UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION REPORT

Docket No. 71-9797
West Valley Melter Package
Revision No. 0

SUMMARY

By letter dated October 16, 2014, and supplemented April 16, 2015, the U.S. Department of Energy (DOE) West Valley Demonstration Project (WVDP) submitted an application for a Special Package Authorization for the West Valley Melter Package (WVMP). The WVMP will be transported from the West Valley site to the Waste Control Specialist (WCS) disposal site in Andrews, Texas. Authorization is requested for a one-time only shipment primarily by rail.

The exterior surface of the melter was coated with a polymeric barrier system to ensure fixation of the surface contamination. The WVMP is a Type B, fissile exempt, rectangular shaped package, 15'9" long by 12'7" wide by 12'6.5'', with eight shock absorbers and an impact limiter. The maximum fully loaded weight is approximately 390,800 lbs.

NRC staff reviewed the application using the guidance in NUREG-1609, "Standard Review Plan for Transportation Packages for Radioactive Material." The package was evaluated to meet the regulatory requirements of 10 CFR Part 71, and where applicable to the requirements of 10 CFR 71.41(d) – Special Package Authorization - which states that the applicant shall demonstrate that "the overall level of safety in transport …is at least equivalent to that which would be provided if all the applicable requirements had been met." For example, the absence of fracture toughness testing data on the 6 inch and 4 inch thick carbon steel plates led the applicant to establish a limited service temperature of 3°F, a temperature found to be reasonable by staff in a first approach. However, based on the range of possible limited service temperatures, and as a conservative approach to ensure that the 6 inch steel plates are not subject to brittle fracture conditions, the staff is imposing a condition that the package shall not be transported if the ambient temperature is below 15°F. With this condition, the staff finds that cold conditions do not substantially reduce the effectiveness of the package. The containment is not leak-tight but the applicant demonstrated compliance with the leakage dose rates stipulated in 10 CFR 71.51(a)(1) and (a)(2).

Based on the statements and representations in the application, the staff concludes that a Special Package Authorization is acceptable and meets the requirements of 10 CFR Part 71. Accordingly, the package is authorized for a one-time only shipment for disposal.

Reference

Safety Analysis Report for the West Valley Melter Package, SARWVMP-01, Revision No. 1, April 2015.

1.0 GENERAL INFORMATION

1.1 Special Package Authorization

The application was reviewed to meet the requirements of 10 CFR Part 71 and where applicable to meet the requirements of 10 CFR 71.41(d) – Special Package Authorization. This provision of the regulations is intended to apply only in limited circumstances and only to one-time shipments, as is the case for the WVMP package.

As required by 10 CFR 71.41(d), "packages for which compliance with other provisions of these regulations, i.e., 10 CFR Part 71, is impracticable shall not be transported, except under special package authorization." The provision states that a special package authorization may be issued if the applicant demonstrates the following:

(1) compliance with the other provisions of the regulations is impracticable,

(2) requisite standards of safety established by the regulations are demonstrated through means alternate to the other provisions, and

(3) the overall level of safety in transport for these shipments is at least equivalent to that which would be provided if all the applicable requirements had been met.

The review of the WVMP application considered the above stated requirements and noted where the provisions of 10 CFR 71.41(d) are applicable.

1.2 Package Description

The WVMP is a rectangular shaped package, 15'9" long by 12'7" wide by 12'6.5'' high, with eight shock absorbers and an impact limiter. The maximum weight of the package is approximately 390,800 lbs. The impact limiter, constructed of steel plate and foam filled steel tubing, is attached to the shock absorbers on the bolted door side of the Grouted Melter Package (GMP). The impact limiter is made of 2" by 9" steel plates and foam-filled 6" by 10" tube steel. The WVMP package is constituted by the GMP with the impact limiter (IL) in place.

The GMP consists of a container and of the melter which is completely encased in Low Density Cellular Concrete (LDCC):

(i) The container, fabricated with SA516, Grade 70 carbon steel, has a bolted side door recessed into the container secured with 32 ASTM A193-B7 1½-inch diameter bolts. This bolted side door has a neoprene gasket.

(ii) The melter has an exterior structural steel frame with its interior lined with refractory materials. The maximum envelope dimensions of the melter are 11'10" long by 10'9 ¾" wide by 10'5 ½" high. All external surfaces of the melter are coated with three layers of a contamination fixative. The interior of the melter contains refractory material, vitrified glass, and LDCC. The weight of the melter, its refractory, and the residual vitrified glass, is approximately 107,500 lbs.

The containment feature is the WVMP's container. This containment is not leak-tight, but demonstrates compliance with 10 CFR Part 71 leakage dose rates for normal conditions of

transport (NCT) in 10 CFR 71.51(a)(1) and with hypothetical accident conditions (HAC) in 10 CFR 71.51(a)(2).

The gamma shielding features of the WVMP include the 6" thick side walls of the container and the 4" thick top and bottom, made of SA516 carbon steel. The next gamma shielding feature is the LDCC, filling the annular space in the container. The innermost gamma shielding feature is the melter. The melter contains refractory brick, Inconel, and Type 304L stainless steel. The neutron dose is negligible.

1.3 Contents

The melter contains four primary source terms consisting of (1) the heel contained within the melter cavity, (2) the residual glass contained within the cracks, crevices and interstitial spacing in the refractory bricks, (3) the plugged discharge pour spout, and (4) the surface contamination on the melter exterior. Each of these source terms was characterized independently using analytical data associated with the processed high level waste materials, and swipe sample results. In characterizing the melter, a conservative approach was taken to ensure that the isotopic distribution and associated activity was bounded. Decay correction was incorporated in the final content.

The physical form of the contents is solid. The chemical form of the contents is oxide and nonreactive. The total activity associated with the melter is 3,554 curies, with Cs-137 (Ba-137m) and Sr-90 (Y-90) contributing greater than 99.8 percent of the activity. Other nuclides present include actinides, other fission products, activation products, and other associated daughter products, with a combined contribution to total activity of less than 0.2 percent. The total number of A_2s for the WVMP package is 214.9.

The melter contains fissile radionuclides in the form of Pu-239, Pu-241, U-233, and U-235 with a bounding fissile content of 81.56 grams. Of the 81.56 grams of fissile material, 80.90 grams is contained within 467 kg of vitrified glass contained within the melter. The remaining 0.66 grams of fissile material is fixed to the outer surface of the melter's body. The WVMP is fissile exempt and there are no criticality control features.

2.0 STRUCTURAL EVALUATION

The objective of the structural review is to evaluate the structural performance of the package for meeting the requirements of 10 CFR Part 71, including performance under both NCT and HAC. This application was submitted under 10 CFR 71.41(d), and as said in Section 1.1 above, the applicant must demonstrate that the overall level of safety for the package shipment is at least equivalent to that which would be provided if all the applicable requirements of 10 CFR Part 71 had been met. Specifically, with the material procurement, fabrication and examination already completed, it is impractical to meet all the structural design provisions of ASME B&PV Code Division III, Section ND, for a Type B transportation package, including the fracture toughness of the ASTM A516 steel not being able to meet the -40°F requirement in still air or the -20°F initial condition for the NCT and HAC tests.

2.1 Description of Structural Design

2.1.1 Discussion

According to the applicant, the WVMP package consists of two components: the GMP and the IL. The GMP consists of a rectangular shaped steel walled container with sacrificial shock absorbers welded to all eight corners. The container is constructed of ASTM A516 Grade 70 steel plate. The top and bottom are 4 inches thick and the sides are 6 inches thick. All sides, including the top and bottom, of the container are welded with the exception of the side door which is secured with 32 1.5 inch ASTM A193 B7 bolts evenly spaced around the perimeter. The shock absorbers are made of assemblies of 3 inch thick A36 steel plate and are welded to the corners of the container. Inside the container is the vitrification melter encased in 1000 psi LDCC.

The application explains that the IL consists of a window frame-like structure of 2 inch by 9 inch ASTM A36 structural plate that fits over the door and inside the shock absorbers and is attached to the shock absorbers by shear pins that are welded to remain in place. The IL also includes 6" by 10" structural tube that is welded to the 2" by 9" steel frame-like structure and filled with closed-cell, 20 lb/ft^3 density polyurethane foam.

Figure 2-1 in the application illustrates all the components of the WVMP. Table 2-2 of the application summarizes the weights of the individual components that comprise the WVMP. The total weight of the package is 390,800 lbs, with the center of gravity less than 3 inches from the geometric center.

2.1.2 Identification of Codes and Standards for Package Design

The applicant explains that the WVMP is classified as a Type B, Category II package in accordance with NUREG/CR-3854. The ASME fabrication code criteria for a Type B, Category II package is ASME B&PVC, Section III, Division I, Sub-section ND.

The WVMP was originally designed and fabricated as an IP-2 package in accordance with 49 CFR Part 173. Fabrication was accomplished under AWS D1.1, and consequently does not meet all the requirements of Sub-section ND; therefore, under 10 CFR 71.41(d), the applicant must demonstrate that the overall level of safety in transport for the shipment is at least equivalent to that which would be provided if all the applicable requirements of 10 CFR Part 71 had been met. The applicant also uses ASME B&PV Section VIII, Division 2 to establish the maximum strain limit in a multi-axial stress environment and API-579/ASME FFS-1 2007, Fitness-For-Service, to establish the Limiting Service Temperature (LST) in lieu of having fracture toughness data for the ASTM A516 steel plates.

The design criteria for structural analysis, load combination, and fracture toughness for the WVMP structural components are based on ASME B&PVC, Section III, Sub-section ND and Appendix F, and Regulatory Guides 7.6, 7.8 and 7.11.

The staff has reviewed the package structural design description and determined that it is consistent with the guidance provided in Chapter 2 of NUREG-1609, and concludes that the contents of the application satisfy the requirements of 10 CFR 71.31.

