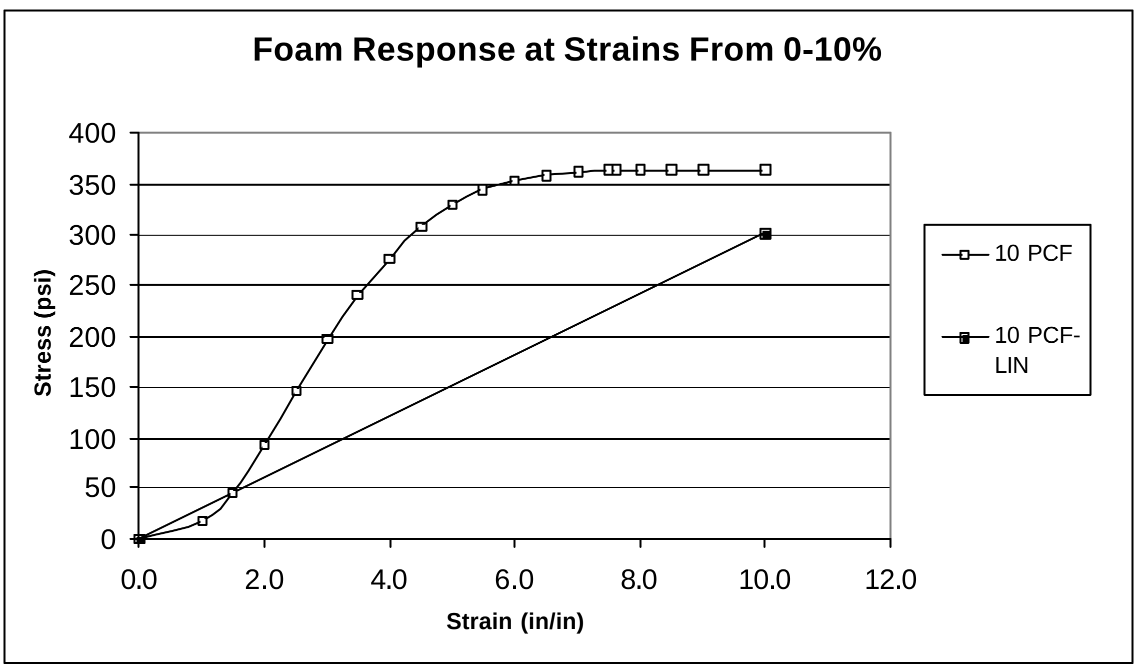

Figure 2-105A Foam Response at Strains from 0-10%

2-23 Provide a description of the finite element models used for calculating bolt axial and shear forces, Table 2-26. For the resulting forces, justify the basis for using the ultimate strengths in the interaction equation evaluation of factors of safety for the bolts subject to concurrent tensile and bi-axial shear forces. It is not clear from the information provided whether the bolts were allowed to yield in the finite element analysis of the drop accident, which could markedly affect the calculated bolt forces. The staff notes that bolt interaction equations generally do not lend themselves to an evaluation involving material ultimate strengths.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

No changes required to the SAR. The following is provided for clarification:

A schematic of the finite element bolt model is shown in Figure 2-23. This is representative of all bolts used in the shipping package. It consists of a 3D beam element whose end nodes are in the plane of the layers being joined by the bolt. The end nodes are attached to the shell or solid elements either by being shared or by being tied using a penalty-based constraint.

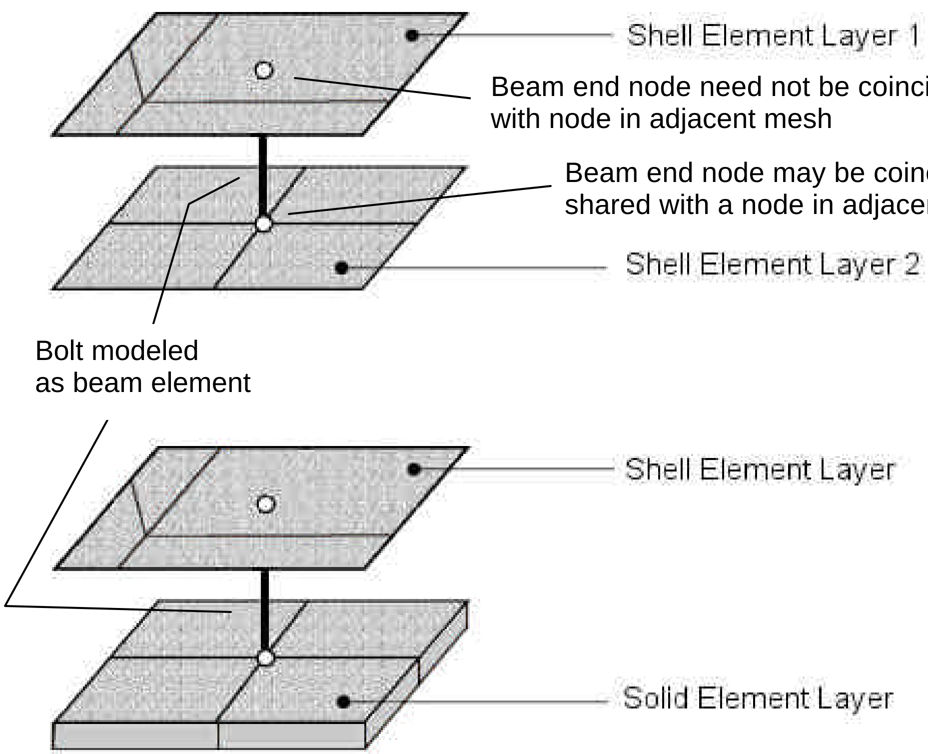

Figure 2-23 Bolt FE Models

Bolt material was modeled as steel with isotropic hardening. Thus, the bolts are indeed allowed to yield and still function until the criteria shown in the bolt interaction equation (equation H-2 in the SAR) is violated. Allowing the bolt to yield is acceptable since the packages are not to be used after testing and it is not required that there be no leakage after impact for this package. We believe the requirement of no leakage after impact for many packages is the main reason bolt failure criteria are generally based on yield strength in package analyses. Further, the use of bolt interaction equations using ultimate strengths is generally accepted for situations where yielding is not objectionable.

2-24 Verify that Table M-2 is a correct reference as cited in Note 2 of Table 2-26. Table M-2 is not included as part of the application.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

Revised Table 2-26.

2-25 Provide a discussion clarifying the apparent discrepancy between the statement provided on page 2-148, "[t]he prototype packages employed 11 pcf foam along the axial section of the package and 16 pcf foam in the endcaps," and the information provided in Figures 2-95 and 2-112 which indicate that the end cap for the Prototype Test Unit was filled with the 11 pcf, rather than the 16 pcf, foam.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

The following figure, Figure 2-95, has been replaced:

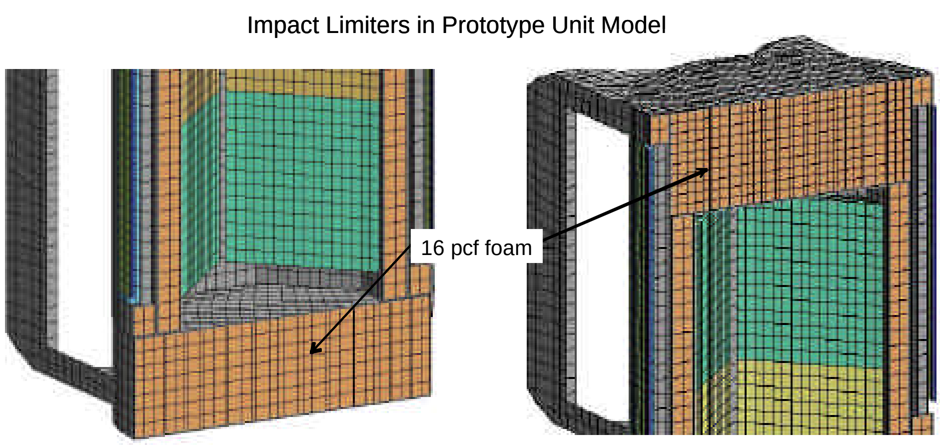

Figure 2-95 Impact Limiter in Prototype Unit Model

2-26 Provide a capabilities summary of the analytical models developed and benchmarked for the package drop analysis, including a discussion, as an example, of why the connector bolts for both the top and bottom Clamshell head pieces were not predicted by the finite element analysis but were observed to shear-out during the bottom nozzle 9-meter CG-over-the-corner drop tests, for analytical modeling of the packaging. It is not clear from the information provided whether the reported damages, such as those that appear to be associated with the bottom nozzle end drop, were predictable with the finite element analysis. Limitations of the finite element analysis models in predicting structural damages, such as those exhibited in Figures 2-115 and 2 -117, should also be clearly delineated to facilitate safety review.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

<u>Westinghouse Response</u>:

Section 2.12.3, paragraph 3 will be revised to read:

> The finite element models developed for the Traveller were not developed to predict actual stress and strains accurately. With the computational resources available, the models can identify regions of high stress and strain but cannot accurately predict component failure unless predicted values are significantly above or below failure points. Instead, they were developed to understand relative deformations, decelerations and energy absorption between drop orientations. The models have been used to compare predicted stresses and strains for different drop orientations to allow intelligent selection of drop orientations for testing. The Traveller program utilized extensive full-scale tests to prove the acceptability of the Traveller design. These tests results are described in sections 2.12.4 below and the results are compared with the FEA in this section.

The following is provided for clarification:

The finite element models are capable of determining which drop orientations will result in the most damage to the package and to the fuel assembly. The models are not capable of predicting the exact extent of damage. Thus, it is imperative to augment/calibrate the predictions with actual test data. Also, the models are better able to warn of possible problems than to rule them out. This is because computational time limitations restrict the mesh refinement possible in global models such as these. Thus, predicted stresses and strains are not always accurate enough to exclude the possibility of a material failure in regions of high stress.

Our experience is that parts predicted to incur the highest loads and deformations in the simulations are the same ones most damaged in actual tests. Even so, the models can not necessarily predict the exact damage. For example, the model should not be used by itself to ascertain whether a particular bolt will fail or not in a given drop. If, however, there are test results showing this bolt can sustain loads in a similar orientation, we can compare predicted results from simulations of the two similar drops and determine which orientation results in the highest bolt loads. If the predictions indicate the loads are bounded by the tested orientation, we can say with some reliability that there should be no bolt failure in the un-tested drop orientation. However, if the loads are higher in the un-tested orientation, we must acknowledge a possible problem and look to the bolt interaction equations to judge its severity. In this latter case, the bolt can only be judged okay if its predicted factor of safety is large.

Thus, the model's capability to predict bolt integrity in highly loaded bolts is limited to orientations where test data exists at similar locations. Even so, it should be noted that throughout the development of the Traveller package there has been only one actual bolt failure that (arguably) contradicted the models. This was an overpack hinge bolt that failed during a horizontal drop onto the hinge side of the package. This failure was ultimately attributed to the large head of this relatively large bolt directly hitting the drop pad. Indeed, smaller diameter bolts with smaller protected heads survived this drop. Aside from this one instance, no bolt failures occurred that were not predicted or at least explained after the fact by our models. (The failure shown in Figure 2-115 was entirely the result of very faulty manufacture resulting from time compression during prototype development and did not involve bolt failure. Rather the top plate “holes” were actually oversized slots. Because the hole was slotted and also oversized, an insufficient amount of material was clamped underneath the bolt heads and the plate simply pulled loose during the drop test. Likewise, the bottom clamshell plate separation in Figure 2-117 resulted from material rupture – not bolt failure. In this case, an insufficient edge distance between the outer diameter of the countersunk clearance hole and the bottom edge of the door lead to material pullout or “bearing” failure.)

Our experience is that the most difference between test and simulation occurred when the model simply did not have sufficient geometrical details. When these details were added, actual measured deformations were closely matched by analysis and all actual material failures were replicated by analysis. We believe that the final models have sufficient detail for any drop orientation. Even so, the models can warn of a possible problem much better than they can rule out the possibility of a failure. This is because computational limitations limit the mesh refinement possible in global models such as these. Thus, predicted stresses and strains are simply not accurate enough to exclude the possibility of a material failure in regions of high stress.

2-27 Provide a discussion explaining the apparent discrepancy between the measured vertical decelerations of 191 g in Table 2-30 and 205 g in Figure 2-91.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

<u>Westinghouse Response</u>:

The following figure, Figure 2-91, has been replaced:

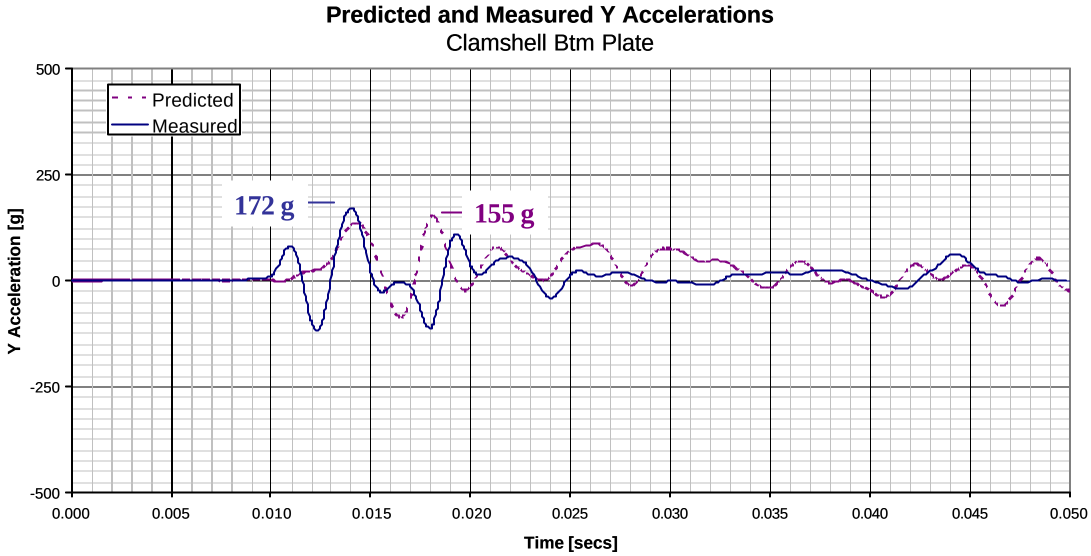

Figure 2-91 Predicted and Measured Y Accelerations

2-28 Provide a discussion clarifying the drop angle/orientation depictions of Test 1.2 and Test 1.3 in Figure 2-129 for the respective CG-Over-Corner and pin puncture tests. It is not clear how the drop angle of 108^o was defined for Test 1.2. The puncture drop of Test 1.3 does not appear to have the package hinge side of the Outerpack land on the puncture pin as described in the text.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

The following text has been added to Section 2.12.4.2.1 and Figure 2-129 has been replaced:

A pitch angle of 72 degrees was measured along the outerpack surface for Test 1.2. The angle of 108 degrees should be located as shown in Figure 2-129. The reference to "hinge side" in Test 1.3 indicates the package side that pivots, rather than the actual hinge. The impact point of Test 1.3 (Figure 2-132) was on the top nozzle end and on the pivot (left) side of the package.

