WVDP PACKAGE DESCRIPTION REPORT

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1.0 GENERAL INFORMATION

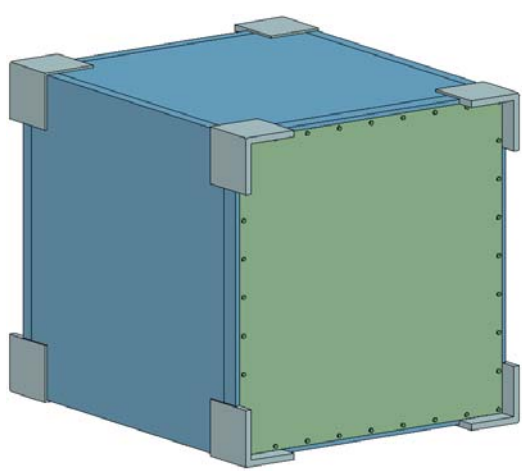
1.1 Introduction

In 1983 the DOE selected vitrification (i.e., the incorporation of radioactive waste into glass) as the preferred method for solidifying the residual waste that remained at the West Valley Demonstration Project. Vitrification did not actually begin until 1996 and continued until September of 2002 when the facility was permanently shutdown. During the six-year operation of the West Valley vitrification facility, liquid waste was retrieved from underground waste tanks, pumped to the Vitrification Facility and combined with glass-forming chemicals. The waste was then superheated inside a glass melter and poured into stainless steel canisters to cool.

The glass melter portion of the Processing Equipment is a relatively large component and is to be packaged and transported to another DOE facility for analysis prior to ultimate disposition as waste. This document describes the proposed Transportation System consisting of the carbon steel shipping container that will be used for transport of the Processing Equipment from the West Valley Demonstration Project (WVDP) in West Valley, New York. This packaging is intended for a single use and a sketch of the package configuration is shown in Figure 1-1. The radioactive materials will be transported under a DOT exemption pursuant to 49CFR Part 107.105 with transport via rail. The route particulars are not available at present, but will be an integral part of the Transportation and Emergency Response Plan at the time of shipment.

Figure 1-1

WVDP Shipping Container Configuration



The proposed Transport System consists of the IP-2 packaging, which is used to contain the Class 7 (radioactive) materials and a Transportation and Emergency Response Plan.

The following exemption is being requested for the use of the WVDP Package:

1. That the 3-meter dose rate be considered at 3-meters from the exterior of the component as prepared for transport.

This document presents the analyses performed to demonstrate that when the proposed packaging is used for transport of this Class 7 radioactive material, it provides safety significantly greater than that of an IP-2 package.

The radiological characteristics of the Class 7 material are discussed herein and a detailed characterization report is provided in Appendix A to this report.

The structural analysis to analyze the proposed packaging for a one-foot drop in the worst orientation is presented in Appendix B. While not required by regulation, a hypothetical accident condition consisting of a ten-foot drop was analyzed to demonstrate the robust nature of the packaging and the results are presented in Appendix C.

Section 2.0 describes the Package structural design features. Packaging compliance with the requirements of 49CFR Part 173 and the basis for compliance with these requirements is discussed in Section 3.0. A summary of the radiological characterization and shielding analysis performed to demonstrate compliance with external radiation level requirements is described in Section 4.0.

1.2 Package Description

This section provides a general description of the proposed package that is the subject of this exemption request.

1.2.1 Radioactive Contents

The Processing Equipment is comprised of a stainless steel outer housing with an exterior structural steel frame. The interior is lined with various refractory materials. The maximum envelope dimensions of the material are 10'-9 ¾" wide x 11'-10" long x 10'-5 ½" high and the weight is 107,500 lbs.

The Class 7 (radioactive) material consists of surface contamination on the steel equipment housing and structural steel support frame, and LSA material in the form of refractory material, and residual glass. A detailed description of the radiological characterization results is presented in Appendix A.

The radioactivity was estimated using industry accepted practices and benchmarked with radiation level measurements to quantify the activity of the components of interest.

During the course of operations, the exterior surfaces of the Processing Equipment were contaminated to a maximum contamination level of 16.7 $\mu Ci/cm^2$ and an average of about 5.73 $\mu Ci/cm^2$ as shown in Appendix A. This is a relatively small percentage, less than 1%, of the total activity.