2.2 Materials

The applicant states that the container was procured as a 49 CFR 173.411 Industrial Packaging Type 2 (IP-2) package with the associated fabrication and quality assurance requirements and that the WVMP provides an equivalent level of safety with the requirements of NUREG/CD-3019, "Recommended Welding Criteria For Use in the Fabrication of Shipping Containers for

Radioactive Materials," and the ASME Boiler and Pressure Vessel Code, Subsection ND. The applicant documents this assertion in Table 1 in Appendices 1.3.5 and 8.3.2 of the application.

2.2.1 Material Properties and Specifications

Table 2-3 of the application lists the material specification for each component of the WVMP. The materials of construction do not meet ASME specifications, but do meet ASTM specifications. Table 1 of Appendix 8.3.2 of the application lists the ASME Section III, Division 1, Subsection ND provisions that the applicant contends are impractical to meet and identifies the method by which the applicant shows an equivalent level of safety for the material provisions.

The staff has reviewed Table 1 of Appendix 8.3.2 and finds that the equivalent level of safety in accordance with 10 CFR 71.41(d) presented by the applicant for material requirements is acceptable, because the ASME (SA) and ASTM (A) material specifications are identical.

2.2.2 Prevention of Chemical, Galvanic, or Other Reactions

The applicant stated that the materials from which the WVMP is fabricated and the contents will not have significant chemical, galvanic or other reactions in air or water atmospheres. Additionally, the foam insulation is chemically inert and carries no detectable chlorides and the closed-cell nature of the foam precludes water absorption.

Based on the description of the WVMP in the application, the staff concludes that, to the maximum credible extent, there are no significant chemical, galvanic or other reactions among the packaging components, or between the packaging components and the contents in dry or wet environment conditions. Furthermore, considering the dimensions of the container walls, the accepted corrosion rates of carbon steel, and the length of time it will be in service, the staff concludes that any corrosion that may take place will have no significant effect on the structural integrity of the package.

2.2.3 Effects of Radiation on Materials

The applicant stated that the steel structure and bolting material will experience no degradation or activation as a result of the neutron and photon dose rates calculated in Chapter 5 of the application. Additionally, based on experiments conducted at the University of Michigan, the radiation will have no effect on the compressive strength or intumescent properties of the polyurethane foam.

Based on the description of the WVMP in the application, the lack of a significant neutron source in the contents, and the length of time it will be in service, the staff concludes that the applicant's consideration of the effects of radiation on the material that comprise the package containment is acceptable.

2.3 Fabrication and Examination

The applicant states that the WVMP was designed and fabricated in accordance with AWS D1.1 vice ASME B&PV Code, Section III, Division 1, subsection-ND as required by NUREG/CR-3854 for a Type B, Category II package.

The applicant contends that the WVMP provides an equivalent level of safety with the requirements of NUREG/CD-3019 and the ASME Boiler and Pressure Vessel Code, Subsection ND. The applicant documents this assertion in Tables 2 through 6 in Appendices 1.3.5 and 8.3.2 of the application.

2.3.1 Fabrication

Tables 2 and 3 of Appendix 8.3.2 of the application lists the ASME design and fabrication provisions, respectively, that the applicant contends are impractical to meet and the method by which the applicant shows the equivalent level of safety for these design and fabrication provisions. Table 5 of Appendix 8.3.2 of the application lists the ASME welding provisions that the applicant contends are impractical to meet and the method by which the applicant shows the equivalent level of safety for those provisions.

2.3.2 Examination

Table 4 of Appendix 8.3.2 of the application lists the ASME examination provisions that are impractical to meet and the method by which the applicant shows the equivalent level of safety.

The staff has reviewed Tables 2 through 6 of the Appendix 8.3.2 of the application and finds that the equivalent level of safety in accordance with 10 CFR 71.41(d) presented by the applicant for design, fabrication and examination provisions is acceptable, because the container was welded with an approved welding procedure under a quality assurance program that meets the intent of ASME B&PV Code, Section III, Division 1, subsection-ND and the major structural welds were inspected by visual and magnetic particle examination.

2.4 Lifting and Tie-Down Standards for All Packages

2.4.1 Lifting Devices

According to the application, there are four lifting lug attachment plates. Each is a 1 inch thick A572 Gr 60 steel plate that is 21” x 20.75” with a 9.25” x 15.25” section cut out of the center (see item 20 on Sheet 7 of DWG No. 4005-DW-001). The attachment plate is secured to the WVMP with a 0.5” groove weld around the outside and a 1” fillet weld around the inside. Lifting lugs are attached to the attachment plates using eight 1 inch diameter bolts. Neither the lifting lugs nor the bolts are part of the package and are therefore not within the scope of the evaluation. The applicant determined the weld yield capacity of each attachment plate to be 1,650,000 lbs, which is governed by the strength of the base metal of the attachment plate. With a package weight of 390,800 and a total capacity of the four attachment plates of 6,600,000 lbs, the factor of safety for lifting is well above three that is required by 10 CFR 71.45(a).

2.4.2 Tie-Down Devices

The applicant states that two modes of tie-down will be used for the WVMP:

> For truck transport, the applicant considers a specialized two-lane width carrier that is sufficiently wide enough to accommodate the full footprint of the WVMP. The securement is a combination of shear blocks at the base of the package and cables secured to the attachment plates. The hardware that connects to the attachment plate is not part of the package and is therefore not within the scope of the evaluation.

> For railcar transport, the securement consists of blocking and hold-downs at the lower four corners. The extended plates of the four bottom corner shock absorbers are used for hold-down clamps. On the side of the impact limiter, these clamps fit over the IL tube and contact the IL frame where it connects to the shock absorber as shown in figure 2-6 of the application.

The upper shock absorbers do not lend themselves to tie-down or lifting, and the railcar attachment plates on the bottom of the package will be marked “Not for Lifting or Tie-Down.” Because marking a potential tie-down feature of the package “not for use,” does not meet the intent of the 10 CFR 71.45(b)(2) for rendering a structural part of the package that could be used for tie down inoperable, the staff is imposing a condition that the railcar attachment plates on the bottom of the package shall not be used for lifting or tie-down of the package for transport and shall be conspicuously marked “Not for Lifting or Tie-Down.” With this condition, the staff finds that this is acceptable for a one time shipment.

From the static analysis for both configurations, the applicant determined that the maximum load on each attachment plate is 1,494,000 lbs which is less than the yield capacity of 1,650,000 lbs for the attachment plate connections. For the bottom shock absorber attachments, the applicant determined the maximum combined effective stress on the shock absorber, due to bending and shear, to be 29,900 psi, which is less than the yield stress for the A36 steel shock absorbers.

The applicant states that the 1 inch attachment plates will fail before the 6 inch and 4 inch thick steel walls under excessive loads and that this would not impair the package from meeting the other requirements of 10 CFR Part 71. Due to the relative thicknesses of the attachment plates and the container walls, it is not anticipated that failure of the attachment plates will degrade the effectiveness of the package; therefore, the staff finds this to be acceptable and notes that this applies to the shock absorbers as well.

The staff reviewed the calculations and determined that the stress on the shock absorbers is conservative because the applicant did not account for friction between the package and trailer/railcar which serves to reduce the load on the shock absorbers. Additionally, in the static analysis, the applicant only considered the clamping restraint on two shock absorbers for lateral and transverse acceleration forces. Based on the configuration, all four shock absorbers will contribute to the restraint of the package in these directions, and therefore further reduces the load on each shock absorber.

Based on the staff’s review of the applicant’s evaluation, and considering Condition No. 8, the staff determined that it is consistent with the guidance provided in Chapter 2 of NUREG-1609, and finds that the package meets the requirements of 10 CFR 71.45.

2.5 General Considerations for Structural Evaluation of Packaging

2.5.1 Analysis Approach

The applicant used a combination of hand calculations and finite element analysis (FEA) using the ABAQUS FEA software. The FEA model is a complete, three-dimensional model of the entire package. Nodal density and element type are selected based on the type and degree of the expected structural response. The metal components are modeled using classical metal plasticity based on isotropic behavior. The stress-strain behavior is based on ASME code

specification values and code equations. The IL, including the shock absorbers, incorporates element deletion to simulate a maximum possible damage state on the underlying GMP.

The model uses material properties at room temperature. 10 CFR 71.71 and 71.73 both state that the initial conditions for the test described in the respective sections must be based on the ambient temperature preceding and following the tests remain constant between -20°F and 100°F which is most unfavorable for the feature under consideration. At an ambient temperature of -20°F, the applicant determined that the container temperature is -19.9°F (Table 3-1 of the application). For the purposes of the impact tests, a lower temperature will cause a lower value for the Young's modulus which will increase the deceleration and cause a higher g-load on the package. The Young's modulus increases by approximately 2% from -20°F to 78°F for the container materials. The staff finds that this increase will have negligible effects on the resulting g-load for the impact testing and finds that using the material properties at room temperature are acceptable for the tests of 10 CFR 71.71 and 10 CFR 71.73.

The model was verified and validated against 15 problems, 14 using ABAQUS/Standard and one using ABAQUS/Explicit that involves a cask drop with a foam impact limiter. Reference 27 of Appendix 2.12.2 describes each of the problems in detail. The applicant set acceptance criteria of within 3% for problems in which closed form analytical solutions are available and 5% when the results are compared with statistically valid experimental data. The applicant states that the results obtained from the model data files, corresponding to the fourteen test cases, were all within 3% of the theoretically calculated values. The applicant states that the results from test case 15, for which there are no theoretically calculated values, are acceptable because they follow the trend exhibited by the actual experiment. The staff determined that the applicant's process of verification and validation of the ABAQUS Implicit and Explicit products is reasonable and finds that it is acceptable for use.