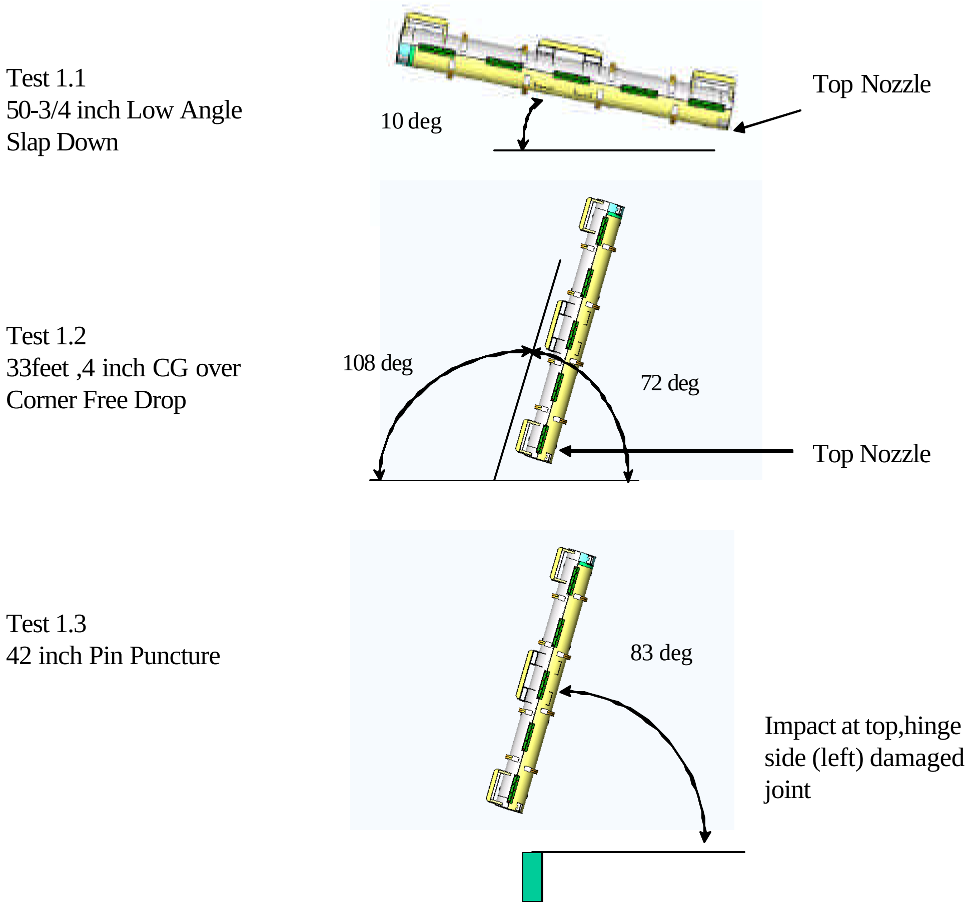

Figure 2-129 Drop Orientation for QTU Test Series 1

2-29 Revise the SAR to include a drop test evaluation of the package transporting the loose rods in a rod box or rod container.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.31(a)(2).

Westinghouse Response:

The following text has been added as a new section – Section 2.11.1:

2.11.1 Rod Box

The Traveller Clamshell is designed to accommodate PWR fuel assemblies. To accommodate loose fuel rods, two rod storage containers have been examined. One, is a 304 stainless steel rod pipe with a maximum diameter of 6.625 inches (6" Schedule 40 pipe), length of 168 inches, and a total weight of 635 lbs (loaded). The second option is a 304 stainless steel box width with a 5.12 inches cross-section. This box is 170.5 inches long and weighs 660 lbs loaded. Other optional designs are being examined which would reduce total length to 169 inches to allow use with the Traveller STD package.

The rod pipe and rod box are both designed to be contained within the Clamshell and restrained axially and radially. Although the rod box has a smaller wall thickness than the tube (0.059 vs 0.280 inches), both are substantially stiffer than the PWR fuel assemblies that the Clamshells normally carry. This, combined with the substantially lower weight of the loaded rod pipes or boxes (660 lb for the rod box vs. 1753 lbs for the fuel assembly used in the drop testing described) make accident scenarios with the rod pipe or rod box less challenging. The rod pipe or box, reinforce the Clamshell to prevent change in fuel geometry. The lower weight, reduces loads on Clamshell and Outerpack. The lower fuel load, reduces criticality concerns. It was therefore concluded that the Traveller package with a rod pipe or rod box is bounded by the CTU tests described.

Chapter 3 Thermal Evaluation

3-1 Revise the SAR to specify the orientation of the certified test unit (CTU) with regard to the fire test pool. Specifically, state the distance the bottom of the package was positioned above the fire pool surface and the distance the pool extended beyond the ends of the package.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.73.

Westinghouse Response:

The following text and figure have been added to Section 3.6.4:

> Figure 3-27A shows the orientation of the Certification Test Unit (CTU) for the thermal test. The bottom of the package was positioned approximately 1 meter from the top of the fire pool surface. The distance of the outer facility walls beyond the edge of the package were 67" at the ends and 71.5" at the sides.

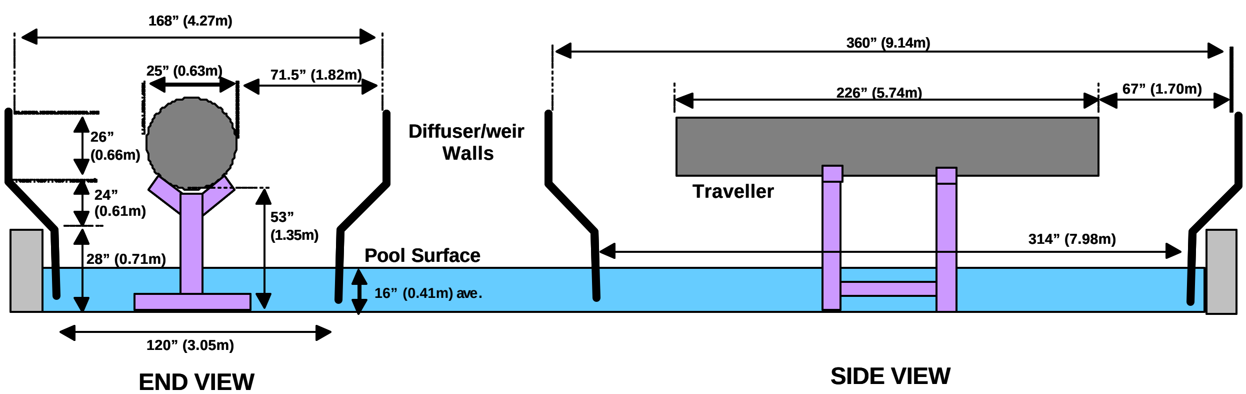

Figure 3-27A Orientation of CTU for Thermal Test

3-2 Revise Section 3.6.4 of the SAR to explain why the 30 minute average flame temperature of 859 ^{0}C and the temperature of 833 ^{0}C measured from the directional flame thermometers (DFTs), is lower than the 904 ^{0}C package skin temperature for the fire test of the CTU.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.73.

Westinghouse Response:

The following text and Table 3-4A have been added to Section 3.6.4.1:

> Twenty-two (22) thermocouples were used to measure external conditions on and around the Traveller package during the February 10, 2004 fire test. These sensors were located as shown in Figure 3-30 in the SAR. Due to the natural instability of open flames, combined with wind effects, these thermocouples were periodically uncovered. As shown in Figures 3-38 through 3-43, this resulted in large variations in measured temperature. These variations are largest at the corners of the pool fire where small disruptions in the flame would change air temperature at the thermocouple location. These disruptions were the smallest at the package skin because it was in the center of the pool fire.

Table 3-4A below, summarizes the thermocouple data for the test. Some of the thermocouples had average temperatures under 800°C but all experienced temperatures above 900°C during the test, demonstrating that the fire covered the complete pool area. Some of the minimum temperatures recorded are due to the time selected for the 30 minute average. A fire this size cannot start instantaneously, nor did it end instantaneously. As a result, the 30 minute period selected for averaging data includes data when some TC were beginning to heat up and when some were already cooling off after the fire. The data still shows that the average skin temperature, the average DFT temperature and the average temperature of TCs in the flame were all above 800°C for the 30 minute period selected.

Table 3-4A Summary of Recorded Temperatures During Burn Test

TC Location	30 Minute Ave (°C)	Max Temp (°C)	Min Temp (°C)
NE Lower Flame	727	959	275
NE Upper Flame	925	1245	493
E Lower Flame	926	1155	489
E Upper Flame	904	1163	532
SE Lower Flame	714	962	291
SE Upper Flame	924	1245	484
NW Lower Flame	630	906	329
NW Upper Flame	748	1059	458
W Lower Flame	997	1162	640
W Upper Flame	1027	1173	661
SW Lower Flame	827	1032	230
SW Upper Flame	1000	1213	598
NE DFT	804	907	454
SE DFT	801	964	338
NW DFT	854	1016	541
SW DFT	876	1003	594
NE Skin	878	1058	610
E Skin	917	1073	699
SE Skin	903	1088	542
NW Skin	725	990	492
W Skin	974	1080	682
SW Skin	1028	1143	719

Because the thermocouples in the corners of the pool were not engulfed as long as the package itself, the 30 minute average temperature for the corners is lower than in the center of the pool. The total average for all of the thermocouples in the flame was 862°C versus 812°C for the corner thermocouples in the flame. The DFT average readings are also lower for similar reasons. The DFTs insulated the thermocouple and attached face plate from convective heat transfer. Radiative heat transfer was dominate by design. Because these devices faced away from the package, they recorded equilibrium temperature based on radiation from the fire and reradiation to cold surfaces outside the fire, without contribution from convection. The skin temperature is an equilibrium temperature that includes convective heat transfer from hot combustion gasses. As a result, its temperatures should be higher.

As described in the discussion of thermal analysis results (section 3.6.1) the long length to diameter ratio of the Traveller package minimizes the role of axial heat transfer inside the package. Non-uniform external temperatures produce non-uniform internal temperatures during fire tests. This fundamental mechanism allowed useful data to be obtained in the seam burn and impact limiter burn tests described in sections 3.6.2 and 3.6.3. This mechanism was demonstrated by the very low clamshell temperatures measured adjacent to the heated sections in those tests. During the CTU burn test, the average skin temperature at the North end, middle and South end of the package was 801°, 946°, and 915°C respectively. Peak interior temperatures recorded by the non-reversible temperatures strips were 116°C at the North end of the package, 177°C at the middle of the package, and 143°C at the South end of the package. At the center of the package, where the average exterior skin temperature was 946°C, the corresponding interior temperatures were acceptable for all materials in the package.

3-3 Revise the SAR to explain why exceeding the melting temperature of the polyethylene is acceptable and provide documentation of its material properties at these temperatures. Additionally, provide justification as to how it was determined that the moderator maintained at least 90-percent of its hydrogen post fire.

Figure 3-45 in the SAR and related description indicate that the polyethylene moderator exceeds its melting temperature of 125-138 ^{0}C (see Table 3-2) at four of six locations measured. No justification is provided other than implicitly from an examination of the moderator after the fire where it is stated that the moderator had no significant damage.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.73.

Westinghouse Response:

The following text has been added to Section 3.6.4.1:

Ultra-high molecular weight (UHMW) polyethylene was selected as the neutron moderator for the Traveller package because of its high hydrogen content, its ductility at very low temperatures and its high viscosity at temperatures well above its melt point due to the long molecular chains (MW=3,000,000 to 6,000,000). The relative solution viscosity as measured by ASTM D4020 must be greater than 1.4[1] and is typically found to be 2.3 to 3.5 dl/gm[2] (at 135°C). As a result, UHMW polyethylene does not liquefy above its melt temperature and molded UHMW polyethylene parts are typically made at relatively high temperatures (190° –200°C) and very high pressures (70-100 bar)[3]. Its excellent stability allows it to be used in some applications at temperatures as high as 450°C[4]. Experience in the Traveller test program has shown that the material will soften but not run, even when heated to near vaporization temperature (349°C). However, the Traveller design encapsulates the moderator with stainless steel. This is primarily done to prevent oxygen from reaching the moderator, should it reach vaporization temperature, but it does serve a secondary function of ensuring that the moderator does not significantly distort or flow at high temperatures.

The highest measured temperature inside the package was 171°C which is lower that the typical process temperature used to create the UHMW sheets installed in the Traveller. Unchanged appearance and more importantly, unchanged weight indicate that the plastic did not loose a significant amount of its hydrogen during the test.

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1 Stein, H.L., "Ultra High Molecular Weight Polyethylene (UHMWPE)," Engineered Materials Handbook, Vol. 2, Engineering Plastics, 1998.

2 This is a typical value observed in many manufacturers specifications: Crown Plastics (crownplastics.com/ properties.htm).

3 Ticona Engineering Polymers information on compression molding, www.ticona.com/index/tech/processing/compression_molding/gur1.htm.

4 Stein, H.L., "Ultra High Molecular Weight Polyethylene (UHMWPE)," Engineered Materials Handbook, Vol. 2, Engineering Plastics, 1998

3-4 Provide justification as to why the location of the temperature strips on the upper half of the outerpack would be representative or bounding of temperatures for the moderator in the lower half.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.73.

Westinghouse Response:

The following text has been added to Section 3.6.4.1:

Earlier analysis and tests had shown that, if there was no substantial infiltration of hot gas into the package, interior temperatures would remain low during the fire test. This is shown in the results of both the seam burn tests and the impact limiter burn tests (sections 3.6.2 and 3.6.3). In these tests, interior temperatures rose between 50° and 110°C during and after the test. These values are conservative because the tests were performed on a previously burned package where the polyurethane had already turned to char. The primary design concern was hot gas infiltration during the CTU burn test. This would add substantially more heat and cause higher temperatures. This was observed in an earlier burn test (QTU-1). This package was oriented in the same fashion as the CTU, with one Outerpack seam facing the pool surface. Distortion of the Outerpack walls caused hot gasses to enter the package and flow around the clamshell. Because of the geometric arrangement of the Outerpack seam lip, this flow was directed preferentially over the top of the clamshell (as oriented when the package is resting on its feet). Polyurethane ignited at four locations in this region and burned. The moderator under the clamshell was undamaged. Based on this evidence, it seemed best to concentrate the temperature indicating strips on the moderator surface that was expected to be the hottest if significant hot gas infiltration occurred.

3-5 Provide a picture and description in the SAR of the damaged Traveller package resulting from the regulatory drop before the fire test. Include an evaluation of this structural damage with regard to its impact on the fire results.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.73.

Westinghouse Response:

The following text has been added to Section 3.6.4:

> (Please see section 2.12.4.2.3 in the Safety Analysis Report (pp 3-183 through 3-192) for description of the CTU drop tests and the resulting damage.)

3-6 Revise the SAR to include an evaluation of the sensitivity of the various temperature measuring instruments and explain the impact of this sensitivity analysis on the recorded fire temperature and the moderator temperature.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.73.