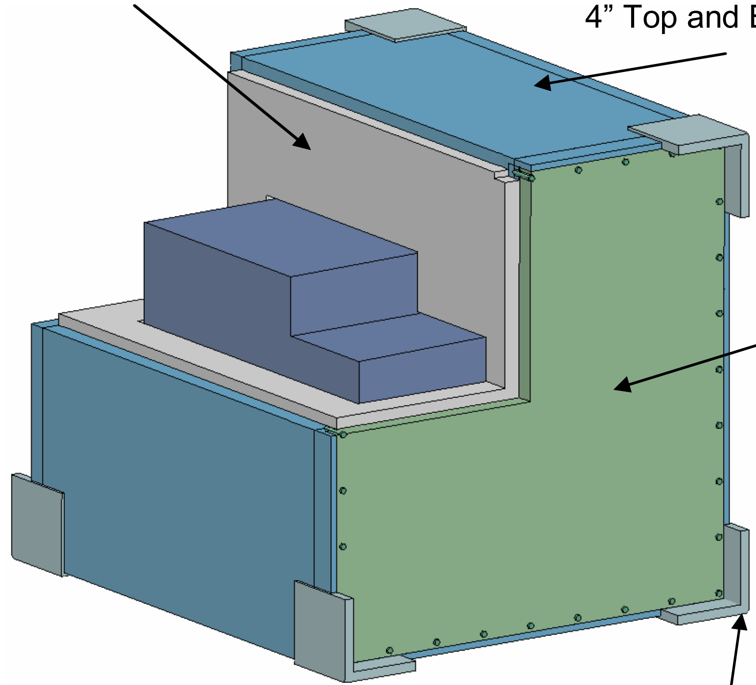
At the time of planned shipment, October 1, 2004, the Processing Equipment contains 4,570 total curies, of which 4,314 are from Cs-137.

1.2.2 Packaging

A cutaway section of the container, with its integral impact absorption system, is shown on Figure 1-2. As shown it is a rectangular shaped steel container made from SA-516, Grade 70 carbon steel.

Figure 1-2

WVDP Shipping Container Configuration (Cutaway Section)



The container has an overall envelope dimension of 14’ 11” long x 12’ 8” wide x 12’ 6” high with box dimensions of 13’ 5” long x 12’ 6” wide x 12’ 4” high. It has a removable side cover as shown on Figure 1-2. The side cover is recessed into the container. It is sealed with a neoprene gasket and bolted in place with thirty six (36) 1-1/2 inch diameter bolts.

The weight of the empty container is approximately 210,000 lbs. The Processing Equipment weight is 107,500 lbs. The total weight of the Package, which includes the radioactive contents, low-density cellular concrete (LDCC) and the container, will be approximately 360,000 lbs.

The Package was designed and constructed to provide containment under the normal conditions of transport as defined in 49CFR 173 for an Industrial Package Type 2 (IP-2).

The WVDP package will be transported with the benefit of the shock absorption plates attached to each of the corners as shown in Figure 1-2. For this transport, the container was structurally analyzed for a one-foot drop scenario, as required by the regulations. The dynamic drop analysis was performed using an ANSYS finite element model. The analysis demonstrates that the package is more than adequate to meet the requirements of an IP-2 package in all possible drop orientations including the worst orientation. The structural analysis results are presented in Appendix B.

The combined effect of packaging the Processing Equipment within a thick carbon steel walled container, filling the voids with grout, then totally encasing the contents with low density cellular concrete provides a very robust containment boundary between the Class 7 materials and the environs. As shown on Figures 1-1 and 1-2, the package has a recessed cover that will be permanently closed via thirty-six (36) closure bolts on the cover plate. The joint gap and closure bolt heads will be covered after final closure with a thin (1/8") metal cover seal welded to the container. This bolted configuration coupled with the gasket between the container body and the cover and the seal welded metal cover will render the radioactive materials inaccessible to the environs.

The major features of the Package include:

1. All Processing Equipment internal void spaces are filled with grout and
2. All external surfaces of the equipment and equipment frame are coated with Bartlett's PBS™ contamination fixative. The use of a fixative renders all surface contaminants fixed on the equipment surface.
3. The equipment is totally encased with low-density cellular concrete within the container.
4. Containment of the concrete encased equipment with a thick carbon steel container.
5. Closure lid bolt tightening and gasketed sealing to provide a positive seal between the radioactive contents and the environs.
6. Seal welded metal cover for the joint gap and closure bolt heads.
7. Closure of all penetrations between the container cavity and the environs.
8. A simple and integral sacrificial shock absorption system.