The walls of the package are connected using one inch partial penetration double groove welds with a backing fillet on the inside. Since the plates are modeled with continuum shell elements, the nodal connectivity only imposes tensile and shear capacity. The staff requested the applicant to justify the analysis for the welded joints that attach the steel plates that comprise the walls, top, and bottom of the package, because the weld loads are not able to be directly tracked. The applicant assessed plastic stress and strain at the weld joints to identify drop orientations that place the highest demands on the welded joints. The applicant chose the HAC center of gravity (CG) over side edge orientation for an enhanced FEA model where the actual weld joint is modeled with through thickness connector elements on the top and bottom surface nodes only. This enhanced FEA model mesh density results in evenly spaced nodes 3.1 inches apart in a direction parallel to the plane of the plate where each connector represents a weld area of 3.1 inches times the appropriate weld throat. The connector element is then modeled with calculated tensile and shear capacities which are removed when these capacities are reached. Once the connector element fails, it is removed from the model. The staff finds that the revised model to evaluate the structural performance of the welded joints for the HAC CG over side edge orientation only is acceptable for use with this one time shipment, because this orientation places the largest load on the welds, and bounds the loading associated with the other NCT and HAC drop orientations.

2.5.2 Minimum Package Size

The smallest overall dimension of the WVMP is over 12 feet; therefore, the staff finds that the package meets the requirements of 10 CFR 71.43(a) for minimum size.

2.5.3 Tamper-Indicating Features

The applicant states that the WVMP consists of two 4 inch thick steel plates and three 6 inch thick steel plates welded together to form a container that houses the melter which is encased in concrete. There are five penetrations used for grouting and inspection which are sealed with circular plugs secured with recessed screws that form a flush finish, and tamper indicating tape is placed over each plug. The 6” thick steel side door is attached with 32 bolts. An impact limiter is pinned and welded to the corner shock absorbers and covers the bolts on the side door. The applicant states that attempts to defeat the closure devices would require mechanical destruction of the structural components.

The staff has reviewed the tamper indicating features of the package as described in the application, and finds that the design of the package as described above meets the requirements of 10 CFR 71.43(b) for a tamper-indicating feature.

2.5.4 Positive Closure

As stated in section 2.5.3 of this SER, the WVMP consists of five welded steel plates and a bolted steel door. The door fits into a recessed opening which creates a perimeter and a face contact region that is filled with a room temperature vulcanization (RTV) to create a seal. The 2” x 9” steel plates of the impact limiter frame fit over the door and are pinned (and the ends of the pins are welded) to the shock absorbers to create a positive closure.

Because the package, as described above, includes a bolted steel door that cannot be opened unintentionally or by pressure from within the package, the staff finds that the package meets the requirements of 10 CFR 71.43(c) for positive closure.

2.6 Normal Conditions of Transport

2.6.1 Heat

The applicant analyzes the WVMP for a 100°F ambient temperature with maximum insolation and an internal heat load of 9.21 watts in Chapter 3 of the application. According to the applicant, the maximum normal operating pressure (MNOP) for the WVMP is 12 psig. The maximum container wall temperature is 209°F with an average through wall temperature of 100°F and a gradient of 10°F. The maximum LDCC temperature is 183°F with an average bulk temperature of less than 150°F. As a result of the 100°F ambient condition with maximum insolation, the top plate of the container experiences the highest temperature increase which heats to an effective average temperature of 200°F. The upper portions of the side walls only heat to approximately 160°F.

The applicant computed the stress in the WVMP container walls from the worst case MNOP and worst case reduced/increased external pressure. The resulting pressure demand of 23.3 psig produced a stress of 5,000 psi on the container top plate. Based on the temperature rise from 160°F to 200°F, the applicant determined the stress in the top to be 9,000 psi due to thermal expansion. Finally, based on the 12 psig MNOP, the applicant calculated the load on the closure bolts to be 7,813 lbs/bolt.

Table 2-6 of the application lists the stress and the stress allowable for primary membrane, primary membrane plus bending, secondary and primary plus secondary stress as well as the bolt loads. The comparison of the actual stress to the stress allowable indicates there is a large

margin of safety for all cases. As a result of the margin of safety, the staff finds that heat does not substantially reduce the effectiveness of the package.

2.6.2 Cold

In Appendix 2.12.2 of the application, the applicant determines a lowest service temperature (LST) of 3°F, the minimum ambient temperature in which the package can be shipped. The LST is set to protect the ASTM A516-70 steel from low temperature embrittlement. The applicant used API-579, Appendix F to determine the Nil Ductility Transition Temperature (NDTT). Appendix F provides a procedure to determine the lower bound fracture toughness of a material when testing data is not available.

Using a computed NDTT of -22.3°F and extrapolating curves from NUREG/CR-1815 (Recommendations for Protecting Against Failure by Brittle Fracture in Ferritic Steel Shipping Containers Up to Four Inches Thick), the applicant applies a 25°F offset to the NDTT to arrive at an LST of 3°F. The applicant further states that NUREG/CR-3826 (Recommendations for Protecting Against Failure by Brittle Fracture in Ferritic Steel Shipping Containers Greater than Four Inches Thick) indicates the same value in that for a flaw aspect ratio of 0.5 inches, the offset (LST - NDTT) can be interpolated between 4 inches (20°F) and 8 inches (53°F) to achieve a value from 30°F – 35°F.

The staff reviewed Appendix 2.12.2, NUREG/CR 1815, NUREG/CR-3826 and the procedures of API-579. The applicant arrived at an LST of 3°F using NUREG/CR-1815 which applies to ferritic material up to 4 inches thick. NUREG/CR-3826 is more appropriate because most of the container walls are 6 inches thick; therefore, the staff conducted a confirmatory analysis using NUREG/CR-3826. Table 4 of the NUREG reports a mean NDTT of -23.8°F for A516 grade 70 steel. The staff plotted the offset temperatures from Table 3 of the NUREG against the respective thicknesses to determine an offset temperature for a 6 inch material with a flaw aspect ratio of 0.5 (used by the applicant to confirm their results). Based on this curve, the offset temperature is 38°F, which, when added to the NDTT, produces a limiting service temperature of 14.2°F. This method produces a value of LST that is more conservative than that of the applicant’s analysis.

The staff reviewed additional literature that indicates the NDTT for ASTM A516 can be as low as -30°F. Using this lower value for NDTT and the staff’s method of analysis produces a LST of 8°F which indicates that the applicant’s LST value of 3°F may be reasonable. Because there is no fracture toughness data for this material, and based on the range of possible LSTs, as a conservative approach to ensure the 6 inch steel plates are not subject to brittle fracture conditions, the staff is imposing a condition that the package shall not be transported if the ambient temperature is below 15°F. With this condition, the staff finds that cold conditions do not substantially reduce the effectiveness of the package.

2.6.3 Reduced External Pressure

As stated in the application, the internal pressure of the WVMP is 12 psig at one atmosphere ambient pressure. A reduction in the atmospheric pressure to 3.5 psia will produce a differential pressure of 23.2 psig in the container. In Appendix 2.12.2, the applicant demonstrates that the container walls can sustain a differential pressure of 97 psig. Additionally, the applicant demonstrated that at 23.2 psig, the load on the bolts that secure the plugs in the 4.5 inch diameter openings is 123 lbs, which is far below their allowable load of 4,800 lbs. Based on the staff’s review of the pressure calculations of Appendix 2.12.2, the staff concludes that the

applicant's demonstrations are reasonable, and that reduced external pressure does not substantially reduce the effectiveness of the package.

2.6.4 Increased External Pressure

The applicant demonstrates that an increase in the atmospheric pressure to 20 psia will produce a differential pressure of 6.7 psig in the container. Based on the staff's review of the applicant's pressure calculations in Appendix 2.12.2, the staff concludes that the calculations are reasonable and therefore, that increased external pressure does not substantially reduce the effectiveness of the package.

2.6.5 Vibration

The applicant evaluated the WVMP for vibration based on a composite over-the-road power spectral density (PSD) obtained from The Design and Development Guide for NNSA Type B Packages (SG-100), Revision 2, published by the Department of Energy. Because the effective g-load from a PSD is dependent on the response frequency of the system being shipped, the applicant considered all frequencies between 1 – 1000 Hz and determined that the worst case occurs at 75 Hz and assumed 100% of the mass acts at that frequency. The applicant also assumed 10% structural damping, which is considered to be conservative. Using the general equation (Eq. 6-2 of Appendix 2.12.2), the applicant determined the maximum root mean square (RMS) g-load to be 1.01g and the maximum g-load (3 to 4 times the RMS) to be 4.0g.

The applicant used this value to compute the maximum stress in the LDCC and the maximum stress in the 32 closure bolts that attach the door to the container. As a result of the 4.0g vibration load, the maximum stress in the LDCC is 78 psi which is much less than the documented 1200 psi compressive strength and the maximum stress in the bolts is 19.5 ksi which is less than the yield strength of 105 ksi.

The staff reviewed the calculations in Appendix 2.12.2 and other literature that discusses shock and vibration. NUREG/CR-0128, Shock and Vibration Environments for a Large Shipping Container during Truck Transport (Part II), uses a 3% damping because, "experience has shown this to be representative of the response of metal-to-metal connections." The staff computed the RMS g-load at 75 Hz using the same PSD used by the applicant, with a 3% damping, and obtained an RMS g-load value of 1.86g which, when multiplied by 3, yields a maximum vibration load of 5.58g. Although a 3% damping produces a higher g-load using the PSD methodology, the peak accelerations reported in NUREG/CR-0128 were about 4.5g, which is similar to that obtained by the applicant. Since the margins of safety for the stress within the LDCC and the closure bolts are extremely high, the staff concludes that a higher g-load will have no impact on the structural performance of the LDCC or the closure bolts and that vibration does not substantially reduce the effectiveness of the package.

2.6.6 Water Spray

The applicant states that the package exterior is constructed of steel with no openings and that water spray will have no effect on package performance. Based on the materials of construction of the WVMP, the staff finds that water spray does not substantially reduce the effectiveness of the package.

2.6.7 Free Drop

The applicant evaluated the WVMP for the one foot free drop by analytical simulations using the ABAQUS/Explicit dynamics computer code. The applicant used the three drop orientations listed below to simulate NCT.