Westinghouse Response:

The following text has been added to Section 3.6.4:

> The primary sensors used in the tests were Omega XCIB-K-4-12 thermocouples connected via approximately 50 ft of 20 gage type K, Teflon coated, extension wire. The type K thermocouples have standard limit of 4°F (2.2°C) or 0.75% between 32° and 2282°F (0° and 1250°C). The 20 gage chromega/alomega wire has a resistance of 0.586 ohms per double foot of length. Two types of data recorders were used. Two Omega OM-CP-OCTTEMP 8 channel data recorders were used for 14 channels of data. These recorders have a -270° to 1370°C temperature measurement range for Type K thermocouples and 0.5°C accuracy for type K thermocouples. The recorders were purchased new from Omega and were used within the time limit of their original factory calibration. Eight channels of data were recorded using a Instrunet, data acquisition system with an INET-100 external A/D box connected to a Toshiba Satellite notebook computer running Windows XP Professional using a INET-230 PC card controller. This system, with Type K thermocouples has an accuracy of ±0.6°C between -50° and 1360°C. The lowest average temperatures from the CTU burn test were the DFT readings which had an 834°C, 30 minute average temperature. Adding the worst case thermocouple and data recorder errors results in a 6.8°C average error. This is not sufficient to lower average temperature below 800°C.

3-7 Revise the SAR to clarify the last sentence in Section 3.1.1 which states, "[t]he package survived the test with maximum internal temperatures less than 150 ^{0}C." This conflicts with the information provided on Figure 3-45 which shows moderator temperatures exceeding 150 ^{0}C.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

Changed "… internal temperatures less than 150°C." to "… internal temperatures less than 180°C." The last paragraph of Section 3.1.1 reads as follows:

> The package survived the test with maximum internal temperatures less than 180°C. The results of this test are described in section 3.5 and appendix 3.6.4.

3-8 Expand Table 3-1 of the SAR to include other significant Traveller package materials (*e.g.*, polyurethane foam, fibreglass seals, refractor insulation). Also, for conformity with the other materials listed in this table, the polyethylene moderator should include its melting point rather than ignition/boiling point with a footnote explaining its behavior and rational for its acceptance criteria.

This information is required in accordance with 10 CFR Part 71.33 which states that applications must include a description in sufficient detail to identify the package accurately and provide a sufficient basis for evaluation of the package.

Westinghouse Response:

The following information has been added to Table 3-1:

Fiberglass seals (Thermojecket S)	1000°F (long term)	Temperature not measured/Seals present after fire test
Refractory fiber felt insulation	2300°F (melt)	177(2)

The following information has been added to Table 3-2:

Fiberglass seals (Thermojecket S)	NA(2)	538°C(1) 1000°F	NA(2)	NA(2)
Refractory fiber felt insulation	0.097 g/cc .0035 lb/in^3	1260°C 2300°F	.06 W/m-K .034 BTU/hr-ft-F	1.0 J/g-°C 0.239 BTU/lb-°F

Notes:

(1) Maximum use temperature for Federal Mogul Product with acrylic resin added to reduce fray.

(2) Seal is used to minimize hot gas infiltration. It is not used as thermal insulation and, because of its low mass, its heat capacity is insignificant.

3-9 Provide a discussion reconciling the differences between the thermal analysis provided in Section 3.6.1, Traveller Thermal Analysis, and the fire test results. An alternative would be to delete Section 3.6.1 if this information is extraneous.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

The following text has been added to Section 3.6.1:

> The thermal analysis performed demonstrated several important features/characteristics of the design. Because of the urethane foam insulating the Outerpack, exterior skin temperatures quickly rise to near equilibrium with the fire outside the package. The clamshell and fuel assembly temperature, rise very slowly due to the insulation and the specific heat of the aluminum clamshell, polyethylene moderator, and the fuel assembly. The primary mechanisms that can result in significantly higher internal temperatures is hot gas infiltration during the fire and internal combustion during and after the fire test. We do not believe that these mechanisms can be

accurately predicted by analysis. As a result, the Traveller team chose to demonstrate the package using pool fire tests, culminating with a full-scale fire test.

The seam burn tests with continuous hinge sections demonstrated approximately 60°C temperature rise during and after the test which was in close agreement with the 50°C temperature rise predicted by the analysis. The CTU burn test demonstrated internal temperatures between 116° and 177°C. This is 112° to 173°C higher than the air temperature that morning. These values are only 66° to 127°C higher than the equilibrium package temperatures maintained by heaters before the fire. As noted above, the external skin temperature at the middle of the package was significantly higher at the middle. Secondly, the amount of hot gas entering the package at different locations along the length clearly affects the local internal temperatures. Greater quantities of hot gas probably entered that package at that location.

Because of the fundamental limitations of the analysis (e.g., inability to predict precise geometry changes during the fire) the analysis model was never refined and exact agreement was never anticipated with test results. The analysis does illustrate the fundamental mechanisms involved and the general characteristics of the package response, assuming no significant gas infiltration or geometry changes.

3-10 Revise the SAR to clearly state that the package after the fire test was allowed to burn until it naturally extinguished. Also, include a discussion why none of the means used to extinguish the pool fire had any adverse impact on allowing the package to burn as long as it naturally could.

Section 3.6.4, the first sentence of the forth paragraph, states, "[a]fter the pool fire was extinguished, the package was removed from the pool and allowed to cool." While Section 3.6.4.1, the last two sentences of the second paragraph states, "...although burning polyurethane from the package reignited residual fuel at one end of the pool shortly afterwards. This was extinguished using the fire suppression system. Both statements are opened ended with regard to the package being allowed to burn until naturally extinguished.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.73.

Westinghouse Response:

The following text and Figures 3-27B and 3-27C have been added to Section 3.6.4:

The fire test facility was originally designed to terminate the fire test by shutting off fuel flow and allowing the fuel at the surface of the pool to burn off. Testing revealed that, in some circumstances, excess fuel could buildup on the pool surface causing the fire to continue burning for five minutes or longer. As a result, a simple fire suppression system was added to the facility. A water hose was connected to a nearby fire hydrant, Figure 3-27B. This hose utilized a suction line to siphon standard fire suppressant foam into the line, Figure 3-27C. The hose discharged into a single pipe that fed into the pool a few inches above the water level. When activated, the system would inject foam horizontally onto the surface of the pool, well below the test article. When used in combination with the fuel shutoff valves, the pool fire was extinguished within 60 seconds. This system did not cool the test article when in use and the package was allowed to naturally extinguish itself after the test. This was demonstrated by the CTU burn test, where the polyurethane at the Outerpack vent ports continued to burn many minutes after the fire suppressant was used on the pool surface.

Figure 3-27B Fire Fighters Standing by Fire Suppression System

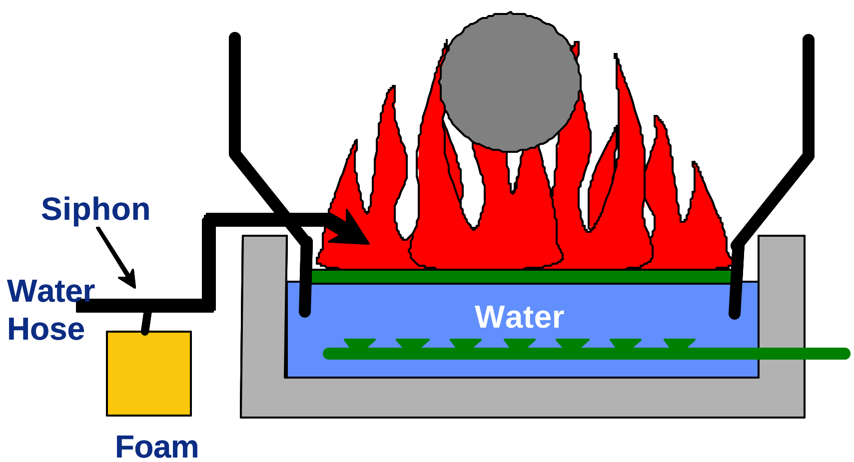


Figure 3-27C Approach to Suppress Pool Fire at End of Test

3-11 Editorial: Correct typographical error in Section 3.6.3 of the SAR, the fifth line should read: "... pillow is separately encased..."

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

Corrected typographical error in Section 3.6.3 of the SAR, the fifth line now reads: "... pillow is separately encased..."

> A Traveller package was subjected to two burn tests after being tested in a full series of regulatory drops. This test series focused on the heat transfer characteristics of the bottom end of the package. This end in referred to as the bottom impact limiter. The top and bottom impact limiters are divided into two regions with high (20 lb/ft^3) density foam in the outer regions and low density foam (6 lb/ft^3) pillows inside. The foam pillow is separately encased in stainless steel with a 0.64 cm (0.25 inch) impact plate to minimize the chance of exposing the foam. Each pillow also has a 0.64 cm (0.25 inch) thick plate out the outer end as a heat sink to reduce peak temperatures in a fire. The foam pillow is also separated from the inside end of the outer impact limiter foam with approximately 0.32 cm (0.125 inches) of refractory fiber felt insulation.

3-12 Editorial: Correct inconsistency in terminology. Page 3-26, mentions "refractor insulation" and Page 3-46, mentions "refractory felt."

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

The term "refractory fiber felt insulation" is used in all places.

Chapter 6 Criticality

6-1 Provide a proposed Certificate of Compliance with a specification of the contents to be authorized for shipment in the package.

A clear indication of the contents to be shipped in the Traveller package is needed to assure compliance with the regulations. The provisions in the Certificate of Compliance must be consistent with the assumptions and modeling of the analysis. Examples of a Certificate of Compliance may be found in Docket Nos. 71-9239, 71-9292, and 71-9272.

This information is being requested in accordance with the provisions of 10 CFR 71.33 which requires an application to include a description in sufficient detail to identify the package accurately and provide sufficient basis for evaluation of the package.

Westinghouse Response:

Westinghouse will prepare and submit the proposed wording for the contents section of the certificate of compliance.

6-2 Revise and edit the SAR to correct the editorial and quality control errors in Section 6.

Some examples but by no means a complete set of the errors present are provided here (additional examples are identified in some of the other RAIs in this section):

a. In the second, third, and fourth sentences in Section 6.10.5, the references to Tables 6-32, 6-33, 6-25, and 6-26 are incorrect;

b. Some of the values in Table 6-8 are not the same as in the later sample input files;

c. The atom densities for polyethylene in Table 6-10 are incorrect, and

d. There are missing or inconsistent values in Tables 6-11 and 6-12.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

Westinghouse agrees that section 6 contains editorial errors and inconsistencies. The entire section will be reviewed and substantially revised. In addition to items (a) – (d) pointed out here, other corrections will be made where needed.

6-3 Revise the SAR and analyses to make the specifications of the boron and B-10 concentration values in the poison plates consistent with the values specified in the drawings. Note B on Sheet 1 of Drawing No. 10004E58 specifies a minimum areal density of B-10 in the borated aluminum and BORAL laminate/composite poison plates. The values given in Section 6.1.1.4.3, Section 6.1.1.4.4, Table 6-8, Table 6-10, the other input files, and the drawings should all be consistent with the credit taken for B-10 in the criticality analyses. It is noted that the atom number density for B-10 calculated by SCALE using the material specifications in the sample input files of actual calculations results in a value that exceeds the minimum specified in the drawings when adjusted for the appropriate credit fraction and plate thickness.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

The SAR and analyses have been revised to make the specifications of the boron and B-10 concentration values in the poison plates consistent with the values specified in the drawings. Below are given description of the changes that have been made in the locations you mention plus the other places where the poison plates are discussed.

It was decided not to pursue licensing of borated aluminum as neutron poison at this time. Hence, references to it have been removed from this section.

Drawing No. 10004E58
Note B on Sheet 1 of Drawing No. 10004E58 is correct as written. However, the paragraph will be changed to clarify that the laminate plate is BORAL:

> Borated aluminum poison plate shall possess a minimum areal density of 0.018 g/cm^2 of B-10, and the laminate/composite boron poison plate (BORAL) shall possess a minimum areal density of 0.024 g/cm^2 of B-10. The poison plate thickness shall be 0.125 inches ±0.006 inches.

Section 6.1.1.4.3 Borated Aluminum
This section has been deleted. Borated aluminum will not be used as a neutron poison at the present time.

Section 6.1.1.4.4 BORAL
The information provided in Section 6.1.1.4.4 (BORAL) will be corrected. It states that the maximum areal density is 0.025 g/cm^2. it will be changed to read 0.024 g/cm^2. Also, calculations will be made that reflect a B-10 number density that is 75% of 0.024 g/cm^2, which is 0.0180 g/cm^2. The second paragraph of Section 6.1.1.4.4 will be revised to read:

> The BORAL sheets measure 0.125 inches (0.3175 cm) thick, including cladding and core. The nominal thickness of the cladding and core are as follows: Cladding (0.0179 inches/0.0455 cm), Core (0.0892 inches/0.2266 cm), Cladding (0.0179 inches/0.0455 cm). The maximum areal density loading for ^{10}B that corresponds to this thickness is 0.0240 g/cm^2, which equates to a B4C loading of 36.5%. This analysis assumes 75% credit for areal density, which equates to 0.0180 g/cm^2.

Table 6-8
Table 6-8 was included as a sample input deck to show input lines for material properties, not to specify the B-10 content for the accident case. This particular input deck represents the 0.01 g/cm^2 B-10 areal density case for the BORAL sensitivity study, which is reported in Section 6.7.8.

Table 6-10
The atom number densities for BORAL in Table 6-10 are incorrect. The number densities given are for 0.01 g/cm^2 B-10 areal density. The table should provide the number densities for

the accident case, which for BORAL is 0.0180 g/cm^2. Table 6-10 will be revised to give the corrected number densities.

Section 6.7.8 Reduction of Boron Content in Neutron Absorber
This section will be revised to analyze the baseline model at B-10 areal densities of 0.0050, 0.010, 0.0162, 0.0180, 0.024, 0.030, and 0.035 g/cm^2. Results for the Traveller XL will be plotted in figure 6-18 and listed in Table 6-39.

Section 6.10.8.5 Boron Content Sensitivity Study
The revised tables in this section will be include results from the sensitivity study and number densities that were used. The tables are included below.

Table 6-39 Results of Boron Sensitivity Study

Run #	^{10}B Areal Density (g/cm^2)	ks	sks	ks+2´ sks
B10--0050	0.0050	0.9682	0.0008	0.9698
B10-0100	0.0100	0.9478	0.0010	0.9498
B10-0162	0.0162	0.9389	0.0009	0.9405
B10-0180	0.0180	0.9377	0.0008	0.9393
B10-0240	0.0240	0.9329	0.0009	0.9347
B10-0300	0.0300	0.9295	0.0009	0.9313
B10-0350	0.0350	0.9284	0.0009	0.9302

Table 6-39A Number Densities for Boron Sensitivity Study

Run #	^{10}B Areal Density (g/cm^2)	B-10	B-11	C	Al
B10-0050	0.0050	0.0013272	0.0053882	0.0016789	0.05203
B10-0100	0.0100	0.002655	0.010776	0.003358	0.048643
B10-0162	0.0162	0.0043003	0.017458	0.0054396	0.044443
B10-0180	0.0180	0.0047781	0.019398	0.0060439	0.043223
B10-0240	0.0240	0.0063708	0.025864	0.0080586	0.039158
B10-0300	0.0300	0.0079635	0.032329	0.010073	0.035094
B10-0350	0.0350	0.0092907	0.037718	0.011752	0.031706

6-4 Clarify the method for modeling the rubber shock mounts. Section 6.1.1.5.2 states that the rubber shock mounts are modeled as void in the array cases. This is not consistent with the information given in the sample input files.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

Westinghouse agrees that the shock mounts were incorrectly modeled as water for HAC package array cases in the SAR model. Section 6.1.1.5.2 (Shock Mounts) correctly states that the shock mount should be modeled as full density water for the individual package cases and as void for the array cases. The media type was not changed when modifying the individual case model for HAC array calculations. In the revised models, the shock mounts will be modeled as rubber (mixture #14) with a density of 1.59e-20 for array cases. This is done to enable the analysts to "see" the rubber shock mounts in place when using the keno-3d software.