These design features, which provide for total containment, plus the administrative controls invoked by the Transportation and Emergency Response Plan, ensure that the Class 7 (radioactive) materials will be contained during transport.

2.0 STRUCTURAL EVALUATION

This section describes the materials of construction and criteria used for the design and analysis of the Package.

2.1 Materials of Construction

The primary materials used to construct the Package consist of:

ASTM SA516 Grade 70 Carbon Steel – The package top, bottom, sides, end cover and other parts of the Package and temporary attachments thereto.

ASTM A36 Carbon Steel – The sacrificial shock absorbers, which are integral to the container corners.

Tie-downs – The Package will be tied down with a system of bolting and tie-down straps or chains.

Weld Metals – Weld electrodes will be specified as required per American Welding Society (AWS) D1.1 – 1998, Structural Welding Code – Steel, for the applicable weld procedure and base material.

Bolting – End cover bolts made of ASTM A193-B7, used to fasten the container cover to the container body.

2.2 Package Design Criteria

The Package is designed in accordance with the requirements of 49CFR 173 with guidance from AISC (American Institute of Steel Construction) to meet all of the structural and shielding requirements for shipment of radioactive material.

2.3 Package Construction

The Package shall be of welded construction and shall meet the inspection and welding requirements of AWS D1.1 (American Welding Society).

2.4 Rigging and Handling Devices

The design and operation of rigging and handling devices will be per the requirements of Department of Energy Standard, Hoisting and Rigging, DOE-STD-1090-2001, dated April 2001. The lifting lugs are analyzed with a safety factor of three as required in 49CFR 173.410 (b). The load bearing portions of the Package required for rigging and handling will be designed in accordance with AISC requirements to ensure ample design margins are maintained.

2.5 Tie-down Sub-System

2.5.1 Tie-down System Design Criteria and Analysis Results

The design of the rail tie-down system will be in accordance with the applicable requirements of the American Institute of Steel Construction (AISC) and the American Welding Society (AWS) D1.1 - 1998, Structural Welding Code - Steel. The system shall be subjected to loads commensurate with the appropriate load cases regarding the tie-down system loads due to rail transport, shock and vibration.

The tie-down system assemblies, including all bolts, supports, tie-down appurtenances and devices, connections and the Package are analyzed with standard analytical methods. The results of these analyses demonstrate that when the Package is transported via rail, ample design margins exist relative to the applicable code requirements.

3.0 REGULATORY COMPLIANCE DISCUSSION FOR CLASS 7 MATERIALS

This section describes the features of the Package in the context of the requirements of 49CFR Part 173 for Class 7 (radioactive) materials transported in Type 2 Industrial Packages (IP-2). Any exemptions requested relative to these requirements and the basis for the exemptions is also discussed.

3.1 General Design Requirements (173.410)

3.1.1 Handling (173.410(a))

The Package must be designed so that "*The package can be easily handled and properly secured...on a conveyance during transport.*"

The Package design provides four (4) removable lifting devices on each of the upper corner shock absorbers to allow for easy rigging and handling. Once loaded on the railcar, the package will be secured using the corner shock absorbers for securement attachments.

3.1.2 Lifting Attachments (173.410(b))

The Package must be designed so that; "*Each lifting attachment that is a structural part of the package must be designed with a minimum safety factor of three against yielding when used to lift the package in the intended manner, and it must be designed so that failure of any lifting attachment under excessive load will not impair the ability of the package to meet other requirements...*"

The Package has four (4) removable lifting devices on the upper corner shock absorbers of the package. The lifting lugs were analyzed with a safety factor of three**.**

The Package must be designed so that; "*Any other structural part of the package which could be used to lift the package must be capable of being rendered inoperable for lifting the package during transport or...*"

After loading and before transport, the lifting devices on each of the upper corner shock absorbers will be removed. No additional lifting devices or attachments will be required.

3.1.3 Exterior Protrusions (173.410(c))

The Package must be designed so that; "*The external surface, as far as practicable, will be free from protruding features and will be easily decontaminated.*"

The Package surfaces are free of any protruding features and painted to ensure easy decontamination, if required, prior to shipment.

3.1.4 Water Collection Pockets (173.410(d))

The Package must be designed so that; "*The outer layer of packaging will avoid, as far as practicable, pockets or crevices where water might collect.*"

When placed on the transport conveyance there are no pockets that can collect water.