> CG Over Edge: The applicant expects this drop to produce the most damage to the impact limiter. With the WVMP tilted up with the CG over the bottom tip of the impact limiter, the limiter is in its most vulnerable condition for shearing away from the package. The applicant's goal for this simulation is to demonstrate that the impact limiter remains in place after the NCT, it protects the package such that there is no damage to the grouted melter and any damage to the impact limiter will not impair its function during the HAC drop. The applicant's simulation resulted in a minor damage to the lower impact limiter tube, a shear pin stress less than allowable, a closure bolt stress less than allowable, and a less than 0.005% damage to the LDCC with no change in the door seal.
>
> Impact Limiter Side Down Drop: The applicant states that this orientation, expected to challenge the impact limiter's ability to protect the bolted side door, is the orientation for which the impact limiter was designed. The applicant's simulation resulted in an insignificant amount of damage to the impact limiter. The shear pin stresses and the closure bolt stresses remained below allowable values, and the LDCC damage was less than 0.06% and there were no gaps in the door seal.
>
> Flat Side Down: This orientation targets an impact on one of the flat sides that is not protected by the impact limiter or the shock absorbers which produces the highest g-load on the package for the NCT drop and represents the bounding load on the LDCC. The applicant chose a right side down orientation because the melter-to-LDCC-to-wall condition is considered to be the worst case.

Four of the bolts experienced tensile and shear stress interaction greater than 1.0. The applicant considers this acceptable for the following reasons.

- The 100,000 lb tensile load is transient in 4 of the 32 bolts.
- The tensile capacity of the bolts is 136,700 lbs, so they are not expected to fail

Approximately 0.05% of the LDCC is crushed, and this occurs in the area adjacent to the melter, not the wall, and no gaps appear at the door face or perimeter seal.

Two of the shear pins experience shear stress above the allowable limit. The applicant judges the pins to be adequate for the following reasons:

- While the shear stress of 16,327 psi is above the NCT limit of 14,400 psi, it is still below the shear yield stress of 21,600 psi.
- The shear load is transient and less than the static yield condition.
- The shear stress in the pins immediately next to these pins is below the allowable limit., and if yielding of these pins occurs, the pins immediately adjacent will share more of the load.
- The tensile load in the shear pins is essentially zero during the high shear conditions.

2.6.8 Corner Drop

The WVMP is a rectangular package exceeding 50 kg and is not a fiberboard, wood, or fissile material cylindrical package; therefore, the test required by 10 CFR 71.71(c)(8) is not applicable.

2.6.9 Compression

Because the weight of the WVMP exceeds 11,000 lbs, 10 CFR 71.71(c)(9) is not applicable.

2.6.10 Penetration

The applicant states that the package is unaffected by the penetration test which is bounded by the puncture test. The container walls are constructed of 4 inch thick and 6 inch thick steel; therefore, the staff concludes that a 1.25 inch diameter cylinder weighing 13 pounds, dropped from 40 inches will have no adverse effect on the package and that penetration does not substantially reduce the effectiveness of the package.

The staff reviewed the structural performance of the package under NCT and considering Condition No. 6, determined that it is consistent with the guidance provided in Chapter 2 of NUREG-1609, and concludes that there will be no substantial reduction in the effectiveness of the packaging.

2.7 Hypothetical Accident Condition

The applicant evaluated the WVMP for the thirty foot free drop by analytical simulations using the ABAQUS/Explicit dynamics computer code.

2.7.1 Free Drop

The applicant evaluated the WVMP for seven different 30 foot drop orientations that were chosen to maximize demands on different components. Appendix 2.12.2 contains the detailed analysis for the conditions of the package reported in the application, which include the impact deceleration (g-load), the condition of the bolts, the percentage of LDCC that is crushed, the door gaps (both face and perimeter seal), the condition of the IL connector pins and the strain/deformation of the package. For containment and shielding purposes, the applicant assumes all of the crushed LDCC escapes from any door seal gaps or other breaches in the container. The seven orientations include:

- End Drop – Impact limiter side down to target the bolted side door
- Side Drop - flat side down to target the LDCC as a result of the high g-load
- Corner Drop - CG over front corner to produce high demand on the door seal
- Oblique Drop –
  - CG over side edge to maximize the load on the container walls and the plate-to-plate welds
  - CG over front edge to produce the most damage to the impact limiter
  - CG over top side down to investigate the effects of the gap between the top plate and the LDCC
  - Back side edge down

The end drop orientation targets the bolted side door, which the applicant believes to be the most vulnerable part of the package, and for which the impact limiter was designed. The maximum deceleration for this orientation is 97.5g. As a result, many of the bolts at the mid-span of the door fail, but because the IL connector pins are loaded to only 30% of their capacity, the IL remains in place, which keeps the door in place. The applicant reports a face seal (FS) gap of 0.18 inches and a perimeter seal (PS) gap of 0.1 inches at the mid-span of the door where the bolts fail, and zero inches for both FS and PS at the corners where the IL connects to the shock absorbers. The applicant estimates about 5.5% of the LDCC is crushed.

The side drop orientation does not incorporate the impact limiter or the corner shock absorbers, which places a high deceleration load of 546g on the package and ultimately the LDCC which absorbs about 40% of the impact energy. As a result, the applicant reports 35% of the LDCC will be crushed. Some of the bolts on the mid-span impact side of the container fail. The largest demand on the connector pins occurs on the impact side, but these are only loaded to about 50% of their ultimate capacity. The applicant reports a maximum PS displacement of 0.33 inches at the mid-span of the door on the impact side and a FS displacement of zero.

The corner drop orientation places a high demand on the door seal due to the application of the load. As in the End Drop, the impact limiter absorbs most of the kinetic energy and the resulting deceleration is 53g. Approximately 11% of the LDCC is crushed, and most of the bolts fail. The largest load placed on the IL connector pins occurs in one pin within the shock absorber on the impact side and approaches 92% of its ultimate capacity. The neighboring pins are loaded to 80% capacity.

Although the pins in the shock absorber on the impact corner are loaded beyond their yield strength, the applicant reports that they do not fracture and the IL remains in place. The largest door gaps appear at the mid-span of the door. The FS at the mid-span nearest the impact side is 1.5 inches with a corresponding PS gap of 3.2 inches. At the mid-span furthest away from the impact, the FS gap is 3.2 inches and the PS gap is 0.9 inches. At the corners, the maximum gaps are 1.25 inches on the FS and 0.9 inches on the PS.

The oblique drops involve impact with one of the edges. The most damaging of these orientations is the CG over side edge that does not engage the impact limiter or the shock absorbers. This drop results in a deceleration of 137g. The applicant reports that nearly all bolts fail in shear, and 30% of the LDCC is crushed.

The IL connector pins are loaded to 80% of their ultimate capacity and maintain the IL in a position to provide door restraint. This orientation causes the walls at the impact corner to bend outward, opening up the angle between them and imparts a tensile load on the inside weld and a compressive load on the outside weld. The applicant reports that approximately five feet of the inside weld nearest the door fails. Less than one foot of the outside weld fails at this end also, but the walls are constrained by the shock absorber.

The staff reviewed the analysis and results from the ABAQUS drop simulations and determined that, following the free drop test, the package containment boundary is breached: the worst case orientation produces gaps at the door seal and potentially cracks in the welds between the container walls.

2.7.2 Crush

Because the weight of the WVMP exceeds 11,000 lbs, 10 CFR 71.73(b)(2) is not applicable.

2.7.3 Puncture

The applicant used a combination of explicit FEA and supporting hand calculations to evaluate the sequential HAC puncture scenario for three different locations that maximize damage to the package.

- Puncture bar impact near the front edge of the container to maximize damage at the bolted side door.
- Puncture bar impact on the IL to attempt to shear off the IL. Following the 30 foot drop, the IL is the only credible structure maintaining the bolted door in place.
- Puncture bar impact to the center of the container bottom.

The applicant determined the resulting deceleration from the 40 inch drop is approximately 6g. Because the puncture bar is mild steel, it causes little damage to package even after the damage imparted by the 30 foot drop. At most, one support member from the IL could be eliminated by the puncture bar, but the remaining portions of the frame are enough to keep the door in place.

2.7.4 Thermal

The thermal loads on the package would most likely be due to thermal expansion only since the package is not expected to be able to retain pressure following the HAC drop tests. The applicant conservatively assumes the package is leak-tight, consistent with ANSI N14.5, and attains a maximum pressure of 73 psig.

The applicant stated that the WVMP and the bolting have the same thermal expansion coefficient; therefore, they expand uniformly with temperature. The thermal expansion of the WVMP walls is larger than that of the LDCC; therefore no load will be induced on either the container walls or the LDCC as a result of the fire. Additionally, the thermal analysis shows that the melter experiences very little temperature change, so no load is induced on either the melter or the LDCC as a result of the fire.

The applicant reports primary membrane, primary membrane plus bending, secondary and primary plus secondary stresses as a result of the HAC fire scenario in Table 2-8 of the application. The largest stress ratio (actual/allowable) is 87% as a result of primary plus secondary stress.

2.7.5 Immersion – All packages

The applicant states that the 21.7 psig external pressure is bounded by the HAC internal pressure of 73 psig, because flat plates have the same stress response to internal pressure as they do for external pressure. Based on the results of the HAC drops tests, in which the worst case orientation produces gaps in the door seal, the staff concludes that the immersion test will have no effect on the structural performance of the package.

The staff reviewed the packaging structural performance under HAC and determined that it is consistent with the guidance provided in Chapter 2 of NUREG-1609, and concludes that the

packaging has adequate structural integrity to satisfy the containment, shielding and temperature requirements of 10 CFR Part 71.

2.8 Evaluation Findings

Based on review of the statements and representations in the application, the staff concludes that the structural design has been adequately described and evaluated and that the package has adequate structural integrity to meet the Special Package Authorization requirements of 10 CFR 71.41(d), provided the following conditions are met:

(i) The railcar attachment plates on the bottom of the package shall not be used for lifting or tie-down of the package for transport and shall be marked conspicuously marked “Not for Lifting or Tie-Down.”
(ii) The ambient temperature along all transport routes for both heavy haul truck and rail shall be greater than 15°F.