Westinghouse modified the shock mount configuration in both the Traveller STD and Traveller XL packages subsequent to making the license application submittal in April. The purpose of the revised configuration was to improve over-the-road handling, and had no bearing on the safety of the package. However, the new placement affected the criticality model because it included a larger cutout in the polyethylene moderator block (6.0 inch diameter) to accommodate the shock mount. The model in the March application SAR shows that there are 22 shock mounts (11 pair) evenly distributed in the outerpack. The revised configurations for the Traveller XL and Traveller STD are different. The Traveller STD has cutouts for 4 pair of shock mounts at either end of the outerpack (16 shock mounts total). The Traveller XL has cutouts for 3 pair at either end, not evenly spaced, plus a pair at the axial center of the outerpack. This gives a total of 14 shock mounts. The new configurations are shown in the revised license drawings in Section 1.

Section 6.1.1.5.2 (Shock Mounts) will be revised to read:

6.1.1.5.2 Shock Mounts

Testing indicates that the shock mounts remain intact and hold the Clamshell in place. However, their contribution as a moderator is insignificant and therefore, they are modeled as full density water in the single package cases and as void spaces in the array cases.

The Traveller STD and Traveller XL have different shock mount configurations, which can be seen in the license drawings. Both configurations are symmetrical about the center of the outerpack. The Traveller STD configuration features four pair of shock mounts at either end of the outerpack, spaced 9.0 inches (22.9 cm) on center, with the end pair about 18 inches (45.7cm) from the end. The Traveller XL configuration has three pair of shock mounts at either end plus a pair in the middle. The pair at the end is about 15 inches (37 cm) from the end. The second pair is 36 inches (91.4 cm) from the first pair, and the third pair is 18 inches (45.7 cm) from the second.

Section 6.3.1.2.1 (Outerpack Model) will be revised to read:

6.3.1.2.1 Outerpack Model

The actual Traveller STD and Traveller XL outerpacks are identical with the exception that the XL is longer than the STD and the shock mount configurations are different. The shock mount configurations are shown in License Drawing 10001E58. The criticality evaluations will use the same outerpack model for both the STD and XL calculations with the exception of shock mount configuration. The outerpack model is described further in Appendix 6.10.4.

Section 6.10.4.2 (Outerpack Model) will be revised to read:

6.10.4.2 Outerpack Model

The Outerpack is defined in unit 10. Figure 6-29 gives a sample of the unit 10 input lines for the Traveller. Some features of the outerpack model are: the shock mounts and shock mount cutouts are defined using cylinders; and the six moderator blocks are defined with cuboids. Figure 6-30 through Figure 6-32 show various renderings of the outerpack. The shock mount configuration for the Traveller XL is a conservative arrangement of the actual configuration. As seen in figure 6-32, there are two pair of shock mounts at the end spaced 18 inches center-to-center. The second set was moved to be 18 inches from the first pair in order that the expanded section of fuel would "see" two pair of shock mounts.

Also, the following has been added to section 6.3.4.5 (Conservative Material Assumptions)

Shock mount placement is important to criticality because the shock mounts penetrate the moderator through a 6 inch (15.24 cm) cutout. The shock mount configuration for the Traveller STD is modeled according to drawing, relative to either end of the outerpack. The Traveller XL is modeled conservatively in order to maximize the extent to which the 100-cm section of expanded lattice of the fuel assembly is placed over the shock mounts. Hence, the shock mounts are not placed at either end as shown in the license drawing and described in section 6.1.1.5. The first pair is locted 15 inches from the end. The second pair is 18 inches (45.7cm) from the first, and the third is 36 inches from the second. The gap between the first two pair of shock mounts is eliminated in order to maximize the interaction between the expanded sections of fuel.

6-5 Provide the basis for assuming a 90-percent density for the polyethylene moderator blocks, Section 6.1.1.5.3. The assumed density of the moderator blocks in the Overpack should be consistent with the condition of the polyethylene after deterioration due to aging and the hypothetical accident conditions.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.35.

Westinghouse Response:

The ASTM D 4020 UHMW polyethylene moderator blocks have density = 0.93 g/cc. It is modeled at 90-percent of 0.92 g/cc, which is 0.828 g/cc. The basis for assuming a 90 percent density rests upon two factors.

First, Westinghouse has researched deterioration of UHMWPE due to aging and has found that the material holds up extremely well over time. Also the moderator will not be exposed. It is covered, and hence shielded and protected.

Second, concerning hypothetical accident conditions, the following is provided.

The certification test unit (CTU) interior was examined after the burn test. Internal temperature strips recorded peak temperatures under 177C throughout the package with one possible exception. Approximately 2 m (6 ft) from the bottom of the package, one set of temperature strips was unreadable due to heating and urethane deposits. An examination of the fuel assembly and the moderator blocks showed no significant heat damage.

An examination of the moderator blocks after the burn test revealed no significant damage. One small portion of moderator at the bottom end of the package showed signs of combustion. The very localized nature of the burn marks (on both the moderator and the refractory felt that covered the moderator) indicates that this was probably caused during the fabrication process. The stainless steel cover sheets are welded into place after the moderator blocks are bolted in and covered with insulation. It appears that the welding torch was applied to the steel immediately after moderator installation causing a small amount of damage. A brown spot was observed on the back side of one moderator block attached to the outerpack lid. The polyethylene at this location appears to have been heated to melt temperature. A very small amount of flow occurred away from the hot spot. This melt spot was small and did not result in a measurable loss of material.

The Traveller outerpack has twelve polyethylene moderator blocks in eight locations. These blocks were weighed before installation in the package and after the fire test and disassembly. The table below compares the two sets of measurements. With the exception of the two blocks attached to the lower left side of the outerpack base, all of the measurements agree. The polyethylene blocks contained approximately 86.5 lbs of hydrogen. The objectives required that the moderator lost no more than 8.7 lbs. The weight measurements show that the moderator retained sufficient hydrogen and that there was no significant weight loss within the accuracy of the measurements.

Position	Wt Before Test (lb)	Wt After Test (lb)	Gain (Loss) (lb)	Wt Before Test (kg)	Wt After Test (kg)	Gain (Loss) (lb)
Base top left	47.1	47.1	0.0	21.4	21.4	0.0
Base top right	47.2	47.2	0.0	21.4	21.4	0.0
Base lower left	44.6	44.8	0.2	20.2	20.3	0.1
Base lower right	46.3	46.2	(0.1)	21.0	21.0	0.0
Lid top left	40.4	40.7	0.3	18.3	18.5	0.1
Lid top right	40.4	40.1	(0.3)	18.3	18.2	(0.1)
Lid lower left	40.4	40.6	0.2	18.3	18.4	0.1
Lid lower right	40.4	40.3	(0.1)	18.3	18.3	0.0
Total	**346.8**	**347.3**	0.5	**157.3**	**157.5**	0.2

6-6 Clarify how the polyurethane foam region was modeled. Section 6.1.1.6.5 states that the polyurethane foam region was modeled as a void; however, some of the input files provided, *e.g.*, Table 6-28, indicate that the foam was modeled as water.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.35.

<u>Westinghouse Response</u>:

Individual package accident cases are modeled with water filling void spaces. The region normally occupied by foam is assumed to be void for the accident case where foam is consumed by fire. The discussions in Section 6.1.1.5.1 (Polyurethane Foam) and Section 6.1.1.6.5 (Region 5 – Polyurethane Foam Region) will be revised to read:

6.1.1.5.1 Polyurethane Foam

Results from the formal thermal test and the numerous scoping burn tests that were conducted indicate that an unpredictable amount of the polyurethane foam burns away. Therefore, no credit is taken for the foam under accident conditions. Rather, the foam is considered to be a floodable void space and will be modeled either as a void or filled with water, depending upon which is the most conservative.

6.1.1.6.5 Region 5 – Polyurethane Foam Region

The polyurethane foam region is the floodable space that is formed when the polyurethane foam burns away. As mentioned above, since it is difficult to predict how much foam will actually burn away, the entire foam region is modeled as water for the individual package and as a void for the arrays cases. These are the most conservative configurations.

6-7 Provide an analysis whose results meet the acceptance criteria for the case where the outer radius of the Overpack is at its optimum tolerance value. Section 6.1.1.7 states that the Overpack outer radius is 12.5 inches $\pm$ 1.0 inch. Section 6.5.3.1 in NUREG-1609 states that the criticality analysis should consider the manner of dimensional tolerances that maximizes reactivity.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.35.

Westinghouse Response:

Westinghouse has revised the SAR to include discussion of an outerpack diameter search, in which the HAC license-basis case was run with the outerpack at either limit. It should be noted that the model discounts the existence of the circumferential stiffeners which would actually increase outerpack spacing. Hence the 24 inch spacing is actually an extreme and unlikely scenario.

A new section 6.7.11 is added.

6.7.11 Outerpack Diameter

An analysis was performed to evaluate the effect that varying the outerpack diameter has on keff. Cases were run to bound the manufacturing tolerance band. Results indicate that a change in package diameter equivalent to manufacturing tolerance has virtually no affect on system keff. Results are given in Table 6-39B. A sample input deck is provided in Table 6-39C.

In addition, table 6-39E has been added to the SAR. Note that the result for the 24 inch diameter spacing is 0.9405, which satisfies the 0.94 limit.

Table 6-39E Results of Outerpack Diameter Study

Run #	Outerpack Diameter (inch)	ks	sks	ks+2´ sks
XL-HAC-ARRD24-100	24	0.9387	0.0009	0.9405
XL-HAC-ARRAY-100	25	0.9377	0.0008	0.9393
XL-HAC-ARRD26-100	26	0.9357	0.0008	0.9373

6-8 Revise Table 6-2 to show the maximum value of calculated k_{eff} for the single Traveler XL package under the hypothetical accident conditions that was reported in Table 6-16.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.35.

Westinghouse Response:

Table 6-2 will be revised as follows.

Table 6-2 Summary Table for Traveller STD with PWR Fuel Assembly	
Traveller STD	**K_{eff}**
Single Package	
Normal	n/a
HAC	0.865
Package Array	
Normal	0.254
HAC	0.897

6-9 Clarify the statement that the Traveller and Traveller XL have the same Outerpack. Section 6.3.1.2.1 states that the Overpack for the Traveller and Traveller XL are the same while the drawings indicate that the lengths are different and Section 6.10.4.1 states that the moderator blocks are different. The SAR should be clear on the differences and justify modeling deviations from the actual package configuration.

This information is being requested in accordance with the provisions of 10 CFR 71.33 which requires an application to include a description in sufficient detail to identify the package accurately and provide sufficient basis for evaluation of the package.

Westinghouse Response:

Section 6.3.1.2.1 will be revised as found in the response above.

Section 6.10.4.1 will be revised as below. See response to 6-4 for the revised Section 6.10.4.2.

6.10.4.1 Introduction

The Traveller packaging model consists of the Outerpack (unit 10) and clamshell (unit 11). The same Outerpack input deck is used for the Traveller STD and Traveller XL calculations. The axial dimensions for the Traveller XL are used for the Traveller STD because axial differences do not affect results. The shock mount configuration used in the model is a conservative arrangement that bounds both the STD and XL configurations.

The primary difference between the STD and XL models is the lateral dimension of the clamshell where the face-to-face dimensions are different. The STD clamshell is modeled at 9.1 inches and the XL clamshell is modeled at 9.6 inches.

6-10 Clarify the number of shock mounts contained in the Traveller and Traveller XL. Section 6.3.1.2.1 states that 26 holes are modeled in the Overpack to represent the shock mounts. The model in the input files contains only 22 shock mounts. The drawings do not appear to specify a set number of shock mounts. Clarify these discrepancies, adjust the analyses accordingly, and add this specification to the drawings.

This information is being requested in accordance with the provisions of 10 CFR 71.33 which requires an application to include a description in sufficient detail to identify the package accurately and provide sufficient basis for evaluation of the package.

Westinghouse Response:

The shock mount issue is addressed in the responses above.

6-11 Correct the molecular formula for polyethylene, the BORAL core thickness, and the compositions of arbmrubber and arbmbor-al in Table 6-9.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

Table 6-9 has been revised.

6-12 Clarify the modeling of the polyurethane and shock mounts in the normal conditions case. Section 6.3.4.6 says that in the normal conditions case the polyurethane and shock mounts were modeled as void while the information in Table 6-15 indicates that these two items were modeled at nominal density. Also see items 6-4 and 6-6 above.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.35.

Westinghouse Response:

Shock mount and polyurethane modeling under normal conditions of transport are clarified. Because both will survive normal transport conditions, both are modeled at nominal density..

6-13 Clarify how the neutron absorber plates were modeled in the normal conditions case. Section 6.4.3.6 states that the neutron absorber plates were modeled the same in the routine conditions case and the normal conditions case while the information in Table 6-15 indicates that they were modeled differently.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

<u>Westinghouse Response</u>:

Table 6-15 (not included) has been revised. The neutron absorber plates are modeled at 75% B-10 areal density for the normal condition of transport and the HAC license-basis-case. This equates to an areal density of 0.0180 gm/cm^2.

6-14 Provide the location of the discussion of the rearrangement of the package contents and the effect of temperature changes for the normal conditions of transport case. Section 6.3.4.6 states that these two areas are discussed elsewhere in the SAR but it is not clear where these discussions occur.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.35.

<u>Westinghouse Response</u>:

Section 6.3.4.6 was revised to clarify. The conclusions drawn on package contents rearrangement and effect of temperature changes for normal conditions are based on the package condition after the HAC testing. The contents will see no adverse effect from the normal condition criteria.

6-15 Clarify how the polyurethane foam region was modeled in the hypothetical accident conditions analysis for a single package. Section 6.4.1.2 states that the foam was modeled as void but the Region 5 line in Table 6-15 indicates that this was modeled as water.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

<u>Westinghouse Response</u>:

The polyurethane foam was initially modeled as a void for both the individual cases and the array cases. In the revised calculations, the foam is modeled as water for the individual package cases and as a void for array cases. Table 6-15 has been revised to indicate this.

6-16 Clarify the moderation condition in Region 3 of the package (inside the Clamshell but outside the fuel assembly envelope) in the analysis of an array of packages under the hypothetical accident conditions. Section 6.6.1 states that this region is modeled as void while the input file provided in the SAR indicates that this volume is modeled as flooded. The SAR needs to be revised to be consistent throughout.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

Westinghouse agrees that Region 3 was inadvertently modeled as flooded even though the text indicates it is modeled as a void. The region should have been modeled as a void in order to promote maximum interaction between packages in the array.

It was found that there is no difference between the two conditions. However, the revised HAC models record this region as a void.

6-17 Justify using 100 cm as the licensing basis for analyzing the effect of lattice expansion of the fuel rods in the hypothetical accident conditions. The application proposes to have a variety of fuel assembly classes approved for this package. The licensing base must bound all fuel types authorized for transport in the Traveller.