3.1.5 Feature Safety Impacts (173.410(e))

The Package must be designed so that; "*Each feature that is added to the package will not reduce the safety of the package*."

No features have been added to the Package which reduce its safety.

3.1.6 Normal Transport Vibrations (173.410(f))

The Package must be designed so that*; "The package will be capable of withstanding the effects of any acceleration, vibration or vibration resonance that may arise under normal conditions of transport without any deterioration in the effectiveness of the closing devices on the various receptacles or in the integrity of the package as a whole and without loosening or unintentionally releasing the nuts, bolts, or other securing devices even after repeated use.*"

The Package will be transported via rail, and will be designed to withstand the vibration that is anticipated under normal conditions of transport. With controlled movements of the Package during transportation, vibrations will be minimized such that no degradation of the effectiveness of the Package will occur due to the vibration loads.

3.1.7 Chemical Compatibility (173.410(g))

The Package must be designed so that; "*The materials of construction of the packaging and any components or structure will be physically and chemically compatible with each other and the package contents..*."

The materials used for the Package include carbon steel and neoprene. These materials are compatible with each other.

3.1.8 Valves (173.410(h))

The Package must be designed so that; "*All valves through which the package contents could escape will be protected against unauthorized operation*."

There are no valves on the Package.

3.2 Free Drop Under 173.465(c) Per (173.411(b))

Under 173.465(c), IP-2 packages must satisfy the requirements for the free drop test, which provides: "*The specimen must drop onto the target so as to suffer maximum damage to the safety features being tested*."

A one-foot corner drop followed by a slap down represents the worst-case orientation during normal conditions of transport for this Package. This analysis was performed using finite element methods for impact loads using conservative assumptions to determine stresses and maximum deformations resulting from the postulated worst case drop scenarios.

The results of the analysis demonstrate that ample design margins exist relative to the applicable code allowables for the Package. Neither the structural integrity of the container body nor the shielding capability was compromised under this condition. Accordingly, the container provides more than adequate safety relative to an IP2 package.

The results of these structural analyses are presented in Appendix B

3.2.1 Analysis Results

3.2.1.1 Loss or Dispersion of Contents

The results of the impact analyses indicate that the integrity of the Package and its closure devices are not compromised by the deformation resulting from the impact loads due to the postulated drop conditions. Moreover, the intrinsic nature of the Package contents (i.e., refractory brick, residual glass, and steel), which are fully encased in low-density cellular concrete, prevents dispersion.

To further demonstrate the robust nature of the packaging and its contents a hypothetical accident condition consisting of a ten-foot drop was analyzed. The analysis results are presented in Appendix C. As shown in Appendix C, while six (6) of the 36 closure bolts may fail, the packaging and the equipment itself remain intact and the residual glass material that contains the vast majority of the activity is not available for release.

Under hypothetical fire accident conditions per 10CFR 71.73 (c) 4, exposing the package to an 800^{o} C fire for a period of 30 minutes would not melt the residual glass allowing it to flow freely. There are three barriers between the fire and the glass within the Processing Equipment:

1. The outer packaging consisting of carbon steel that is 4 to 6 inches thick,
2. Low Density Cellular Concrete (LDCC) between the outer packaging and the body of the Processing Equipment, and
3. The body of the Processing Equipment consisting of a metal shell and refractory brick that is at least 12 inches thick.

These barriers will clearly prevent the glass from reaching a temperature of 800^{o} C. After 30 minutes, the glass may reach a temperature of 500^{o} C or so.

The residual glass, contained in this equipment, was designed to be melted at temperatures over 1000^{o} C. At 500^{o} C, the glass is just starting to soften. Unlike metals, glass does not melt at a particular temperature, but soften over a range of temperatures. This particular glass composition would not begin to flow under its own weight until its temperature reaches at least 900^{o} C.[8]

3.2.1.2 <u>Increase in Radiation Levels</u>

There is no loss of shielding when the package is dropped under normal conditions of transport as required for an IP-2 package.

3.3 Stacking Test 173.465(d) As Per (173.411(b))

Under 173.465(d), IP-2 packages must be; "*subjected for a period of at least 24 hours to a compressive load equivalent to...five times the mass of the package...*"

The Package has been analyzed to easily withstand the compressive load equal to five times its mass.[9]

3.4 Contamination Controls (173.427(a)(4))

Packages must meet the contamination control limits specified in 173.443.