3.0 THERMAL EVALUATION

The staff reviewed the WVMP application to verify that the thermal performance of the package has been adequately evaluated for the tests specified under NCT and HAC, and that the package design satisfies the thermal requirements of 10 CFR Part 71. The application was also reviewed to determine whether the package fulfills the acceptance criteria listed in Chapter 3 of NUREG-1609, "Standard Review Plan for Transportation Packages for Radioactive Material,” as well as associated Interim Staff Guidance (ISG) documents.

3.1 Description of the Thermal Design

According to the applicant, the design features that are significant with respect to heat transfer in the WVMP are the steel plates (container), impact limiters (not credited in the thermal analysis), the air gap between the concrete surface and container plates, the LDCC, and the melter. The melter structure is comprised of Inconel Type 304 stainless steel, and Type 304L stainless steel. As an approximation, the properties of the melter steel are set equal to the properties of Type 304L stainless steel. The refractory material is a combination of Monofrax K-3 and Zirmul, as described in the application. The radiolytic heat generation calculations are summarized in Appendix 3.5.2 of the application. The maximum package decay heat is 9.21 W.

As described above, the staff reviewed the applicant’s description of its thermal design, and confirmed that it is consistent with the guidance specified in Chapter 3 of NUREG-1609. Therefore, the staff finds the description of the thermal design meets the thermal requirements of 10 CFR Part 71.

3.2 Material Properties and Component Specifications

Material property tables for the WVMP components are included in Section 3.2 of the application. The applicant states that the materials present in the package include LDCC, refractory material, Type 304 stainless steel, Type SA516 carbon steel, and glass. The staff reviewed the thermal properties, provided in the application, which include thermal conductivity, density, heat capacity, and fractional dehydration as a function of temperature and the heats of hydration and vaporization (for the LDCC). Table 3-5 of the application summarizes limiting temperatures for the WVMP components. Separate limiting temperatures are listed for (i) NCT and the HAC for dropping the WVMP, and for (ii) the HAC fire.

The staff reviewed the references provided by the applicant, supporting the material properties and confirmed that the properties were either determined experimentally or by referencing approved codes and standards [(ASME Boiler and Pressure Vessel Code, Section II (Materials), Part D (Properties)]. The staff reviewed the component specifications and verified that the structural analysis performed in Chapter 2 of the application demonstrates that materials stresses are within acceptable limits for the design limiting temperatures for the WVMP components.

The staff has reviewed the material properties and component specifications used in the thermal evaluation, and concludes that they are sufficient to provide a basis for evaluation of the package against the thermal requirements of 10 CFR Part 71.

3.3 Description of the WVMP Thermal Model

To perform the thermal evaluation of the WVMP package the applicant developed a one-quarter three-dimensional (3-D) model based on the finite element modeling code COMSOL Multiphysics. The COMSOL thermal model uses the actual outer dimensions for the container and approximates the contents of the WVMP as a nested series of cubes, with the innermost cube comprised of the radioactive glass in the melter heel, the spout, and any glass dispersed into the refractory of the melter. In the thermal model, this inner core is surrounded by a layer comprised of the melter refractory and structural steel, a layer of the LDCC used to stabilize the melter in the package, and the steel container walls. There is also a 10-inch thick air space between the top surface of the LDCC and the top container wall. This air pocket is present because the WVMP was not completely filled with LDCC. The 10-inch air gap is included in the thermal model. The applicant performed thermal analyses using different grid sizes to ensure that the discretization was sufficiently fine to calculate a grid-independent temperature profile of the WVMP.

The applicant’s developed thermal model assumed that radiolytic heating occurs at a uniform rate throughout the glass. The applicant stated that this is not necessarily a conservative assumption. However, since the melter glass has a relative high thermal conductivity compared to the LDCC, when it is modeled as a monolith, the melter glass should be at a relatively uniform temperature regardless of the distribution of the radiolytic heating.

As stipulated by 10 CFR 71.71, the applicant assumed that the air surrounding the WVMP during NCT is still. Consequently, the heat transfer coefficients are based on natural convection from exterior surfaces. The applicant used different natural convection correlations for the top surface of the WVMP, the vertical side surfaces, and the bottom surface. All correlations are for turbulent natural convection since, due to the large size of the WVMP, the natural convection flow is in the turbulent range for any significant temperature differences.

The applicant stated that enhancement of heat transfer in the air gap accelerates heating of the LDCC during fire exposure but also increases the rate of cooling after the fire, when heat is redistributed from the container frame to the LDCC. Because temperatures inside the LDCC peak during this cool-down period, the applicant stated that it is not apparent whether enhancement of heat transfer by natural convection in the air gap results in higher or lower peak temperatures, amounts of water vapor generated by cement dehydration, and pressurization by this water vapor. Due to this uncertainty, the applicant performed HAC analyses for both with and without including natural convection in the air gap. During the fire exposure, the rate of natural convection heat transfer to the bottom of the container exceeds the corresponding rate

of heat transfer to the top of the container. After the fire, the rate of natural convection from the top is greater than from the bottom. From these observations, the applicant assumed that the net rate of heat transfer to the air gap is maximized when the container is upside down. In other words, the applicant states that for external natural convection, the upside down orientation is conservatively bounding with respect to heating of the air gap. The applicant's developed thermal model included natural convection for the air gap inside the WVMP using an effective thermal conductivity. The air thermal conductivity was modified using a Nusselt number which was obtained using appropriate correlations for enclosed cavities. During HAC, the applicant's thermal model assumed there is no heat transfer to the bottom surface during the cool-down period after the fire exposure.

The staff reviewed the applicant's developed thermal models, thermal properties, assumptions, and boundary conditions applied to the model, and based on the heat transfer characteristics of the analyzed geometry, the staff determined the analysis adequately captures the physics of the heat transfer problem posed by the package.

The staff has reviewed the methods used in thermal evaluation and concludes that they are described in sufficient detail, consistent with Chapter 3 of NUREG-1609, to permit an independent review of the thermal design.

3.4 Thermal Evaluation under Normal Conditions of Transport

3.4.1 Heat and Cold

The applicant used the thermal model described earlier to perform the package thermal evaluation under NCT and subject to solar insolation. Table 3-6 of the application summarizes the NCT results. The maximum temperature for exposure to 100°F air is 105.4°F, for the melter glass. Although the thermal model predicts a surface temperature very close to the ambient air temperature, the applicant stated that the glass temperature must be assigned as the bounding maximum surface temperature, because of the close proximity of one arm of the melter to the bolted side door on one side of the WVMP. The maximum glass temperature of 105.4°F does not closely approach the limiting surface temperature of 185°F. The minimum temperatures for exposure to -20°F and -40°F ambient air are -19.9°F and -39.9°F, respectively. The maximum temperature with insolation is 209.4°F, for the container.

The applicant stated that the WVMP is an exclusive use shipment, such that the 10 CFR 71.43(g) requirement of 185°F maximum temperature at the accessible surface of the package is applicable. The thermal analysis performed by applicant shows that the maximum temperature of the accessible surface of the package is less than 110°F which satisfies the regulatory requirement.

3.4.2 Maximum Normal Operating Pressure

The applicant calculated a maximum normal operating pressure of 12 psig based on an average temperature of 184°F. The applicant's calculated maximum WVMP pressure was obtained assuming the active pressurization of the container is from the air pocket at the top of the WVMP. The pressurization also accounts for the vaporization of hydrated water to add to the mass of air initially present in the air pocket. The applicant used standard methods to calculate the maximum normal operating pressure and the staff finds the methods and calculations acceptable.

3.4.3 Maximum Thermal Stresses

The maximum thermal stresses during NCT event are discussed in Chapter 2 of the application and are evaluated in Chapter 2 of this SER.

The staff has reviewed the package design, construction, and preparation for shipment and concludes that the package material and component temperatures will not exceed the specified allowable limits during NCT consistent with the tests specified in 10 CFR 71.71.

3.5 Thermal Evaluation under Hypothetical Accident Conditions

3.5.1 Initial Conditions

The applicant takes the initial conditions used for the thermal model of the fire test from the WVMP NCT analysis at the end of a 12-hour period of insolation with a content decay heat of 9.21 W. The staff confirmed that all temperatures used as initial conditions are at their maximum values, per the NCT analysis. The applicant states that the package experiences minimal damage after the penetration and drop tests and that the damage does not affect the package thermal performance. The staff confirmed that these results are consistent with what is stated in Chapter 2 of the application.

The applicant stated that inclusion or omission of natural convection in the air pocket inside the WVMP gave mixed results for changes in the maximum calculated temperatures and pressure.

The applicant observed that the maximum pressure due to heating and generation of water vapor from cement dehydration was higher with natural convection omitted. The applicant's approach was to cite the results calculated without including natural convection in the WVMP air pocket, because the margin between the calculated maximum pressure and the limiting pressure is smaller than the margins between the calculated and maximum pressures.

3.5.2 Fire Test Conditions

The applicant used the finite element WVMP thermal model described earlier to determine the temperature of the container during the fire accident specified in 10 CFR Part 71. A 30 minute, 1475°F fully engulfing fire was simulated followed by a 12 hour cooling period to ensure that maximum local temperatures are reached and that the maximum amount of dehydration has occurred.

A transient calculation was performed with heating from a constant 800°C fire for 30 minutes followed by cooling for 12 hours. The calculation started from the temperature profile obtained for NCT with insolation. No solar insolation was applied in the transient calculation during the heating phase of the fire test; however, insolation was applied during the 12 hour cooling phase following the fire. Established correlations for natural convection were again used to derive the appropriate convection coefficient, as described in the application.

3.5.3 Maximum Temperatures and Pressures

The maximum temperatures experienced by the components of the WVMP package calculated by the applicant under an HAC fire event, with an ambient temperature of 100°F and insolation, are provided in Table 3-7 of the application. The staff confirmed that all the temperatures predicted during the HAC are below the component allowable limits. The applicant calculated a

maximum pressure of 73.0 psig based on an assumed maximum air pocket temperature of 727.9°F during HAC. This calculated pressure is lower than the pressure used in Chapter 2 of the application to calculate wall stresses, and is therefore acceptable.