This information is being requested in accordance with the provisions of 10 CFR 71.33 which requires an application to include a description in sufficient detail to identify the package accurately and provide sufficient basis for evaluation of the package.

Westinghouse Response:

The fuel assembly type chosen for the HAC testing was the 17x17 STD XL, the largest and heaviest fuel shipped in the United States. The damage sustained by this fuel assembly will bound damage sustained by other fuel assembly types. Several 9 meter drops were conducted in the course of developing the Traveller. At no time has a fuel assembly suffered the type of damage that is assumed in the safety evaluation. The 100 cm expansion length is a conservative assumption based on what has been observed from actual drops.

The criticality evaluation combines the length of the 17x17 STD XL with the fuel parameters of the 17x17 OFA. This fuel assembly is more reactive over the range of interest (clamshell dimensions.)

6-18 Clarify when the analysis assumed that the pellet-cladding gap was to be dry and when the gap was assumed to be wet. Section 6.7.1 states that for most of the calculations the pellet-cladding pin gap was assumed to be dry but all of the input files provided in the SAR indicate that the gap was flooded. Confirm that the input files provided are the ones used for the analysis.

This information is being requested in accordance with the provisions of 10 CFR 71.33 which requires an application to include a description in sufficient detail to identify the package accurately and provide sufficient basis for evaluation of the package.

Westinghouse Response:

Section 6.7.1 is incorrect. The last sentence will be deleted. Section 6.7.1 will be revised as follows:

6.7.1 Flooding

During transport the package may be subjected to moderation provided by immersion of the package in naturally occurring sources of water (lakes, rivers, ocean, snow, rain) or fire extinguishing agents (water, foams, dry chemicals). Moderator ingress provides varying degrees of moderation inside and outside of the package. The analysis of variance for moderation that is provided by packaging components is evaluated assuming the fuel assembly is moderated with full density water. The greatest interaction between packages, that results in the highest k_{eff} for a package array, occurs when the transport condition causes moderation of the pin-cladding gap and the fuel region, and keeps all other void spaces inside and between the packages dry.

The criticality evaluation considered the Traveller under various flooding schemes to determine the most reactive flooding combination for both the individual package and the array. Note that because the Traveller was not subjected to the immersion test, it is necessary to consider all plausible flooding combinations.

6-19 Clarify whether Region 2 in the Clamshell was modeled as flooded or void. The second sentence in Section 6.7.1.3 implies that Region 2 was modeled as flooded while the third sentence implies that it was modeled as void. The SAR needs to be revised to be consistent throughout.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

<u>Westinghouse Response</u>:

Section 6.7.1.3 is incorrect. The sentence that reads, "*Modeling region #2 to void maximizes the probability that neutrons*…" will be changed to "*Modeling Region #**3 (clamshell region) as a** void maximizes the probability that neutrons*…" Section 6.7.1.3 will read as follows:

6.7.1.3 Most Reactive For Package Array – Preferential Flooding

Preferential flooding (also called differential or sequential flooding) is defined as that scenario in which one cavity of the package remains flooded while one or more of the other cavities drain completely. Referring to section 6.1.1.6 (Floodable Void Spaces) and Figure 6-4, the most reactive configuration for a package array is one in which the neutrons are fully moderated within the fuel region (regions #1 and #2) but where the remaining floodable spaces are modeled as a void to allow neutrons that escape one fuel assembly to have maximum interaction with surrounding packages. Modeling region #3 (Clamshell region) as a void maximizes the probability that neutrons escaping the fuel assembly region will pass out of the Clamshell through the neutron poison. Modeling regions #4 – #6 as voids gives the highest probability of neutron interaction among packages. The array is fully reflected by 20 cm full density water.

The preferential flooding scenario modeled here is unlikely but not impossible. It assumes that the Clamshell drains everywhere except inside the fuel envelope. This scenario does however bound the more likely scenario where the Clamshell drains leaving a water film on the fuel rods.

The preferential flooding study involved rotating the package 45° and then keeping regions #2 and #3 flooded (i.e., the areas inside the clamshell) while varying the level in region #4. It can be seen that keff for the array case drops as region #4 fills because the packages are becoming more isolated. Figure 6-11 shows a rendering of this flooding scenario. Figure 6-12A shows the plot of keff versus water height in the outerpack. Results are shown in Table 6-37A and a sample input deck is found in Table 6-37C

6-20 Clarify in Section 6.7.1.3 whether the fuel assemblies are wrapped in plastic or some other material that may retain water around the fuel. The degree to which water might be retained around the fuel assembly is important when assessing the probability for preferential flooding in the hypothetical accident case.

This information is being requested in accordance with the provisions of 10 CFR 71.33 which requires an application to include a description in sufficient detail to identify the package accurately and provide sufficient basis for evaluation of the package.

Westinghouse Response:

Wrapping the fuel assemblies in plastic or some other material that retains water around the fuel is optional. The flooding sensitivity studies modeled various combinations of water accumulation and retention in the clamshell to identify the most conservative configuration, which is the license-base case.

6-21 Provide the data that support the conclusions reported in Section 6.7.1.4 on the behavior of k_{eff} when partial flooding occurs. The SAR reports that an analysis was performed to study the effect of partial flooding but no data from the study are reported.

This information is being requested in accordance with the provisions of 10 CFR 71.33 which requires an application to include a description in sufficient detail to identify the package accurately and provide sufficient basis for evaluation of the package.

Westinghouse Response:

The model used in the partial flooding scenario was changed. The revised scenario rotates the clamshell 45 degrees so that water rises and falls parallel to the fuel assembly rows. Section 6.7.1.4 will be revised as follows. Also, the data supporting the analyses are provided in tables.

6.7.1.4 Partial Flooding

Partial flooding differs from preferential flooding in that it is defined as changing the water level in all the void spaces concurrently.

The partial flooding study also involved rotating the package 45° and then varying the water levels in regions #2, #3, and #4 together. That is, this scenario assumes that the water level inside the clamshell rises and falls with the water level in the outerpack. As expected, keff begins to drop as soon as the fuel is uncovered. Figure 6-12 shows a rendering of this flooding scenario. Figure 6-12B shows the plot of keff versus water height. Results are shown in Table 6-37B and a sample input deck is found in Table 6-37D.

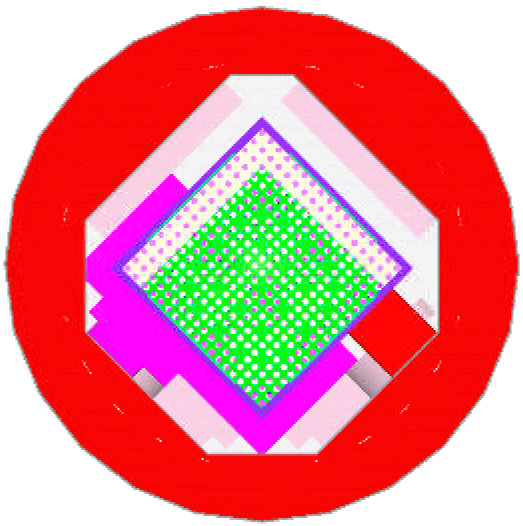


Figure 6-11 Preferential Flooding Scenario

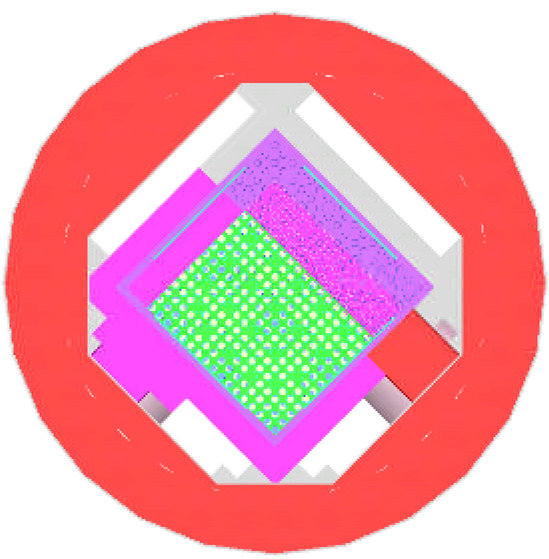


Figure 6-12 Partial Flooding Scenario

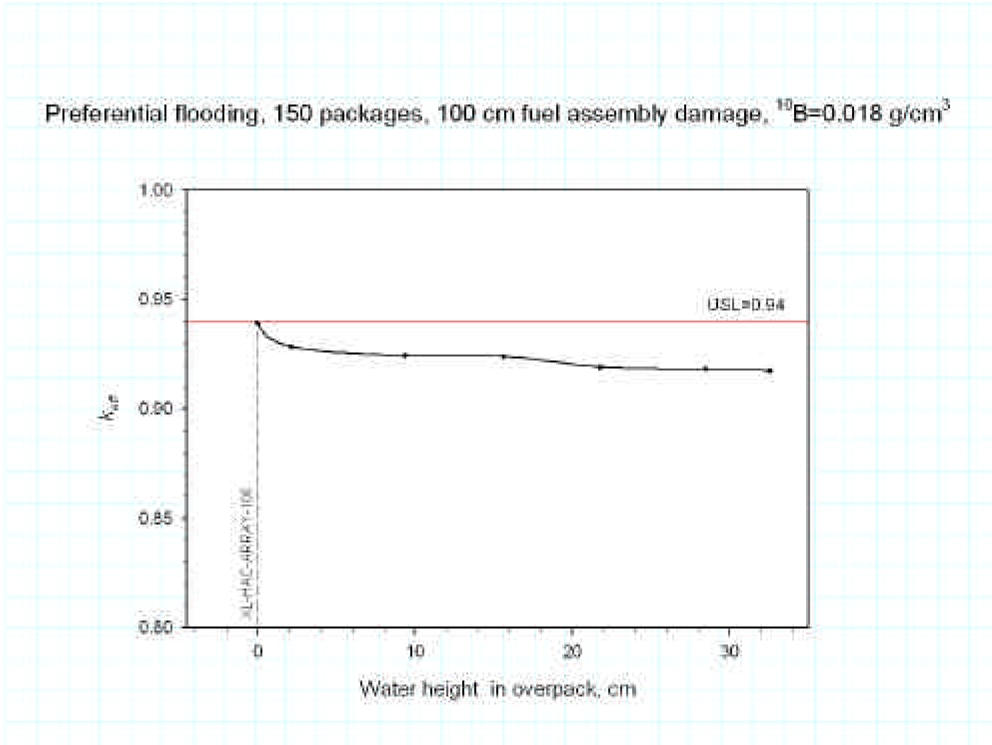


Figure 6-12A Preferential Flooding Scenario

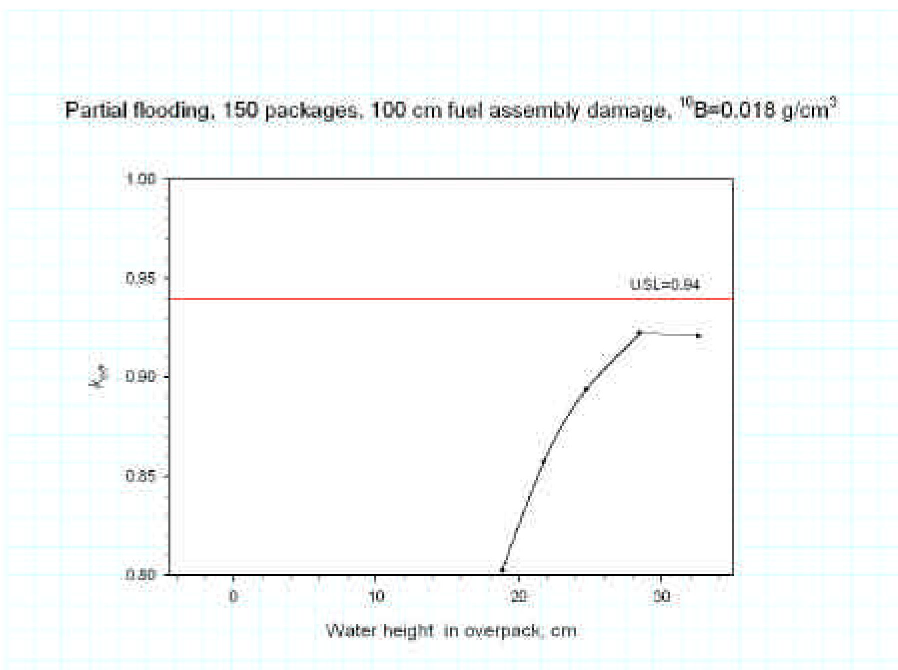


Figure 6-12B Partial Flooding Scenario

6-22 Provide the flooded condition of the other floodable regions in the package for the study that was conducted to show that void between packages in an array maximizes k_{eff}. The model in Table 6-38 and the information in Table 6-15 have some inconsistencies.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.35.

Westinghouse Response:

The flooded conditions of the floodable regions for both the HAC individual package and array cases will be clarified in Table 6-15. Table 6-38 will show the revised HAC array case input deck.

6-23 Clarify in Section 6.7.2 whether the analysis to study lattice expansion was performed for a single package, package arrays, or both.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.35.

Westinghouse Response:

Lattice expansion was evaluated for both individual package and package array.

6-24 Describe in Section 6.7.3 the analysis used to determine annular pellets do not increase k_{eff}. Also, provide the results of this analysis and an input file for the analysis.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.35.

Westinghouse Response:

The annular pellet study data will be included in the SAR. Section 6.7.3 is revised as follows.

6.7.3 Annular Pellets

Analysis has determined that annular pellets in the fuel assembly do not increase keff. Therefore, the fuel assemblies and rods that are allowed to be carried in the Traveller may container annular pellets. Results are given in Table 6-37E. A sample input deck is provided in Table 6-37F. compared with the HAC license basis case, which yielded a keff of 0.9393, including the uncertainty. The same model with the annular pellets yielded a result of 0.9343. Hence, the study demonstrates that annular pellets are bounded by solid pellets.

6-25 Provide the details, results, and an input file for the study that was performed to show that axial displacement of the fuel rods is not important.

Important factors to discuss include the number of packages considered, the flooding conditions, and positioning of the fuel assembly and poison plates. The length of the poison plates and moderator blocks and their relative positions to the active fuel is of key importance. The conclusion needs to be valid for all fuel assembly classes to be transported in the Traveller STD and XL (See Section 6.7.4).

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.35.

Westinghouse Response:

The details, results, and a sample input file are included in the revised SAR.

6.7.4 Axially Displaced Rods

An axial rod displacement study was conducted using as the baseline model an earlier version of the HAC license-basis case model using a Traveller XL. A sample input deck is included in Table 6-37H. It can be seen that this model includes the appropriate positioning of the neutron absorber plates inside the clamshell such that it bounds the actual package. Likewise the moderator blocks are properly positioned inside the outerpack with the shock mount positions conservatively located. This model is acceptable for use in this analysis because it is looking at the relative importance of displacing rods. The analysis looked at the displacement of 0, 4, 8, 12, 20, 28, 56, 92, and 132 rods. The rods are displaced until they reach the top of the Clamshell. Results showed that keff remains constant for a few displaced rods (N=12) and then drops as N increases. The reason is that the displaced rods effectively displace fissil material from high reactivity region (i.e., the region with the expanded lattice) and put them into a region of low reactivity (the region of the top, which is always overmoderated). Taking into account that the expanded lattice is already close to the optimum pitch value (which, for that assembly size, occurs at P≈1.54 cm or 12 displaced rods), not too much advantage is taken from the fact that "holes" appear in the bottom of the fuel lattice. Figure 6-16 shows the model with 92 axially displaced rods. Results are given in Table 6-37G. A sample input deck is provided in Table 6-37H.