The shipment will be made in accordance with WVDP site-specific procedures for shipment of radioactive materials precluding surface contamination. If surface contamination is found on the external surfaces of the package, it would be decontaminated in accordance with site procedures prior to transport.

3.5 Thermal Limitations (173.442)

"*A package of Class 7 (radioactive) material must be designed, constructed, and loaded so that - (a) The heat generated within the package by the radioactive contents will not, during conditions normally incident to transport, affect the integrity of the package, and…*"

The heat load from the worst-case Package contents (i.e., 4,570 Ci) is calculated at approximately 40 watts with the major contributor being Cs-137, the primary gamma emitter.[7] This heat load is negligible.

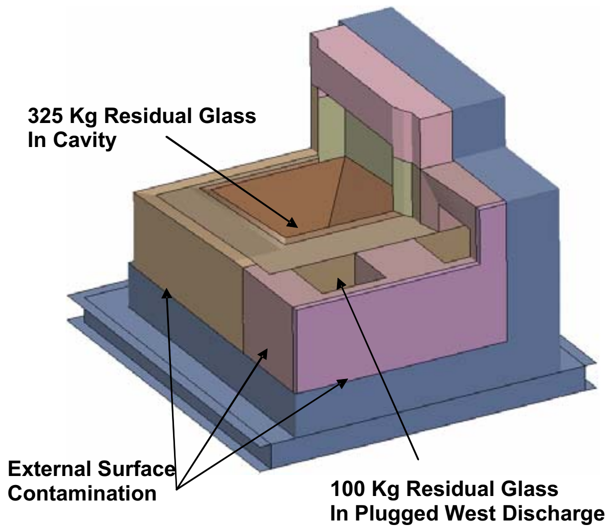
"(b) The temperature of the accessible external surfaces of the loaded package will not, assuming still air in the shade at an ambient temperature of 38 degrees C (100 degrees F), exceed…(2) 85 degrees C (185 degrees F) in an exclusive use shipment."

The internal heat load will have a negligible effect on the glass contained within the package and the ambient temperature of the Package external surface.

3.6 LSA and SCO Material Requirements

The Class 7 material consists of residual glass contained in two internal sections of the equipment as shown in Figure 3-1 and surface contaminants on the portions of the equipment exposed to airborne and slurry contamination. Compliance with LSA and SCO requirements is presented below.

Figure 3-1
Equipment Cutaway



3.6.1 LSA Definitions

LSA III materials are "*solids (e.g., consolidated wastes, activated materials) that meet the requirements of 173.468 and which:*

(i) The Class 7 (radioactive) material is distributed throughout a solid or collection of solid objects, or is essentially ..."

The radioactive materials consist of the residual glass as identified in Figure 3-1. The total radioactivity within the Package is estimated at 4,570 curies.

An exemption is requested that the Package contents be considered a "*collection of solid objects*" and that the requirement of 10 mSv/hr (1 R/hr) at 3-meters, as provided in 173.427(a)(1), be applied from the exterior surface of the Processing Equipment. The basis for this request is that while the residual glass material within the equipment will exceed 10 mSv/hr (1 R/hr) at 3-meters, this residual material is permanently affixed in place by low density cellular concrete, and the container will be permanently closed and sealed. Since there are no normal conditions of transport that could lead to breach of the Package integrity, the only source of radiation exposure would be that from the equipment itself and the dose rates would be less than the 1R/hr at 3-meters.

3.6.2 LSA III Material Leachability (173.468)

LSA III materials are "*solids (e.g., consolidated wastes, activated materials) that meet the requirements of 173.468 and which:*

(ii) The Class 7 (radioactive) material is relatively insoluble, or is intrinsically contained in a relatively insoluble material, so that, even under loss of packaging, the loss of Class 7 (radioactive) material per package by leaching when placed in water for 7 days would not exceed 0.1 A_2"

The LSA material consists of vitrified glass material that was specifically chosen for its ability to stabilize radioactive material. For the vitrified glass to release radioactive material, it would have to be due to leaching. About 0.16% of the glass concentration leaches into the water per References 6, 7, and 8. This results in a maximum release of 742 millicuries, which corresponds to 0.07 A_2, which is well within the limit. It should be noted that four layers of containment exist between the LSA material and the environment including:

- Grout in all internal void spaces
- All equipment penetrations will be sealed
- The equipment will be entirely encased in LDCC and
- A four to six inch thick steel container.