3.5.4 Maximum Thermal Stresses

The maximum thermal stresses during HAC fire event are addressed in Chapter 2 of the application and are evaluated in Chapter 2 of this SER.

The staff has reviewed the package design, construction, and preparation for shipment and concludes that the package material and component temperatures will not exceed the specified allowable short time limits during HAC, consistent with the tests specified in 10 CFR 71.73.

3.6 Evaluation Findings

Based on review of the statements and representations in the application, the staff concludes that the West Valley Melter Package thermal design has been adequately described and evaluated, and that the thermal performance of the package meets the thermal requirements of 10 CFR Part 71.

4.0 CONTAINMENT REVIEW

The objective of the containment review is to evaluate the package design against the containment requirements of 10 CFR Part 71, under both NCT and HAC. This application was also reviewed to determine whether the package fulfills the acceptance criteria of NUREG-1609, "Standard Review Plan for Transportation Packages for Radioactive Material."

4.1 Description of the Containment System

The containment boundary of the WVMP, shown in Figure 4-3 of the application, consists of ASTM SA-516 Grade 70 carbon steel for the package top, bottom, and sides. The containment boundary is 13'5" long, by 12'4" wide, by 12'4" high. The sides are six inches thick, and the top and bottom are four inches thick. Five sides of the package are welded, while the sixth side is a bolted door.

There are two types of containment penetrations in the WVMP. The first type includes five gasketed ports with neoprene gaskets shown on drawing 4005-DW-001, Rev. 7, sheet 4, that are bolted in place. The second type is the bolted side door shown on drawing 4005-DW-001, Rev. 7, sheet 6, that is recessed into the package with a single piece of neoprene gasket and the perimeter joint is sealed with room temperature vulcanization (RTV). The neoprene gaskets of the five gasketed ports and the neoprene gasket on the bolted side door are not credited in the containment analysis; therefore, the predicted maximum temperatures are not provided during the NCT and HAC analyses. The perimeter joint sealed with RTV is also not credited in the containment analysis. The containment boundary for the WVMP and penetrations are conservatively not credited in the containment analysis; therefore, all of the material is assumed to be subject to potential release through the containment system under NCT and HAC.

Section 2.4.3 of the application demonstrates that no internal pressure may arise within the package that will result in unintentional opening of the package. The torque values for the bolted side door and five gasketed plugs are described in Section 7.1.2 of the application from the loading that took place in 2004 and Section 7.1.3 of the application describes the reapplication

of the original torque values to ensure closure of the package; therefore, 10 CFR 71.43(c) is met.

The package does not have a device that allows continuous venting, nor does the package design have provisions to install one; therefore, 10 CFR 71.43(h) is met. Section 4.1 of the application includes a containment system description that is consistent with the guidance in Section 4.5.1 of NUREG-1609, “Standard Review Plan for Transportation Packages for Radioactive Material”, and the staff finds it satisfies the intent of the containment requirements of 10 CFR 71.51(a)(1) and (2) for the one-time shipment of a package that was not designed to be leak-testable.

4.2 General Considerations

The WVMP package will be shipped under the provisions of a Special Package Authorization, containing approximately 3,554 curies of radioactivity, which is equivalent to 214.9 A_2. Approximately 98% of the A_2 are contained within the borosilicate glass matrix adhered to the inside of the melter. Radioactive contamination on the outside of the melter has been fixed in place using a polymeric barrier system (PBS), a hard to remove, impermeable material. The LDCC internal and external to the melter minimizes the dispersible contents from the glass. Therefore, there are multiple barriers in addition to the WVMP containment boundary that must be overcome to result in the release of radioactive content.

The radionuclide content for the containment analysis is described in Table 1, “WVMP Radionuclide Content and A_2 Values,” of calculation package X-CLC-G-00121 in Appendix 4.6.2 of the application, “Estimated WVMP (West Valley Melter Package) Release Rates under Normal Conditions of Transport (NCT) and Hypothetical Accident Conditions (HAC).” The staff reviewed Appendix 4.6.2 as well as the reference, “West Valley Demonstration Project Waste Characterization of Vitrification Melter,” to confirm the radioactive content. The staff also compared the A_2 values used in Table 1 with the A_2 values in 10 CFR 71, Appendix A, Tables A-1 or A-3 based on the appropriate justification provided, and finds acceptable the values used for the radionuclides.

The WVMP was not designed to be a leak-testable package. Therefore an alternate method was used to satisfy the intent of the containment requirements in 10 CFR 71.51(a)(1) and (2). Through the use of the methodology based on the DOE-HANDBOOK-3010-94, “Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities,” the calculation package X-CLC-G-00121 shows that the WVMP satisfies the intent of the release rates in 10 CFR 71.51(a)(1) and (2) which is further described in Sections 4.2 and 4.3 of the application, and summarized in Sections 4.3 and 4.4 of this SER.

Through an analysis in Appendix 4.6.3, “West Valley Grouted Melter Package (GMP) Estimated Time to 5% Hydrogen,” of the application, the applicant showed that the hydrogen generation in the package, conservatively assuming it is leak-tight, will not reach 5% for more than 20 years.

4.3 Containment under Normal Conditions of Transport

The contributions to the NCT release from the borosilicate glass, and LDCC external and internal to the melter were considered due to the impact/drop. The contributions to the NCT release from the LDCC external to the melter were also considered due to the maximum

pressure and decomposition; based on the maximum pressure and temperature, there was no measurable additional release from the glass and LDCC internal to the melter. The staff confirmed that these contributions considered the structural and thermal effects from 10 CFR 71.71.

Chapter 2 of the application shows that the package remains intact during NCT, although the applicant conservatively does not take credit for the WVMP containment boundary by assuming a leak path factor equal to one. The applicant assumed a leak path factor equal to 0.1 for the melter based on the melter not being damaged during NCT and HAC and the relatively low pressures which the staff found acceptable for use during NCT and HAC from the justification provided in Section 5.2.3 of calculation package X-CLC-G-00121.

In Appendix 4.6.2, the applicant provided and the staff reviewed the justification and applicable references for the glass, and LDCC content internal and external to the melter, as well as the damage and release ratios (e.g., damage ratio, airborne release fraction, and respirable fraction) used in the NCT containment analysis. The applicant described conservatisms in the glass, and LDCC content internal and external to the melter, as well as in the damage and release ratios for NCT, and the staff found these to be acceptable based on the justifications and references described in Sections 5.2 and 5.3 of calculation package X-CLC-G-00121. The NCT damage and release ratios were for the glass internal to the melter, and LDCC internal and external to the melter. The non-respirable contributions from the LDCC and borosilicate glass were considered non-applicable during NCT which the staff found to be acceptable because the melter is not damaged during NCT or HAC.

The damage and release ratios were then used in the containment analysis according to the methodology described in the DOE-HANDBOOK-3010-94. The containment analysis for NCT showed that the calculated total release was 2.22×10^{-7} A_2, although the calculation did not include the contribution from the melter spout glass due to impact/drop. With the inclusion of the contribution of the melter spout glass, the containment analysis for NCT would show that the total calculated release was 3.06×10^{-7} A_2. The applicant conservatively stated the total release was less than 1×10^{-6} A_2 during NCT, which remains the case with the inclusion of the contribution of the spout glass.

Because the total release is less than the per hour release requirement in 10 CFR 71.51(a)(1) of 1×10^{-6} A_2/hr and the applicant's containment analysis conservatively assumes no credit for the WVMP containment boundary, the staff finds that the WVMP package satisfies the intent of the containment requirements of 10 CFR 71.51(a)(1) for the one-time shipment of a package that was not designed to be leak-testable.

4.4 Containment under Hypothetical Accident Conditions

The contributions to the HAC release from the borosilicate glass and LDCC external and internal to the melter were considered due to impact/drop. The contributions to the HAC release from the LDCC external to the melter were also considered due to the maximum temperature, maximum pressure, and decomposition; based on the maximum pressure and temperature, there was no measurable additional release from the glass and LDCC internal to the melter.

In addition, the contributions to the HAC release from the LDCC were considered due to non-inhalation. The staff confirmed that these contributions considered the structural and thermal effects from 10 CFR 71.73. Chapter 2 of the application shows that the 30-foot drop HAC would result in a localized damage to the LDCC along with small quantified levels of face seal

displacement and/or perimeter seal displacement, but not a combination that would result in any permanent clear open gaps. As in the NCT analysis, no credit is taken for the WVMP containment boundary by assuming a leak path factor equal to one and by assuming a leak path factor equal to 0.1 for the melter.

In Appendix 4.6.2, the applicant provided and the staff reviewed the justification and applicable references for the glass, and LDCC content internal and external to the melter, as well as the damage and release ratios (e.g., damage ratio, airborne release fraction, respirable fraction, and escape fraction) used in the HAC containment analysis. The applicant described conservatisms in the glass, and LDCC content internal and external to the melter, as well as in the damage and release ratios for HAC, and the staff found these to be acceptable based on the justifications and references described in Sections 5.2 and 5.4 of calculation package X-CLC-G-00121. The HAC damage and release ratios were for the glass internal to the melter, LDCC internal and external to the melter, and non-respirable contributions from the LDCC and borosilicate glass.

The damage and release ratios were then used in the containment analysis according to the methodology described in the DOE-HANDBOOK-3010-94. The applicant's containment analysis for HAC showed that the calculated total release was 2.20×10^{-2} A_2. The applicant conservatively stated the total release was 1×10^{-1} A_2 during HAC. Because the total release is less than the per week release requirement in 10 CFR 71.51(a)(2) of 10 A_2/week for Kr-85 and 1 A_2/week for all other isotopes, and the containment analysis conservatively assumes no credit for the WVMP containment boundary, the staff finds that the WVMP satisfies the intent of the containment requirements of 10 CFR 71.51(a)(2) for the one-time shipment of a package that was not designed to be leak-testable.