6-26 Clarify and justify the length of the poison plates as modeled in the analysis (including the fuel rod axial displacement analysis) versus the length specified in the drawings. The input files indicate a length of 204 inches for the poison plate model while the drawings indicate a length of 168 inches for the Traveler STD and 197 inches for the Traveller XL (See Section 6.7.4).

This information is being requested in accordance with the provisions of 10 CFR 71.33 which requires an application to include a description in sufficient detail to identify the package accurately and provide sufficient basis for evaluation of the package.

Westinghouse Response:

The Traveller XL models used for in the analysis does have a different length than the actual Traveller XL and Traveller STD packages. However, package length is not a significant factor. What is important to criticality safety, and what is captured in the modeling, are the relative lengths and distances of the components that affect k_{eff}. For example, the neutron absorber plate lengths are adjusted such that their positioning inside the clamshell (7.62 cm from the top end and 1.27 cm from the bottom end) conservatively bound the actual standoff distance.

6-27 Provide in Section 6.7.5 the details and results for the study to show the effect of removing the foam from the package. Include a discussion of the different extent of foam removal considered, the number of packages analyzed, and the flooding conditions inside and outside the package.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.35.

Westinghouse Response:

The sensitivity study on the effect of removing foam from the package has no bearing on the evaluation because the HAC conditions assume no foam left in the package. The effect of varying foam density is bounded in the interspersed moderation density analysis, which included varying water density in the foam region.

Section 6.7.5 has been revised to read:

6.7.5 Polyurethane Foam Moderating Effect

Foam is used as both a thermal insulator and impact absorbing material in the Outerpack. The hydrogen content in the polyurethane foam moderates neutrons outside the confinement system boundary of the individual package. Change to the foam composition can significantly affect the interaction between packages in an array. The polyurethane foam starts to burn when the temperature exceeds 600°F (315°C) leaving a low-density char residual material.

6-28 Clarify and provide in Section 6.7.7 more details (including the input file) about the analysis performed to study the effect of reduced density of the moderator blocks. Include a discussion of the number of packages analyzed and the flooding conditions inside and outside the package. In particular, discuss the package component that contained 4.5 wt % boron loading as mentioned in this section of the SAR. Also, clarify whether the density in only the 1.25 inch thick blocks was reduced or in all moderator blocks equally.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.35.

Westinghouse Response:

The requested information pertaining to the moderator block reduced density sensitivity study will be added to a revised Section 6.7.7. Section 6.7.7 will be revised as below. Results and a sample input deck are added to the SAR.

6.7.7 Polyethylene Density

Moderator blocks are a packaging component that provide moderation control by maintaining a fixed amount of moderation between the contents in the individual packages. The polyethylene moderator blocks provide moderation that in combination with a neutron poison effectively reduces the interaction between packages. The fixed moderator and a neutron poison are arranged to function as a neutron flux trap.

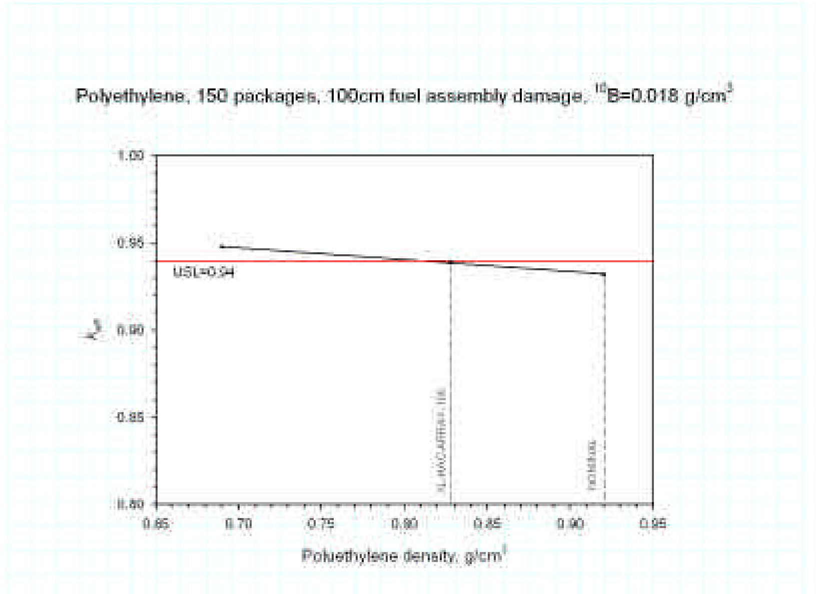


Figure 6-17 Effect of Varying Polyethylene Density

The HAC License-Basis case for the polyethylene was evaluated at densities equating to 100% (ρ = 0.92 gm/cc), 90% (ρ = 0.83 gm/cc), and 75% (ρ = 0.69 gm/cm3) to determine effect. The HAC license basis configuration is an array of 150 packages with the fuel assembly moderated and the remainder of the package regions dry, resulting in the maximum interaction between individual packages in a package array. The polyurethane foam in the outer pack shell is eliminated and replaced with void to maximize the interaction and emphasize the effect of changes in the polyethylene moderator. Figure 6-17 shows the effect on keff of varying the polyethylene density over a range from nominal to 75% nominal density. Results are given in Table 6-39B. A sample input deck is provided in Table 6-38.

6-29 Provide details, results, and an input file for the analysis which concluded that a zirconium reduction did not change k_{eff}. The discussion in Section 6.7.10 includes a reference to the cladding. Studies for previous packages have shown an effect on k_{eff} when the cladding thickness is reduced.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.35.

Westinghouse Response:

The requested information pertaining to zirconium reduction will be added to a revised Section 6.7.7.

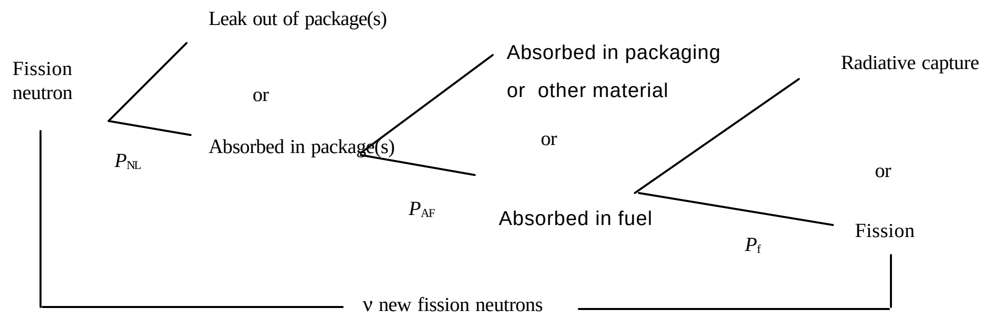
6-30 Describe in Section 6.9.1 the qualitative evaluation of neutron event probabilities that was done to compare the importance of the contents and packaging materials relative to neutron absorption.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.35.

Westinghouse Response:

The qualitative evaluation of neutron event probabilities is given below.

In addition to defining range of applicability derived from parameter bounds for a bias, e.g. AEF, assessing the degree of applicability of benchmark experiments for use in criticality code validations is important. An evaluation of the absorption in materials is used to determine if the critical experiments are representative of the composition, configuration, and nuclear characteristics of the system for which keff is to be determined. The figure below shows the possible absorption events during a neutron generation.



The probabilities for each of these events may be defined as follows:

- PNL = Probability that neutron will not leak out of package(s) before absorption
- 1 - PNL = Probability that neutron will leak out of package(s) before absorption
- PAF = Conditional probability that if neutron is absorbed, it will be absorbed in fuel
- 1 - PAF = Conditional probability that if neutron is absorbed, it will be absorbed in packaging, water reflector, or interspersed moderation between packages in an array.
- Pf = Conditional probability that if neutron is absorbed in fuel, it will induce a fission reaction
- 1 - Pf = Conditional probability that if neutron is absorbed in fuel, it will result in radiative capture.

Each of these probabilities is determined from a final edit of the absorption in the model used to calculate keff. The absorption probabilities for the critical experiment are compared to the system for which keff is to be determined. If the configurations are similar, e.g. geometry, flux spatial and energy distributions, then similar absorption probabilities are an indication that the critical experiment is representative of the nuclear characteristics for the system for keff is to be determined.

6-31 Clarify the dimensions of the polyethylene moderator blocks in the Overpack. Section 6.10.4.1 states that the polyethylene in the lower moderator blocks in the Traveller STD are 1.25 inches thick while the drawings and other text in the SAR indicate that the thickness is 1.75 inches. Revise the text, drawings, and analysis to be consistent with the correct value.

This information is being requested in accordance with the provisions of 10 CFR 71.33 which requires an application to include a description in sufficient detail to identify the package accurately and provide sufficient basis for evaluation of the package.

Westinghouse Response:

This item was addressed in the response to Question 6-9 above.

6-32 Provide a more detailed description in Section 6.10.7 of the analysis for the rod box and rod pipe. Many of the details such as assuming flooding conditions for all cavities are not described. Also, there are inconsistencies that need to be clarified such as the statement in the text that pellet diameters between 0.2 and 0.6 inches were analyzed while the data in the figures represent some values outside this range.

This information is being requested in accordance with the provisions of 10 CFR 71.33 which requires an application to include a description in sufficient detail to identify the package accurately and provide sufficient basis for evaluation of the package.

Westinghouse Response:

Significant revision has been made to section 6.10.7 of the SAR. Information was provided on the fuel rod model and the rod box and rod pipe models in sections 6.3.1.1.2 through 6.3.1.1.4, but this is clarified in section 6.10.7. It should be noted that the analyses included pellet diameters larger than what will be transported in order to bound actual fuel rods. Also, tables are added that provide results of the calculations and sample input decks.

6-33 Show that the results of the analysis for the rod box and the rod pipe are properly optimized. The results reported in Table 6-3 for the rod box and rod pipe are respectively the same for the Single Package and Package Array cases. Discuss the assumed model conditions for the rod container analyses and show that the maximum k_{eff} has been identified considering variations in preferential flooding. Section 6.10.7 only gives results for the single pipe package and an array of packages containing the rod box.

This information is being requested in accordance with the provisions of 10 CFR 71.33 which requires an application to include a description in sufficient detail to identify the package accurately and provide sufficient basis for evaluation of the package.

Westinghouse Response:

This item was addressed in the response to Question 6-32 above.

6-34 Provide tables giving the rod pitch, number of fuel rods, and value of k_{eff} at the point of maximum k_{eff} for each pellet diameter analyzed in the individual package and package array calculations for the rod box and rod pipe. Include all pellet diameters analyzed. As noted above, the range of pellet diameters cited in the text is not consistent with the values indicated in the figures presented.

This information is being requested in accordance with the provisions of 10 CFR 71.33 which requires an application to include a description in sufficient detail to identify the package accurately and provide sufficient basis for evaluation of the package.

Westinghouse Response:

This item was addressed in the response to Question 6-32 above.

6-35 Clarify whether the data plotted in Figure 6-38 are for the package array or a single package. The text states that Figure 6-38 presents data for an individual package while the figure is labeled as being for a package array.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

Section 6.10.7.1 will be revised to indicate that the curve shows k_{eff} vs. pellet pitch for rod box in a package array.

6-36 Provide sample input files for the analysis of the rod box and rod pipe. The examples should be for a case other than a container with closely packed fuel rods.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.35.

Westinghouse Response:

Sample input files for the rod box and rod pipe analyses will be included in the SAR.

6-37 Revise the drawings to provide detail and dimensions for the features that are important for the safe performance of the package.

The drawings lack the detail and dimensions to permit a independent confirmatory analysis of the criticality safety of the package. The level of detail in the drawings should be sufficient to permit the development of an analytical model comparable to the one provided in the input files. While the following is not a complete list, areas of particular concern are:

a. Provide the thickness of the Clamshell box walls.

This key safety component is not specified in the drawings.

b. Show the details of how the shock mounts are attached to the package.

The detail and dimensions in the Section A-A view on Sheet 4 of Drawing No. 10004E58 is not adequate for determining the size of the hole in the moderator blocks that is created by the shock mount and its attachment components. The modeling of the package does not appear to account for the volume taken up by the attachment components. Structurally the attachments are important to the performance of the package.

This information is being requested in accordance with the provisions of 10 CFR 71.33 which requires an application to include a description in sufficient detail to identify the package accurately and provide sufficient basis for evaluation of the package.

<u>Westinghouse Response</u>:

The license drawings will be revised to include this and other information.

6-38 Revise the drawings to show how the fuel assembly, rod box and rod pipe are held in place in the Clamshell and how the moderator blocks are held in place in the Overpack. The drawings do no give information on how the fuel and moderator blocks are restrained from movement in the normal conditions of transport and the hypothetical accident conditions.

This information is being requested in accordance with the provisions of 10 CFR 71.33 which requires an application to include a description in sufficient detail to identify the package accurately and provide sufficient basis for evaluation of the package.

<u>Westinghouse Response</u>:

The license drawings will be revised to include this information.

Chapter 7 Operating Procedures

7-1 Provide clarification as to what the statement in Section 7.1.1.2 “[M]ove the package into for water leaks” means.

This information is being requested to enable the staff to determine compliance with 10 CFR 71.81.

<u>Westinghouse Response</u>:

Change Section 7.1.1.2 to read as follows:

7.1.1.2 Clean Shipping Package

- Use soap or a suitable detergent and water to clean the package.
- Hose down the package and direct a high pressure water stream.
- Move the package into the refurbishing area to check for water leaks.

7-2 Provide clarification as to the maximum number of “fuel assemblies and core components” that are to be transported in a single Traveller transport package, Section 7.1.2.1.

This information is being requested to enable the staff to determine compliance with 10 CFR 71.81.

<u>Westinghouse Response</u>:

Change Section 7.1.2.1 to read as follows:

7.1.2.1 Inspection

- Verify that the fuel assembly and core component have been released and the proper component is being shipped with the assembly.
- Verify that the fuel assembly is properly oriented in the package.
- Verify the number of shock mounts is correct and accelerometers are sealed, calibrated and not tripped.
- Verify general cleanliness and absence of debris on package internals, fuel assembly, package shell lower subassembly prior to closing the package.
- Verify placement and integrity of shipping package gasket.

7-3 Revise Section 7.2.1 to include a statement of what action is to be taken if a security seal is missing.

This information is being requested to enable the staff to determine compliance with 10 CFR 71.81.

Westinghouse Response:

Change Section 7.2.1 to read as follows:

7.2.1 Receipt of Package from Carrier

- Perform an external inspection of the unopened package and record any significant observations.
- Verify that two tamper proof security seals have been properly placed on each package. If either seal is missing or damaged, record the damage and follow site procedures for possible security issues.

7-4 Revise Section 7.3 to either include the “prescribed limits” or a reference to where these “prescribed limits” can be found.

This information is being requested to enable the staff to determine compliance with 10 CFR 71.81.