3.6.3 LSA Limit Calculations

LSA III materials are "*solids (e.g., consolidated wastes, activated materials) that meet the requirements of 173.468 and which;*

(iii) the average specific activity of the solid does not exceed 2E-3 A_2/g."

The content of the Package has A_2/g concentrations below the LSA III limit. The analytical results to support these conclusions are presented below.

Tables 3-1 and 3-2 are DOT classification summary calculations for the Class 7 (radioactive) materials for the Package. Table 3-1 shows the Package glass contents as of October 1, 2004 with the A_2 fractions that go into effect as of that date. The Package contains 4,570 curies, which corresponds to 463 A_2 quantities of radioactive material as of October 1, 2004. The worst case LSA III A_2/g value is conservatively calculated using only the weight of the glass itself, 936 lb. This conservative weight does not include the refractory brick or the equipment itself resulting in maximum concentrations. As shown in Table 3-1, the total A_2/g value is 1.09E-03, which is 55% of the LSA III limit of 2.0E-03 A_2/g. The glass in the main cavity has the highest average specific activity. Its A_2 fraction (436) divided by its weight (approximately 325 Kg) is 1.34E-02, which is 67% the LSA limit. If the total weight of the Class 7 material is used, the A_2/g value is 9.41E-06, which is only 9% of the LSA II limit.

Cs-137, Sr-90, Am-241, Pu-238 and Cm-244 are the nuclides that contribute greater than 95% of the hazard fraction as per 49CFR 173.433(f).

3.6.4 <u>SCO Limit Calculations</u>

A Surface Contaminated Object (SCO) is "*a solid object which is not itself radioactive but which has Class 7(radioactive) material distributed on any of its surfaces..*"

SCO II material is defined as: "*A solid object on which:*

i. The non-fixed contamination on the accessible surface … does not exceed 10^{-2} uci/cm^2 for beta and gamma and low toxicity alpha emitters or 10^{-3} uci/cm^2 for all other alpha emitters;

ii. The fixed contamination on the accessible surface…does not exceed 20 uci/cm^2 for beta and gamma and low toxicity alpha emitters or 2 uci/cm^2 for all other alpha emitters; and

iii. The non-fixed contamination plus the fixed contamination on the inaccessible surface…does not exceed 20 uci/cm^2 for beta and gamma and low toxicity alpha emitters or 2 uci/cm^2 for all other alpha emitters.

The surface contaminants have been fixed by use of the PBS™ fixative and therefore only the fixed contamination limits are applicable. The contamination levels are within the SCO II limits as shown in Table 3-2 below.

Table 3-1
DOT LSA Classification Summary

Nuclide	Total 10/1/2004 Activity (Ci)	A_2 Value (Ci)	A_2 Fraction	A_2/g_{glass}
<H-3>	3.35E-02	1.10E+03	N/A	N/A
C-14	2.12E-02	8.10E+01	2.62E-04	6.17E-10
K-40 (n.o.)	8.19E-02	2.40E+01	3.41E-03	8.03E-09
Mn-54	8.57E-02	2.70E+01	3.17E-03	7.47E-09
Co-60	8.33E-02	1.10E+01	7.57E-03	1.78E-08
Ni-63	1.01E+00	8.10E+02	1.25E-03	2.93E-09
Sr-90	2.47E+02	8.10E+00	3.05E+01	7.18E-05
Zr-95	1.65E+00	2.20E+01	7.49E-02	1.77E-07
Tc-99	1.11E-02	2.40E+01	4.61E-04	1.09E-09
<I-129>	5.64E-03	unlimited	N/A	N/A
Cs-137	4.31E+03	1.60E+01	2.70E+02	6.35E-04
<Ce-144>	1.40E+00	5.40E+00	N/A	N/A
Eu-154	1.21E+00	1.60E+01	7.55E-02	1.78E-07
Th-228	4.09E-02	2.70E-02	1.51E+00	3.56E-06
Th-230	3.65E-04	2.70E-02	1.35E-02	3.18E-08
Th-232 (n.o.)	4.01E-04	unlimited	N/A	N/A
U-232	5.01E-02	2.70E-02	1.86E+00	4.37E-06
U-233	2.06E-02	1.60E-01	1.29E-01	3.03E-07
U-234 (n.o.)	9.81E-03	1.60E-01	6.13E-02	1.44E-07
U-235 (n.o.)	3.76E-04	unlimited	N/A	N/A
U-236	1.13E-03	1.60E-01	7.05E-03	1.66E-08
U-238 (n.o.)	2.25E-03	unlimited	N/A	N/A
Np-237	6.20E-03	5.40E-02	1.15E-01	2.70E-07
Pu-238	6.84E-01	2.70E-02	2.53E+01	5.97E-05
Pu-239	1.59E-01	2.70E-02	5.88E+00	1.38E-05
Pu-240	1.21E-01	2.70E-02	4.49E+00	1.06E-05
Pu-241	3.12E+00	1.60E+00	1.95E+00	4.59E-06
Am-241	3.00E+00	2.70E-02	1.11E+02	2.61E-04
Am-243	3.50E-02	2.70E-02	1.30E+00	3.05E-06
Cm-242	7.33E-02	2.70E-01	2.71E-01	6.39E-07
Cm-243	1.68E-02	2.70E-02	6.23E-01	1.47E-06
Cm-244	4.35E-01	5.40E-02	8.05E+00	1.90E-05
Total	4.57E+03	N/A	4.63E+02	1.09E-03