4.5 Leakage Rate Tests for Packages

The WVMP was not designed to be a leak-testable package. During NCT, the WVMP containment was shown to remain intact. During HAC, the WVMP containment was shown to have small quantified levels of face seal displacement and/or perimeter seal displacement, but not permanent clear open gaps.

The applicant described conservatisms in the damage and release ratios, as well as in the WVMP containment boundary and melter leak path factors used in the NCT and HAC containment analysis calculations. Section 8.1.1 of the application describes that the container was fabricated to NQA-1 requirements and to the design drawings in Chapter 1 of the application. Appendix 8.3.2 of the application also discusses the applicable requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section III, Article ND-5300, that were implemented during the fabrication of the container. The weld visual examination and magnetic particle inspection was summarized in Section 8.1.2 of the application. Visual examination of the container upon receipt was also summarized in Section 8.1.1 of the application.

Based on the containment analysis calculations performed, as well as the fabrication and visual examination of the container, the applicant has satisfied the intent of the release rates during NCT and HAC in 10 CFR 71.51(a)(1) and (2). For the one-time shipment under the provisions of the Special Package Authorization for the WVMP that was not designed to be a leak-testable package, the staff accepts the methods presented.

4.6 Evaluation Findings

Based on review of the statements and representations in the application, the staff concludes that the containment design has been adequately described and evaluated and that the package design meets the Special Package Authorization requirements of 10 CFR 71.41(d).

5.0 SHIELDING REVIEW

The objective of the review is to verify that the shielding of the package provides adequate protection against direct radiation from its contents and that the package design meets the external radiation requirements of 10 CFR Part 71 during NCT and HAC. This application was also reviewed to determine whether the package fulfills the acceptance criteria listed in Section 5 (Shielding Review) of NUREG-1609, "Standard Review Plan for Transportation Packages for Radioactive Material."

5.1 Description of Shielding Design

5.1.1 Shielding Design Features

The shielding design features a container with carbon steel (4" thick on the top and bottom; 6" thick on the sides) for gamma shielding. The density of the steel is 7.98 g/cm^3. The melter inside the container is encased with LDCC, which also fills the void space in the interior of the melter for additional gamma shielding and to prevent (i) migration of any remaining surface contamination, (ii) component shifting, and (iii) dose rate changes during transportation. The density of the LDCC is 1.12 g/cm^3. Additional gamma shielding is provided by the melter itself, which contains refractory brick, Inconel, and Type 304L stainless steel. Because the neutron source, as derived from the source characterization, is negligible, no shielding for neutrons was added. Also, the LDCC provides sufficient shielding for the small neutron sources available.

5.1.2 Summary Table of Maximum Radiation Levels

The applicant performed a shielding analysis for the package, which is designed for exclusive use. In the shielding model, the applicant used distributed sources under NCT and HAC at the locations known to contain radioactive material in the melter, which include the glass heel, a glass plug in one of the discharge spouts, residual glass in the refractory brick lining the melter, and surface contamination on the exterior of the melter. The initial material compositions for the heel, spout, refractory, and surface contamination were calculated using ORIGEN-S to determine the buildup of daughter isotopes. The photon sources computed with ORIGEN-S in each energy group were then used as input to the particle transport calculations in the QADS Point Kernel Module of the SCALE Code System. Photon spectra are shown in Table 5-3 of the application. The applicant calculated the dose rates under NCT and HAC. In the model for the package under HAC, the applicant assumed that the LDCC is consumed by HAC events and therefore modeled the LDCC conservatively as void space.

The applicant documents its shielding analyses in Chapter 5 of the application. Table 5.1 of the application provides a summary of the shielding calculation results for both cases and is reproduced in the following table.

Summary of Dose Rates of the Package (mrem/hr)

Location	NCT			HAC
	Surface	1 m	2 m	1 m
	Maximum Dose Rate (mrem/hr)			
North Side	0.056	0.052	0.037	0.52
South Side	0.043	0.019	0.011	0.84
East Side	0.013	0.012	0.009	0.43
West Side	0.016	0.014	0.011	0.51
Bottom	80.40	16.73	7.50	201.63
Top	2.43	1.18	0.689	429.03
10 CFR 71 Limits	200	N/A[(1)]	10	1000

NOTE: (1) 1 m dose limit (TI≤10) does not apply since package is being shipped as Exclusive Use, meeting dose limits of 10 CFR 71.47(b).

5.2 Source Specification

The melter contains four primary source terms consisting of (1) the heel contained within the melter cavity, (2) residual glass contained within the cracks, crevices, and interstitial spacing associated with the refractory brick, (3) the plugged discharge port (pour spout), and (4) the surface contamination on the melter exterior.

Each of these source terms was characterized independently utilizing available historical information, analytical results, and swipe sample results. In addition, detectors were lowered into the melter nozzles for additional estimates of the source activity. The total activity associated with the melter is 3,554 curies. The total fissile (gram) content of the melter is 81.56 grams. There are no gaseous or liquid radioactive components to the source term.

The applicant's source term was determined using the ORIGEN-S module of the SCALE code system. The contributing mechanisms for photon (gamma) production include: (1) nuclide decay, (2) decay of daughter products, (3) fission product decay, and (4) spontaneous fission. There is no significant neutron component to the source term or dose rate.

The source term evaluations are discussed in Section 5.2 and Appendix 5.5.2 of the application. Based upon a review of the information provided in the application, including the methods used to characterize the source term discussed above, staff determined there is reasonable assurance that the source term has been adequately developed and identified.

5.3 Model Specification

5.3.1 Configuration of Source and Shielding

Ten source configurations are modeled for the WVMP:

- Uniformly distributed in the glass in the melter heel,

- Uniformly distributed in the glass in the melter spout (modeled as a rectangular source),
- Glass in refractory brick above the melter heel modeled as uniform sources on each of the four vertical surfaces of the region above the melter heel,
- Surface contamination on the outside of the melter modeled as uniform sources on each of the four vertical surfaces of the steel surrounding the melter, and
- The source distribution in the melter spout modeled as a rectangle with the cross section equal to that of the cylinder.

Point detectors were modeled adjacent to the package and at one and two meters from the surface of the package for NCT cases. Point detectors were modeled at one meter from the surface of the damaged package for HAC cases.

5.3.2 Material Properties

Six materials are considered in the shielding models: borosilicate glass, steel, LDCC concrete, Monofrax™, Zirmul™, and Inconel. Table 5-7 of the application lists the shield material densities and compositions. The staff reviewed the materials in the models and found them to be consistent with the actual materials' properties.

5.4 Shielding Evaluation

5.4.1 Methods

The applicant used the QADS module of the SCALE Code System with its built-in attenuation and buildup coefficients to perform the shielding analysis. QADS performs multidimensional point-kernel estimation of gamma transport through shielding materials. The applicant also provided a comparison of QADS model results with actual dose rate readings in Appendix 5.5.4. The QADS results were generally conservative when compared to measured dose rates on the package. Although some measured dose rates exceeded the QADS results at various locations, the dose rates were significantly below the limits for those locations.

The staff independently confirmed the dose rates at 2 meters from the package attributed to the pour spot source region, which accounted for almost 100% of the dose rate at 2 meters from the bottom of the package (the area with dose rates closest to the regulatory limit of 10 mrem/hr as shown in Table 5-1, "Summary of Dose Rates of the Package." The staff created a model of the package using the Monaco/MAVRIC shielding code as part of SCALE 6.1. The staff used the applicant's source term in its Monaco/MAVRIC/ model. Several of the detector locations had greater dose rates than those calculated by the applicant using QADS; however, these locations are not the locations of the maximum package dose rates for the surface at 2 meters. The higher dose rates calculated by the staff using MAVRIC were significantly below the applicant's maximum of 7.5 mrem/hr. However, the staff's calculated dose rates were less than 10% of the applicant's for the two locations that resulted in the maximum dose rates of 7.5 mrem/hr. This comparison helps demonstrate that the applicant's model and methods calculate an appropriate dose rate.

The staff evaluated the applicant's shielding models. Based on the statements and calculations presented by the applicant and the staff's independent confirmatory calculations, the staff finds

the applicant's models to be acceptable for the packaging system described in Chapter 5 of the application.

5.4.2 Key Input and Output Data

The applicant provided a listing of the input and output files in Appendix 5.5.3 of the application. The staff confirmed the proper input of key information in the code.

5.4.3 Flux-to-Dose-Rate Conversion

The applicant performed the flux-to-dose-rate conversion using the factors provided in the QADS code. QADS uses the ANSI/ANS-6.1.1-1977 gamma flux to dose rate conversion factors to evaluate dose rates from the package. Because the use of the ANSI/ANS 6.1.1-1977 standard is consistent with NUREG-1609, the staff found that the applicant's flux-to-dose-rate conversion is acceptable.

5.4.4 Radiation Levels

The applicant presented the external dose rates on, and at 2 meters from, the surface of the package in Table 5.1 of the application. All NCT dose rates comply with 10 CFR 71.47(b) for exclusive use purposes. For HAC, the applicant also calculated maximum dose rates at 1 meter from the surface of the package. All HAC dose rates comply with 10 CFR 71.51(a)(2).

5.5 Evaluation Findings

Based on its review of the statements and representations in the application, including applicant responses to staff questions and independent confirmatory calculations, the staff has reasonable assurance that the shielding design has been adequately described and evaluated and that the package meets the external radiation requirements of 10 CFR Part 71.

6.0 CRITICALITY

The WVMP contents are limited to fissile material quantities that meet the exemption standards in 10 CFR 71.15. The applicant estimated the amount of fissile material to be 81.56 grams. Therefore, criticality is not a concern for this package.

7.0 PACKAGE OPERATIONS

The fabrication of the one-time, exclusive use, container was completed in 2004. The melter was loaded into the package in 2004 and the LDCC added in 2013. The GMP components were procured, constructed, and loaded under a Quality Assurance (QA) program meeting the requirements of NQA-1, *Quality Assurance Requirements for Nuclear Facility Applications*.