Westinghouse Response:

Change Section 7.3 to read as follows:

7.3 PREPARATION OF EMPTY PACKAGE FOR TRANSPORT

- Verify the package is empty of contents.
- Verify radiation levels do not exceed limits prescribed in 49 CFR 173.421 (a) (2).
- Verify non-fixed radioactive surface contamination does not exceed limits prescribed in 49 CFR 173.421 (a) (3).
- Verify the package does not contain more than 15 grams of uranium-235.
- Verify the packaging is in unimpaired condition and is securely closed.
- Verify the internal contamination does not exceed 100 times limits prescribed in 49 CFR 173.428 (c).
- Remove any previously applied labels affixed for fuel shipments.
- Affix an “Empty” label.

Chapter 8 Acceptance Tests and Maintenance Program

8-1 Confirm that the reference to the regulation provided in Section 8.1 should be “10 CFR 71.85(c)” rather than “10 CFR 71.85(c)1."

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

The reference should be “10 CFR 71.85(c). Section 8.1 reads as follows:

> Per the requirements of 10 CFR §71.85(c), this section discusses the inspections and acceptance tests to be performed prior to first use of the Traveller package. Complete detailed instructions are outlined within the individual plant operating procedures and quality control instructions pertinent to each specific operation.

8-2 Revise Section 8.1.1 to include a discussion describing the inspection that will be performed to verify that the packaging components are within tolerances on the engineering drawings, the components fit together properly, and that all fasteners are in place and properly installed.

This information is being requested to allow the staff to determine compliance with 10 CFR 71.85(c).

Westinghouse Response:

The following text has been added to Section 8.1.1:

> The Traveller STD and Traveller XL packages have manufacturing drawings that are controlled within a quality control process. The drawings have quality characteristics that must be inspected during the process. These characteristics were selected to ensure that safety related components are within tolerance and properly installed but also to ensure that the package will fit up properly. Source inspection and final release of the package will be performed by Westinghouse to verify the quality characteristics were inspected and that the package is acceptable. Any characteristic that is out of specification must be reported. It will then be dispositioned according to Westinghouse procedure.

8-3 Revise the discussion in Section 8.1.5.1.6 to include reasonable assurance that the leachable chlorides in the polyurethane foam will be <1 ppm. Reasonable assurance could be demonstrated by test results that verify the value of 1 ppm. Although the foam is a closed cell polyurethane foam, the fabrication process may produce a structure that could cause leaching. The revised discussion should address how the value for the leachable chlorides will be demonstrated.

This information is being requested to allow the staff to determine compliance with 10 CFR 71.43(d).

Westinghouse Response:

The following text has been added to Section 8.1.5.1.6:

Leachable chloride testing is required when using stainless steel as the container structure because free chloride ions in contact with the container sides have been faulted as a contributor to stress corrosion cracking. Leachable chlorides will not be greater than 1 ppm when tested in accordance with GP-TM9510: Method for Sample Preparation and Determination of Leachable Chlorides in Rigid Polyurethane Foam or EPA 300.0: Determination of Inorganic Anions by Ion Chromatography.

8-4 Revise Section 8.1.5.2 to include a separate section containing the acceptance criteria for borated aluminum (90-percent credit) and BORAL (75-percent credit). Indicate the correct values for the minimum effective B-10 areal density. Also, correct discrepancies in the SAR concerning the areal density. The acceptance criteria is used to ensure that the manufacturing process is operating in a satisfactory manner. There is a need to have separate acceptance criteria for the borated aluminum and Boral because the testing and selected measurable parameters are different.

This information is being requested under the provisions of 10 CFR 71.33 to allow the staff to verify that the borated aluminum and Boral will maintain criticality control.

Westinghouse Response:

Section 8.1.5.2.1 has been revised and Section 8.1.5.2.1A has been added:

8.1.5.2.1 Borated Aluminum

Boron-10 Areal Density

The Borated Aluminum poison plate minimum ^{10}B areal density for the final thickness of 0.125 ±0.006" is 0.018 gm/cm^2. Acceptance testing may be conducted using neutronics attenuation or chemical analysis to ensure an effective minimum ^{10}B areal density of 0.0163 gm/cm^2 (90% credit of Boron-10). The attenuation are of two types: luminance and transmittance:

a) Neutron Radiograph (luminance) testing – A non-destructive imaging technique for the internal evaluation of materials. It involves attenuation of a neutron beam by an object to be radiographed, and registration of the attenuation process (as an image) on film or video.

b) Neutron Transmittance – A neutron counting testing technique performed to determine the concentration of an isotope in a material. Testing involves placement of test coupons in a calibrated neutron source beam and measuring the number of neutrons allowed to pass through the test material. Based on the number of neutron count, the areal density of the coupon can be calculated and compared to certified standards.

Neutronics Testing Requirements

Neutron Radiograph testing shall be performed for each selected sample with a luminance test or approved equivalent to verify the uniformity of the ^{10}B distribution in the sheet at thermal neutron energies. Inspection results shall be recorded using the appropriate data recording method by the testing facility.

Neutron Transmittance testing shall be performed at thermal neutron energies per approved test method to verify the minimum required ^{10}B concentration. Test coupons are considered acceptable when the transmittance data indicates a ^{10}B areal density equal to or greater than 0.018 gm/cm^2. Statistical data on transmissivity may be coupled with luminescence test data to demonstrate uniformity of the boron material.

Chemical Testing Requirements

Chemical testing may be employed as an acceptable substitute to the neutronics testing to verify the minimum areal density of ^{10}B is present in the poison plate. Prior to ^{10}B verification by chemical testing, the process shall be demonstrated to be equivalent to the neutronics testing described with respect to ^{10}B uniformity and isotopic composition. Test coupons are considered acceptable when the calculated ^{10}B areal density is equal to or greater than is 0.018 gm/cm^2.

Sampling Rates and Test Methods

The inspection levels shall be as stipulated in the supplier submitted process specification(s). Test methods, when not referenced herein, shall be reviewed by Westinghouse Columbia engineering. Sample coupons shall be randomly selected and be representative of the configuration, material, and lot being evaluated.

Requirement	Number of Tests Per Lot	Test Method
Aluminum Alloy Composition	1 per Heat	ASTM B209 and Approved Procedure
Neutron Radiograph	100%$^{(1)}$	Approved Procedure
Neutron Transmittance for ^{10}B Areal Density	100%$^{(1)}$	Approved Procedure
Chemical Testing	100%$^{(2)}$	Approved Procedure

Notes:

(1) For every lot, initial sampling of coupons for neutron transmission measurements and radiograph/radioscopy shall be 100%, which shall be considered normal sampling. Rejection of a given coupon shall result in rejection of any contiguous plate(s). Reduced sampling (50%) may be introduced based upon acceptance of all coupons in the first 25% of the lot. The approved process specification shall reflect the use of reduced sampling, as applicable. A rejection during reduced inspection will require a return to 100% inspection of the lot.

(2) For every lot, initial sampling of coupons for chemical testing shall be 100%, which shall be considered normal sampling. Rejection of a given coupon shall result in rejection of any contiguous plate(s). Reduced sampling of the lot to 95/95 confidence sampling is acceptable based upon acceptance of all coupons in the first 25% of the lot. The approved process specification shall reflect the use of reduced sampling, as applicable. A rejection during reduced inspection will require a return to 100% inspection of the lot.

8.1.5.2.1A BORAL

Boron-10 Areal Density

The BORAL poison plate minimum ^{10}B areal density for the final thickness of 0.125 ±0.006" is 0.024 gm/cm^2. Acceptance testing may be conducted using neutronics attenuation or chemical analysis to ensure an effective minimum ^{10}B areal density of 0.018 gm/cm^2 (75% credit of Boron-10). The attenuation are of two types: luminance and transmittance:

a) Neutron Radiograph (luminance) testing – A non-destructive imaging technique for the internal evaluation of materials. It involves attenuation of a neutron beam by an object to be radiographed, and registration of the attenuation process (as an image) on film or video.

b) Neutron Transmittance – A neutron counting testing technique performed to determine the concentration of an isotope in a material. Testing involves placement of test coupons in a calibrated neutron source beam and measuring the number of neutrons allowed to pass through the test material. Based on the number of neutron count, the areal density of the coupon can be calculated and compared to certified standards.

Neutronics Testing Requirements

Neutron Radiograph testing shall be performed for each selected sample with a luminance test or approved equivalent to verify the uniformity of the ^{10}B distribution in the sheet at thermal neutron energies. Inspection results shall be recorded using the appropriate data recording method by the testing facility.

Neutron Transmittance testing shall be performed at thermal neutron energies per approved test method to verify the minimum required ^{10}B concentration. Test coupons are considered acceptable when the transmittance data indicates a ^{10}B areal density equal to or greater than 0.024 gm/cm^2. Statistical data on transmissivity may be coupled with luminescence test data to demonstrate uniformity of the boron material.

Chemical Testing Requirements

Chemical testing may be employed as an acceptable substitute to the neutronics testing to verify the minimum areal density of ^{10}B is present in the poison plate. Prior to ^{10}B verification by chemical testing, the process shall be demonstrated to be equivalent to the neutronics testing described with respect to ^{10}B uniformity and isotopic composition. Test coupons are considered acceptable when the calculated ^{10}B areal density is equal to or greater than is 0.024 gm/cm^2.

Sampling Rates and Test Methods

The inspection levels shall be as stipulated in the supplier submitted process specification(s). Test methods, when not referenced herein, shall be reviewed by Westinghouse Columbia engineering. Sample coupons shall be randomly selected and be representative of the configuration, material, and lot being evaluated.

Requirement	Number of Tests Per Lot	Test Method
Aluminum Alloy Composition	1 per Heat	ASTM B209 and Approved Procedure
Neutron Radiograph	100%[(1)]	Approved Procedure
Neutron Transmittance for ^{10}B Areal Density	100%[(1)]	Approved Procedure
Chemical Testing	100%[(2)]	Approved Procedure

Notes:

(1) For every lot, initial sampling of coupons for neutron transmission measurements and radiograph/radioscopy shall be 100%, which shall be considered normal sampling. Rejection of a given coupon shall result in rejection of any contiguous plate(s). Reduced sampling (50%) may be introduced based upon acceptance of all coupons in the first 25% of the lot. The approved process specification shall reflect the use of reduced sampling, as applicable. A rejection during reduced inspection will require a return to 100% inspection of the lot.

(2) For every lot, initial sampling of coupons for chemical testing shall be 100%, which shall be considered normal sampling. Rejection of a given coupon shall result in rejection of any contiguous plate(s). Reduced sampling of the lot to 95/95 confidence sampling is acceptable based upon acceptance of all coupons in the first 25% of the lot. The approved process specification shall reflect the use of reduced sampling, as applicable. A rejection during reduced inspection will require a return to 100% inspection of the lot.

8-5 Revise Section 8.1.5.2 to include a statement that neutron transmission testing will be used to verify the minimum effective B-10 areal density for borated aluminum at the 90-percent credit level. An acceptable alternative would be to demonstrate that chemical analysis is an acceptable alternative for verifying the minimum effective B-10 areal density for enriched borated aluminum at the 90-percent level of credit. Also, provide a detailed discussion of the sampling plan and acceptance criteria based on statistical analysis that includes how uncertainties are accounted for in the analysis.

This information is being requested in accordance with the provisions of 10 CFR 71.33 which requires an application to include a description in sufficient detail to identify the package accurately and provide sufficient basis for evaluation of the package.

Westinghouse Response:

Section 8.1.5.2.1 has been revised and Section 8.1.5.2.1A has been added:

8.1.5.2.1 Borated Aluminum

Boron-10 Areal Density

The Borated Aluminum poison plate minimum ^{10}B areal density for the final thickness of 0.125 ±0.006" is 0.018 gm/cm^2. Acceptance testing may be conducted using neutronics attenuation or chemical analysis to ensure an effective minimum ^{10}B areal density of 0.0163 gm/cm^2 (90% credit of Boron-10). The attenuation are of two types: luminance and transmittance:

a) Neutron Radiograph (luminance) testing – A non-destructive imaging technique for the internal evaluation of materials. It involves attenuation of a neutron beam by an object to be radiographed, and registration of the attenuation process (as an image) on film or video.

b) Neutron Transmittance – A neutron counting testing technique performed to determine the concentration of an isotope in a material. Testing involves placement of test coupons in a calibrated neutron source beam and measuring the number of neutrons allowed to pass through the test material. Based on the number of neutron count, the areal density of the coupon can be calculated and compared to certified standards.

Neutronics Testing Requirements

Neutron Radiograph testing shall be performed for each selected sample with a luminance test or approved equivalent to verify the uniformity of the ^{10}B distribution in the sheet at thermal neutron energies. Inspection results shall be recorded using the appropriate data recording method by the testing facility.

Neutron Transmittance testing shall be performed at thermal neutron energies per approved test method to verify the minimum required ^{10}B concentration. Test coupons are considered acceptable when the transmittance data indicates a ^{10}B areal density equal to or greater than 0.018 gm/cm^2. Statistical data on transmissivity may be coupled with luminescence test data to demonstrate uniformity of the boron material.

Chemical Testing Requirements

Chemical testing may be employed as an acceptable substitute to the neutronics testing to verify the minimum areal density of ^{10}B is present in the poison plate. Prior to ^{10}B verification by chemical testing, the process shall be demonstrated to be equivalent to the neutronics testing described with respect to ^{10}B uniformity and isotopic composition. Test coupons are considered acceptable when the calculated ^{10}B areal density is equal to or greater than is 0.018 gm/cm^2.

Sampling Rates and Test Methods

The inspection levels shall be as stipulated in the supplier submitted process specification(s). Test methods, when not referenced herein, shall be reviewed by Westinghouse Columbia engineering. Sample coupons shall be randomly selected and be representative of the configuration, material, and lot being evaluated.

Requirement	Number of Tests Per Lot	Test Method
Aluminum Alloy Composition	1 per Heat	ASTM B209 and Approved Procedure
Neutron Radiograph	100%(1)	Approved Procedure
Neutron Transmittance for ^{10}B Areal Density	100%(1)	Approved Procedure
Chemical Testing	100%(2)	Approved Procedure

Notes:

(1) For every lot, initial sampling of coupons for neutron transmission measurements and radiograph/radioscopy shall be 100%, which shall be considered normal sampling. Rejection of a given coupon shall result in rejection of any contiguous plate(s). Reduced sampling (50%) may be introduced based upon acceptance of all coupons in the first 25% of the lot. The approved process specification shall reflect the use of reduced sampling, as applicable. A rejection during reduced inspection will require a return to 100% inspection of the lot.

(2) For every lot, initial sampling of coupons for chemical testing shall be 100%, which shall be considered normal sampling. Rejection of a given coupon shall result in rejection of any contiguous plate(s). Reduced sampling of the lot to 95/95 confidence sampling is acceptable based upon acceptance of all coupons in the first 25% of the lot. The approved process specification shall reflect the use of reduced sampling, as applicable. A rejection during reduced inspection will require a return to 100% inspection of the lot.