LSA-III Limit	2.00E-03
LSA-III Percentage	55%

< > indicates LLD values
(n.o.) indicates naturally occurring isotope

Glass Weight 4.25E+05 g

Table 3-2
DOT SCO Classification Summary

Nuclide	Slurry Activity 10/1/2004 (Ci)	Airborne Activity 10/1/2004 (Ci)	Total Activity 10/1/2004 (Ci)
H-3	<1.13E-05>	7.94E-06	7.94E-06
C-14	6.90E-06	1.56E-03	1.57E-03
K-40 (n.o.)	2.66E-05	NP	2.66E-05
Fe-55	NP	3.84E-03	3.84E-03
Mn-54	4.87E-05	NP	4.87E-05
Co-60	2.97E-05	4.82E-04	5.11E-04
Ni-59	NP	2.09E-04	2.09E-04
Ni-63	3.30E-04	6.42E-03	6.75E-03
Sr-90	8.17E-02	9.22E-01	1.00E+00
Zr-95	8.22E-03	NP	8.22E-03
Tc-99	3.60E-06	9.08E-06	1.27E-05
I-129	<1.84E-06>	1.59E-04	1.59E-04
Cs-137	1.43E+00	2.66E+00	4.09E+00
<Ce-144>	<8.40E-04>	NP	<8.40E-04>
Pm-147	NP	2.84E-02	2.84E-02
Eu-154	4.15E-04	7.25E-03	7.67E-03
Th-228	1.71E-05	NP	1.71E-05
Th-230	1.19E-07	NP	1.19E-07
Th-232 (n.o.)	1.30E-07	NP	1.30E-07
U-232	1.64E-05	4.21E-04	4.37E-04
U-233	6.69E-06	9.73E-06	1.64E-05
U-234 (n.o.)	3.19E-06	3.41E-06	6.61E-06
U-235 (n.o.)	1.22E-07	3.39E-07	4.62E-07
U-236	3.67E-07	7.92E-07	1.16E-06
U-238 (n.o.)	7.32E-07	2.52E-06	3.25E-06
Np-237	2.02E-06	7.09E-06	9.11E-06
Pu-238	2.24E-04	1.57E-03	1.79E-03
Pu-239	5.16E-05	4.06E-04	4.58E-04
Pu-240	3.94E-05	2.82E-04	3.22E-04
Pu-241	1.05E-03	1.43E-02	1.54E-02
Pu-242	NP	2.28E-05	2.28E-05
Am-241	9.75E-04	1.42E-02	1.51E-02
Am-243	1.14E-05	1.17E-03	1.18E-03
Cm-242	6.96E-05	2.89E-04	3.58E-04
Cm-243	5.56E-06	NP	5.56E-06
Cm-244	1.45E-04	5.10E-03	5.24E-03
Cm-245	NP	1.10E-02	1.10E-02
Cm-246	NP	1.79E-03	1.79E-03
Total	1.52E+00	3.68E+00	5.20E+00
β,γ, LTA Activity	1.52E+00	3.63E+00	5.15E+00
α Activity	2.62E-03	5.05E-02	5.31E-02

	Slurry	Airborne
Surface Area, cm^2	9.08E+04	8.18E+05
β,γ, LTA Contamination, uCi/cm2	1.67E+01	4.44E+00
α Contamination, uCi/cm2	2.88E-02	6.18E-02
β,γ, LTA SCO-II Limits, uCi/cm^2	2.00E+01	2.00E+01
α SCO-II Limits, uCi/cm^2	2.00E+00	2.00E+00
β,γ, LTA %SCO-II	83%	22%
α %SCO-II	1%	3%

<> indicates LLD value
(n.o.) indicates naturally occurring isotope
NP indicates Not Present

4.0 RADIOLOGICAL ANALYSIS

The radiological analysis performed to estimate the relevant 3-meter dose rates and determine the dose rates on the exterior of the package during transport are presented below.