The impact limiter will be procured and installed under the WVDP NQA-1 QA program that meets the requirements of 10 CFR Part 71, Subpart H.

7.1 Package Loading

These previously conducted activities associated with preparing the container for loading the melter included (i) loading the melter into the container, (ii) securing the container bolted side

door, (iii) filling the container with LDCC through ports located on top of the container, and (iv) securing the ports after completion of LDCC emplacement.

Future activities to prepare the WVMP package for transportation include the installation of the impact limiter to the exterior of the GMP. Prior to installation of the impact limiter, the original torque (500 lb-ft) to the bolts associated with the bolted side door of the containment boundary will be reapplied, as well as for the original torque (35 lb-ft) to the bolts associated with the gasketed ports.

Prior to transport, the WVMP package will be marked per 10 CFR 71.85 (c), tamper-indicating devices will be applied to bolted closures of the WVMP, radiation surveys of the package (on contact and at one and two meters from the surface) and non-fixed (removable) contamination surveys will be performed. The WVMP's exterior surface is expected to be free of removable contamination, and package exterior radiation levels will not exceed the limits specified in 10 CFR 71.47 at any time during transportation. Measurement of the WVMP surface temperature will be required prior to offsite transport.

The WVMP will be loaded and secured onto a heavy-haul trailer, then moved to a railcar at the transloading facility for shipment by rail to the Waste Control Specialists (WCS) low-level waste disposal facility. The lifting hardware utilized during initial loading and subsequent transloading evolutions will accompany the shipment so that it can be utilized by WCS in handling of the WVMP.

7.2 Package Unloading

Radiation and contamination surveys of the WVMP will be performed upon its arrival at the WCS disposal site in accordance with WCS written policies and procedures. The WCS Onsite Transportation and Lift Plan for the WVMP will delineate detailed steps associated with the transport of the WVMP from the staging area down into the disposal cell via the current access ramp and into position it underneath the gantry crane.

7.3 Preparation of Empty Package for Transport

This section is not applicable.

7.4 Other Operations

The WVMP surface temperature must be above 3°F at West Valley prior to shipment. The ambient temperature along all transport routes for both heavy haul truck and rail shall be greater than 15°F.

Other weather restrictions normally associated with the utilization of cranes to perform lifts such as loading and unloading the WVMP (e.g., wind speed) also apply.

To organize and coordinate all of the transportation activities, a Transport Emergency Response Plan (TERP) will be developed by MHF Services. The document, currently as Rev. A dated May 8, 2014, will be revised at least 5 months before the planned shipment to be utilized as the transportation operation controlling document throughout the entire shipment from the West Valley site to the WCS disposal site. Exclusive use instruction will be included in the TERP and will identify operating controls such as the minimum required temperature requirement discussed above. The TERP will also include details such as the transportation route, mode of

transportation and transfer locations, distances, processes, and equipment; and identifies responsibilities and interfaces for each transportation activity, including the WVMP package transfer from one conveyance to the next, tie-down instructions and inspection, radiological controls, and WVMP package delivery to the disposal site. Additionally, guidance for interaction with appropriate local and federal agencies in the event of an accident will be provided.

8.0 ACCEPTANCE TESTS

The container was procured as a 49 CFR 173.411 Industrial Packaging Type 2 (IP-2) package and fabricated in accordance with American Welding Society (AWS) Structural Code D1.1.

The WVMP provides an equivalent level of safety with the requirements of NUREG/CR-3019, *"Recommended Welding Criteria for Use in the Fabrication of Shipping Containers for Radioactive Materials,"* and the ASME "*Boiler and Pressure Vessel Code*," Subsection ND. The impact limiter, to be installed before shipment, will be fabricated per ASME Code, Section III, Subsection NF, in accordance with Table 4-1 of NUREG/CR 3854, "*Fabrication Criteria for Shipping Containers.*" No maintenance program is required for the one-time use package.

The acceptance tests and inspections, performed under the WVDP Quality Assurance program, confirmed the container was fabricated in accordance with the drawings and that the LDCC meets the comprehensive strength requirements established by the designer of the GMP. The acceptance tests and inspections for the impact limiter will be accomplished to the same requirements.

8.1.1 Visual Inspections and Measurements

Upon receipt at the WVDP in 2004, in accordance with the site QA program, visual inspections and measurements confirmed that the container did not show any visible shipping damage and met specifications on the purchase order, including gaskets. The level of the LDCC in the annulus was visually monitored as the mixture was being poured using the bullet camera. LDCC placement continued until the melter was completely encased. The following day, after the LDCC placement equipment was removed from the top ports of the GMP, personnel visually re-confirmed that the melter was completely encased in LDCC. The GMP is approximately 93 percent full. The tests confirm the LDCC meets the minimum compressive strength requirements.

Acceptance criteria for the impact limiter inspections include compliance with the specified engineering and procurement requirements. Prior to installation onto the GMP, visual examinations and magnetic particle examinations will be performed on the impact limiter welds. The acceptance criteria shall be those specified in the ASME Boiler and Pressure Vessel Code, Section III, Subsection NF, Article NF-5300, *Acceptance Standards*. During the installation of the IL, the retaining pins will be secured in place with a bevel weld performed by certified welders using WVDP qualified procedures.

8.1.2 Structural and Pressure Tests

Based on analysis showing an appropriate safety factor, no pressure test was performed. The analysis confirms the WVMP integrity under NCT to provide assurance the radioactive materials will remain contained in the package and that the package meets the requirements of 10 CFR Part 71.

Leakage tests are not applicable to the WVMP because there is no pressure vessel or other "leak-testable" boundary associated with the package. The package meets the release limits of 10 CFR Part 71 for NCT and HAC. The NCT release is calculated, with very conservative assumptions, to be 3.06 x 10^{-7} A_2/hr, i.e., less than the 10 CFR 71.51(a)(1) requirement of 1 x 10^{-6} A_2/hr.

The leak path factor used for NCT is for a closed container with no seals. Less than 10^{-1} A_2 is released under HAC using conservative assumptions; this is less than the limit of 10 times an A_2 quantity per week for Kr-85 and 1 A_2 per week for all other isotopes, as specified in 10 CFR 71.51(a)(2), for HAC containment calculations,

The container was fabricated to NQA-1 requirements to the design drawings. Welding was performed to an equivalent level of safety with 10 CFR 71.119: all welds were visually examined and magnetic particle inspected. An equivalent level of safety to the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section III, Article ND-5300, "Acceptance Standards," were implemented in connection with fabrication of the container. The acceptance criteria for these inspections included an equivalent level of safety with the specified requirements. The bolted side door was secured per manufacturer's instructions after the content was installed.

8.1.3 Component and Material Tests

Component and material tests were performed on components of the container that affect package performance. Certified material test reports confirmed the components and materials meet the acceptance criteria, and the West Valley receipt inspection confirmed that the gaskets meet the requirements of the purchase order.

During the LDCC placement process in 2013, one sample from each of the LDCC truck loads was taken to confirm that the 68 to 72 pounds per cubic foot wet density criteria was met. Test cylinders cast from each truck load were tested after 28 days and confirmed the LDCC had acceptable compressive strength. The 28-day compressive strengths for all the cylinders exceeded 1,000 psi .

All plate material for the impact limiter shall be provided with certified material and chemical test reports. These tests shall include determination of the nil-ductility transition temperature for materials three inches thick and over. All base metals and filler materials utilized will be qualified for notch toughness. All welding will be performed in accordance with approved procedures.

8.1.4 Shielding Test

Shielding tests are not applicable for the WVMP. The WVMP is a single use package, shipping a unique content that has already been loaded and sealed. The packaging design does not include any features specifically credited with shielding. The calculated dose rates bound the measured dose rates and are within the regulatory limits.

8.1.5 Thermal Test

Thermal acceptance tests are not applicable. The packaging design does not incorporate active heat transfer features nor are passive heat transfer mechanisms particularly sensitive to normal variations in the materials of construction or fabrication methods.

8.2 Maintenance Program

No maintenance program is applicable for the WVMP package because the WVMP is a one-time only single-shipment package used for transportation and disposal of the melter. The WVMP is a sealed enclosure with no instrumentation or operating control devices that are relied upon for maintaining and monitoring its integrity during the shipment.

CONDITIONS

In addition to the requirements of Subpart G of 10 CFR Part 71, the following conditions apply:

(1) The package is a one-time exclusive use shipment.

(2) The package is constructed and assembled in accordance with Drawing Nos. 4005-DW-001, Revision 7, sheets 1-8; and R-R3-A-00063, Revision 1.

(3) The package must be conspicuously and durably marked with the trefoil symbol and the following information: Type B(U), Model No. 9797, Package Identification Number USA/9797/B(U)-96.

(4) The package authorized by this letter must be transported on a motor vehicle or on a railroad car assigned for the sole use of the shipper.

(5) The package must be prepared for shipment and transported in accordance with Chapter 7 of the application.

(6) The package must be acceptance tested in accordance with Chapter 8 of the application.

(7) Transport of the package may only be initiated if the ambient temperature all along the transport routes, for both heavy haul truck and rail, is greater than 15°F. The ambient temperature will be monitored throughout the transport process and transportation will be stopped should the temperature fall below 15°F.

(8) The railcar attachment plates on the bottom of the package shall not be used for lifting or tie-down of the package for transport and shall be conspicuously marked "Not for Lifting or Tie-Down."

(9) Prior to shipment, package dose rates shall be measured at all locations necessary to demonstrate compliance with 10 CFR 71.47. The measurement procedure must be comprehensive in nature and cover the entire package surface and projected surfaces at 1 and 2 meters as required by 10 CFR 71.47(b)(2), or (b)(3).

(10) The Special package Authorization will expire on August 31, 2020.

CONCLUSION

Based on the statements and representations contained in the application, and the conditions listed above, the staff concludes that the WVMP package meets the requirements of 10 CFR Part 71.

Issued with a letter of approval
on August 5, 2015.