8.1.5.2.1A BORAL

Boron-10 Areal Density

The BORAL poison plate minimum ^{10}B areal density for the final thickness of 0.125 ±0.006" is 0.024 gm/cm^2. Acceptance testing may be conducted using neutronics attenuation or chemical analysis to ensure an effective minimum ^{10}B areal density of 0.018 gm/cm^2 (75% credit of Boron-10). The attenuation are of two types: luminance and transmittance:

a) Neutron Radiograph (luminance) testing – A non-destructive imaging technique for the internal evaluation of materials. It involves attenuation of a neutron beam by an object to be radiographed, and registration of the attenuation process (as an image) on film or video.

b) Neutron Transmittance – A neutron counting testing technique performed to determine the concentration of an isotope in a material. Testing involves placement of test coupons in a calibrated neutron source beam and measuring the number of neutrons allowed to pass through the test material. Based on the number of neutron count, the areal density of the coupon can be calculated and compared to certified standards.

Neutronics Testing Requirements

Neutron Radiograph testing shall be performed for each selected sample with a luminance test or approved equivalent to verify the uniformity of the ^{10}B distribution in the sheet at thermal neutron energies. Inspection results shall be recorded using the appropriate data recording method by the testing facility.

Neutron Transmittance testing shall be performed at thermal neutron energies per approved test method to verify the minimum required ^{10}B concentration. Test coupons are considered acceptable when the transmittance data indicates a ^{10}B areal density equal to or greater than 0.024 gm/cm^2. Statistical data on transmissivity may be coupled with luminescence test data to demonstrate uniformity of the boron material.

Chemical Testing Requirements

Chemical testing may be employed as an acceptable substitute to the neutronics testing to verify the minimum areal density of ^{10}B is present in the poison plate. Prior to ^{10}B verification by chemical testing, the process shall be demonstrated to be equivalent to the neutronics testing described with respect to ^{10}B uniformity and isotopic composition. Test coupons are considered acceptable when the calculated ^{10}B areal density is equal to or greater than is 0.024 gm/cm^2.

Sampling Rates and Test Methods

The inspection levels shall be as stipulated in the supplier submitted process specification(s). Test methods, when not referenced herein, shall be reviewed by Westinghouse Columbia engineering. Sample coupons shall be randomly selected and be representative of the configuration, material, and lot being evaluated.

Requirement	Number of Tests Per Lot	Test Method
Aluminum Alloy Composition	1 per Heat	ASTM B209 and Approved Procedure
Neutron Radiograph	100%[(1)]	Approved Procedure
Neutron Transmittance for ^{10}B Areal Density	100%[(1)]	Approved Procedure
Chemical Testing	100%[(2)]	Approved Procedure

Notes:

(1) For every lot, initial sampling of coupons for neutron transmission measurements and radiograph/radioscopy shall be 100%, which shall be considered normal sampling. Rejection of a given coupon shall result in rejection of any contiguous plate(s). Reduced sampling (50%) may be introduced based upon acceptance of all coupons in the first 25% of the lot. The approved process specification shall reflect the use of reduced sampling, as applicable. A rejection during reduced inspection will require a return to 100% inspection of the lot.

(2) For every lot, initial sampling of coupons for chemical testing shall be 100%, which shall be considered normal sampling. Rejection of a given coupon shall result in rejection of any contiguous plate(s). Reduced sampling of the lot to 95/95 confidence sampling is acceptable based upon acceptance of all coupons in the first 25% of the lot. The approved process specification shall reflect the use of reduced sampling, as applicable. A rejection during reduced inspection will require a return to 100% inspection of the lot.

8-6 Revise Section 8.1.5.2 to include a separate acceptance criteria and sampling plan for Boral using chemical and/or neutron transmission testing to determine the minimum effective areal density. Also, provide clear indication if the criteria is applicable to borated aluminum or Boral.

This information is being requested in accordance with the provisions of 10 CFR 71.33 which requires an application to include a description in sufficient detail to identify the package accurately and provide sufficient basis for evaluation of the package.

Westinghouse Response:

Section 8.1.5.2.1 has been revised and Section 8.1.5.2.1A has been added:

8.1.5.2.1 Borated Aluminum

Boron-10 Areal Density

The Borated Aluminum poison plate minimum ^{10}B areal density for the final thickness of 0.125 ±0.006" is 0.018 gm/cm^2. Acceptance testing may be conducted using neutronics attenuation or chemical analysis to ensure an effective minimum ^{10}B areal density of 0.0163 gm/cm^2 (90% credit of Boron-10). The attenuation are of two types: luminance and transmittance:

a) Neutron Radiograph (luminance) testing – A non-destructive imaging technique for the internal evaluation of materials. It involves attenuation of a neutron beam by an object to be radiographed, and registration of the attenuation process (as an image) on film or video.

b) Neutron Transmittance – A neutron counting testing technique performed to determine the concentration of an isotope in a material. Testing involves placement of test coupons in a calibrated neutron source beam and measuring the number of neutrons allowed to pass through the test material. Based on the number of neutron count, the areal density of the coupon can be calculated and compared to certified standards.

Neutronics Testing Requirements

Neutron Radiograph testing shall be performed for each selected sample with a luminance test or approved equivalent to verify the uniformity of the ^{10}B distribution in the sheet at thermal neutron energies. Inspection results shall be recorded using the appropriate data recording method by the testing facility.

Neutron Transmittance testing shall be performed at thermal neutron energies per approved test method to verify the minimum required ^{10}B concentration. Test coupons are considered acceptable when the transmittance data indicates a ^{10}B areal density equal to or greater than 0.018 gm/cm^2. Statistical data on transmissivity may be coupled with luminescence test data to demonstrate uniformity of the boron material.

Chemical Testing Requirements

Chemical testing may be employed as an acceptable substitute to the neutronics testing to verify the minimum areal density of ^{10}B is present in the poison plate. Prior to ^{10}B verification by chemical testing, the process shall be demonstrated to be equivalent to the neutronics testing described with respect to ^{10}B uniformity and isotopic composition. Test coupons are considered acceptable when the calculated ^{10}B areal density is equal to or greater than is 0.018 gm/cm^2.

Sampling Rates and Test Methods

The inspection levels shall be as stipulated in the supplier submitted process specification(s). Test methods, when not referenced herein, shall be reviewed by Westinghouse Columbia engineering. Sample coupons shall be randomly selected and be representative of the configuration, material, and lot being evaluated.

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Neutron Transmittance for ^{10}B Areal Density	100%[(1)]	Approved Procedure
Chemical Testing	100%[(2)]	Approved Procedure

Notes:

(1) For every lot, initial sampling of coupons for neutron transmission measurements and radiograph/radioscopy shall be 100%, which shall be considered normal sampling. Rejection of a given coupon shall result in rejection of any contiguous plate(s). Reduced sampling (50%) may be introduced based upon acceptance of all coupons in the first 25% of the lot. The approved process specification shall reflect the use of reduced sampling, as applicable. A rejection during reduced inspection will require a return to 100% inspection of the lot.

(2) For every lot, initial sampling of coupons for chemical testing shall be 100%, which shall be considered normal sampling. Rejection of a given coupon shall result in rejection of any contiguous plate(s). Reduced sampling of the lot to 95/95 confidence sampling is acceptable based upon acceptance of all coupons in the first 25% of the lot. The approved process specification shall reflect the use of reduced sampling, as applicable. A rejection during reduced inspection will require a return to 100% inspection of the lot.

8.1.5.2.1A BORAL

Boron-10 Areal Density

The BORAL poison plate minimum ^{10}B areal density for the final thickness of 0.125 ±0.006" is 0.024 gm/cm^2. Acceptance testing may be conducted using neutronics attenuation or chemical analysis to ensure an effective minimum ^{10}B areal density of 0.018 gm/cm^2 (75% credit of Boron-10). The attenuation are of two types: luminance and transmittance:

a) Neutron Radiograph (luminance) testing – A non-destructive imaging technique for the internal evaluation of materials. It involves attenuation of a neutron beam by an object to be radiographed, and registration of the attenuation process (as an image) on film or video.

b) Neutron Transmittance – A neutron counting testing technique performed to determine the concentration of an isotope in a material. Testing involves placement of test coupons in a calibrated neutron source beam and measuring the number of neutrons allowed to pass through the test material. Based on the number of neutron count, the areal density of the coupon can be calculated and compared to certified standards.

Neutronics Testing Requirements

Neutron Radiograph testing shall be performed for each selected sample with a luminance test or approved equivalent to verify the uniformity of the ^{10}B distribution in the sheet at thermal neutron energies. Inspection results shall be recorded using the appropriate data recording method by the testing facility.

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Chemical Testing Requirements

Chemical testing may be employed as an acceptable substitute to the neutronics testing to verify the minimum areal density of ^{10}B is present in the poison plate. Prior to ^{10}B verification by chemical testing, the process shall be demonstrated to be equivalent to the neutronics testing described with respect to ^{10}B uniformity and isotopic composition. Test coupons are considered acceptable when the calculated ^{10}B areal density is equal to or greater than is 0.024 gm/cm^2.

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Notes:

(1) For every lot, initial sampling of coupons for neutron transmission measurements and radiograph/radioscopy shall be 100%, which shall be considered normal sampling. Rejection of a given coupon shall result in rejection of any contiguous plate(s). Reduced sampling (50%) may be introduced based upon acceptance of all coupons in the first 25% of the lot. The approved process specification shall reflect the use of reduced sampling, as applicable. A rejection during reduced inspection will require a return to 100% inspection of the lot.

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8-7 Correct the typographic errors in Section 8.1.5 concerning the areal density of the neutron absorbers. Two of the subsections in 8.1.5 indicate that the areal density can be found in Subsection 8.1.4.2.1. However, there is no subsection 8.1.4.2.1 in the SAR. Also, correct the notes in the table contained in Section 8.1.5.2.6. The table notes references Section 8.1.4.2.3 and 8.1.4.2.4. However, these two referenced sections are not in the SAR.

This information is required in accordance with 10 CFR Part 71.7(a), which states that all information provided to the NRC by an applicant must be complete and accurate in all material respects.

Westinghouse Response:

Section 8.1.5.2.1 has been revised and Section 8.1.5.2.1A has been added:

8.1.5.2.1 Borated Aluminum

Boron-10 Areal Density

The Borated Aluminum poison plate minimum ^{10}B areal density for the final thickness of 0.125 ±0.006" is 0.018 gm/cm^2. Acceptance testing may be conducted using neutronics attenuation or chemical analysis to ensure an effective minimum ^{10}B areal density of 0.0163 gm/cm^2 (90% credit of Boron-10). The attenuation are of two types: luminance and transmittance:

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Notes:

(1) For every lot, initial sampling of coupons for neutron transmission measurements and radiograph/radioscopy shall be 100%, which shall be considered normal sampling. Rejection of a given coupon shall result in rejection of any contiguous plate(s). Reduced sampling (50%) may be introduced based upon acceptance of all coupons in the first 25% of the lot. The approved process specification shall reflect the use of reduced sampling, as applicable. A rejection during reduced inspection will require a return to 100% inspection of the lot.

(2) For every lot, initial sampling of coupons for chemical testing shall be 100%, which shall be considered normal sampling. Rejection of a given coupon shall result in rejection of any contiguous plate(s). Reduced sampling of the lot to 95/95 confidence sampling is acceptable based upon acceptance of all coupons in the first 25% of the lot. The approved process specification shall reflect the use of reduced sampling, as applicable. A rejection during reduced inspection will require a return to 100% inspection of the lot.

8.1.5.2.1A BORAL

Boron-10 Areal Density

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Notes:

(1) For every lot, initial sampling of coupons for neutron transmission measurements and radiograph/radioscopy shall be 100%, which shall be considered normal sampling. Rejection of a given coupon shall result in rejection of any contiguous plate(s). Reduced sampling (50%) may be introduced based upon acceptance of all coupons in the first 25% of the lot. The approved process specification shall reflect the use of reduced sampling, as applicable. A rejection during reduced inspection will require a return to 100% inspection of the lot.

(2) For every lot, initial sampling of coupons for chemical testing shall be 100%, which shall be considered normal sampling. Rejection of a given coupon shall result in rejection of any contiguous plate(s). Reduced sampling of the lot to 95/95 confidence sampling is acceptable based upon acceptance of all coupons in the first 25% of the lot. The approved process

specification shall reflect the use of reduced sampling, as applicable. A rejection during reduced inspection will require a return to 100% inspection of the lot.

8-8 Provide information that demonstrates that a B_4C loading of 36.5-percent in the BORAL will remain durable during normal conditions of transport. BORAL and other neutron absorbers become very brittle when higher loading, such as, 36.5-percent, are used in the matrix.

This information is being requested under the provisions of 10 CFR 71.33 to allow the staff to verify compliance with 10 CFR 71.35, also see Interim Staff Guidance-15, Section X.5.2.7, Page 14.

Westinghouse Response:

The following text has been added to Section 8.1.5.2:

To ensure the BORAL meets the drawing requirements, the plates will be inspected on a periodic basis not to exceed five years per Section 8.2.5. This will ensure that the BORAL maintains its durability throughout its service lifetime. The visual inspection will verify that the plates are present and in good condition. This includes inspection of the BORAL core for chipping or flaking resulting from brittleness. There are no significant loads applied to the BORAL plates, therefore no durability problems should arise during normal conditions of transport.

8-9 Revise Section 8.1.5.2.6 to include a definition of coupon.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.35.

Westinghouse Response:

Revised Section 8.1.5.2.6 to replace paragraph (c) and added new paragraph (d):

c) Coupon (Borated aluminum) – A randomly selected sample of a lot representative of the neutron absorber used for acceptance testing of the candidate material.

d) Coupon (BORAL) – A selected sample of the thinnest section of a lot of the neutron absorber used for acceptance testing of the candidate material.

8-10 Revise Section 8.1.5.2.5 to include the acceptance and rejection criteria for the visual inspection discussed in that section.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.35.

Westinghouse Response:

Revised Section 8.1.5.2.5 as follows:

For all plates, the finished plate shall be free of visual surface cracks, blisters, pores, or foreign inclusions.

Borated Aluminum

Surface roughness shall not exceed 250 RMS maximum.

BORAL

Evidence of foreign material shall be cause for rejection (embedded pieces of B_4C matrix are not considered foreign material). Creases or other surface discontinuities are acceptable on the cladding of the BORAL provided the core is not exposed. If necessary, the plate shall be examined with a 5X glass to determine if a surface indication is a crease or a crack. Surface roughness shall not exceed 125 RMS roughness maximum.

8-11 Revise Section 8.1.5.2 to indicate whether any major or minor processing changes will be employed that could effect the overall durability or neutron effectiveness of Boral. Such processing changes may require the material to be re-qualified to ensure its durability and efficacy.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.35.

Westinghouse Response:

The following text has been added to Section 8.1.5.2:

No processing changes are anticipated for the production of BORAL since the established process will be used to produce the packages.

8-12 Revise Section 8.2 to describe any other inspections performed on a schedule, other than the inspections of the fasteners, brained fiberglass sleaving, or neuronic components, that will ensure the Traveller packaging will continue proper functioning throughout its service life. These inspections may include outside material, impact limiters, or closure mechanisms. Also, include a discussion of corrective measures to be taken if the Traveller packaging is found to be damaged during these inspections.

This information is being requested to enable the staff to determine compliance with the requirements of 10 CFR 71.93.

Westinghouse Response:

Added the following text to Section 8.2:

Visual inspection for damage of all exposed surfaces will be performed before each use. Individual components will also be inspected as described in the sections below. If any defects are found during inspection, the package will be segregated and dispositioned by standard site procedure before its next use.