4.1 Characterization

The Class 7 material was characterized using industry standard practices. The characterization results are documented in Appendix A and a summary of the activities by nuclide is provided in Table 3-1 above. As shown in Tables 3-1 and 3-2, the total activity as of October 1, 2004 is 4,570 curies. This activity is considerably lower than that of the planned vitrified waste shipments from West Valley (193,000 Ci/shipment) and typical vitrified waste shipments or reprocessed material from France (500,000 Ci/Shipment). As stated above, there were efforts to flush the equipment to minimize the concentrations in the residual glass. As a result the concentrations of alpha emitting plutonium isotopes, a primary nuclide of concern, are a factor of more than 25 lower in the residual glass than in the vitrified waste canisters produced.

4.2 Source Term Definition

Based on the isotopic distribution, which has a Cs-137 abundance of greater than 94%, it was assumed that all the gamma dose is from Cs-137 (and it's daughter Ba-137m). Based on the characterization results presented in Appendix A, there are about 4,060 curies of Cs-137 in the main cavity, 252 curies in the plugged west discharge and 4.1 curies of Cs-137 distributed over the external surfaces in the form of surface contaminants.

4.3 3-Meter Dose Rate

A QAD-GCCP-A combinatorial geometry model was used with measured dose rates to determine that the 3-meter dose rates on all sides of the equipment are less than 1 R/hr. Two sources are considered separately when calculating 3-meter dose rates. The source contained in the main cavity represents more total curies and more specific activity, but it does not yield maximum exterior dose rates because it is highly shielded by the refractory material. The source in the West discharge cavity presents the greatest challenge to the 1 R/hr at 3-meter dose rate limit. The maximum 3-meter dose rate is from the bottom of the Processing Equipment at the West discharge port. The maximum 3-meter dose rate is 790 mR/hr.

4.4 <u>Dose Rates from Package Exterior during Transport (173.441)</u>

Dose rates were determined on contact and at 2-meters by using QAD-CGGP-A. All dose rates are based on the earliest anticipated shipping date of October 1, 2004.

The Package shielding configuration consists of a 4” thick carbon steel container top and bottom with 6” thick carbon steel side walls. The container is shown in Figure 1-1 of Section 1.0. Estimated dose rates at the time of shipment were quantified and shown to meet the following requirements

1. Less than 200 mR/hr on the external surface of the Package,
2. Less than 200 mR/hr at any point on the vertical planes projected from the outer edges of vehicle, on the upper surface of the load, and on the lower external surface of vehicle,
3. Less than 10 mR/hr at any point 2-meters from the vertical planes projected from the side of the transport conveyance,
4. Less than 2 mR/hr in any normally occupied spaces.

The maximum contact dose rate is calculated at 30 mR/hr and the maximum 2-meter dose rate was determined to be 6 mR/hr. Based on the configuration of the transport conveyance, all occupied spaces will be well below 2 mR/hr.

5.0 REFERENCES

1. 49CFR Part 107, Hazardous Materials Program Procedures.

2. 49CFR Part 173, Shippers – General Requirements for Shipments and Packagings.

3. AWS, D1.1, "Structural Welding Code-Steel," 1998.

4. AISC, American Institute of Steel Construction, "Steel Construction Manual," Ninth Edition, 1989.

5. DOE-STD-1090-2001, Department of Energy Standard, Hoisting and Rigging, dated April 2001.

6. Electronic mail from R. A. Palmer to E. Posivak dated 5/11/2004.

7. Electronic mail from L. Rowell to K. Tuite dated 5/3/2004.

8. Ronald A. Palmer and Robert H. Doremus, Wiley Series on the Science and Technology of Materials, John Wiley & Sons, pp 101-121.

9. WMG – 4005-CA-040 West Valley Package Stacking Test, 4/30/2004