TESTING OF THE DHLW TRUCK SHIPPING CASK*

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Abstract

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The Defense High Level Waste (DHLW) cask is a Type B packaging currently under development by the United States Department of Energy (DOE). The shipping system is designed to meet a legal weight truck limit of 36 288 kg (80 000 lb). Type B packagings for transporting radioactive materials are required to maintain containment and shielding after being exposed to the environments defined in Title 10, Code of Federal Regulations, Part 71. A combination of testing and analysis is used to verify the adequacy of the cask design. The paper describes the test programme portion of the design verification.

INTRODUCTION

Large quantities of DHLW produced at reprocessing sites of the DOE exist at several locations in the U. S. In order to end interim storage, the waste must be immobilized and prepared for shipment to federal repositories for permanent storage. A program was initiated by the DOE to provide a safe and efficient transportation system for DHLW. Under this program, GA Technologies and Sandia National Laboratories (SNL) are designing and testing a transportation system that is reported in Reference 1. The DHLW shipping cask system is designed to meet a gross vehicle weight limit of 36 288 kilograms (80 000 pounds). The cask is transported horizontally on a semi-trailer, as shown in Fig. 1. The cask (Fig. 2) is designed to transport one canister of borosilicate glass waste. The cask body is a thick wall type 304 stainless steel shell with

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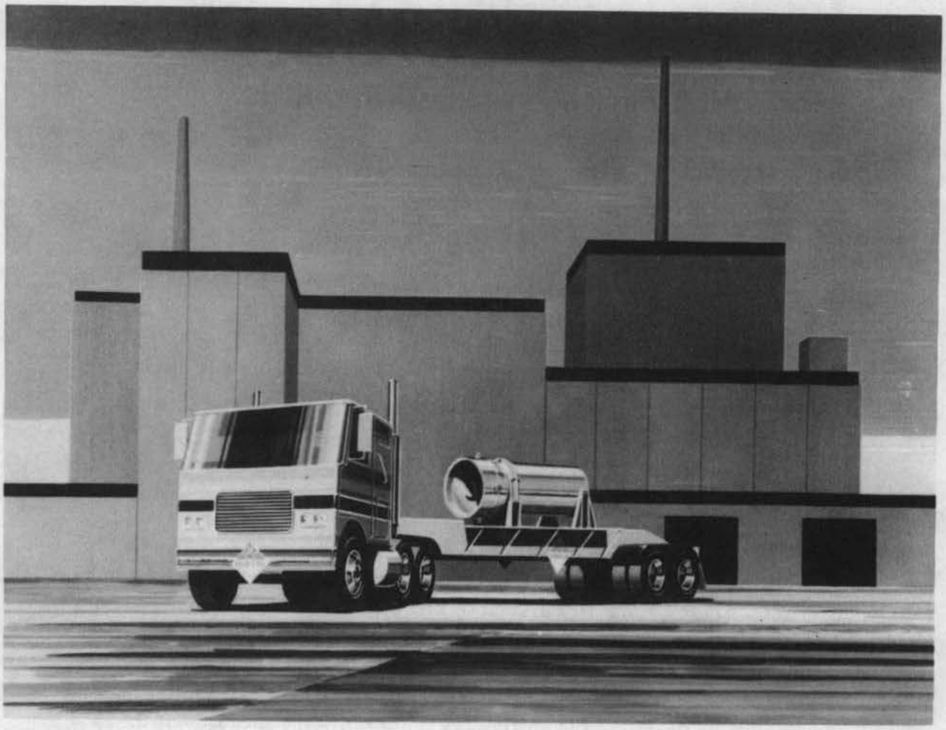

FIG. 1. DHLW truck cask system.

a standard bolted closure. Additional gamma shielding is provided by a stainless steel jacketed depleted uranium sleeve that is removable to provide multi-use flexibility. Integral impact limiters are provided which reduces handling steps at the shipping and receiving facilities. The cask was designed for either remote or manual handling.

TEST PROGRAM

Federal regulations(2) and DOE Orders(3) require that Type B packagings for transporting radioactive materials must maintain containment and shielding for the following hypothetical accident conditions:

1) Impact of a fully loaded package on an unyielding target after a 9 m (30 ft) free fall
2) Impact of a fully loaded package on a 15 cm (6 in) diameter mild steel pin following a 1 m (40 in) free fall
3) Exposure of a fully loaded package to a 800°C (1475°F) thermal source for 30 minutes

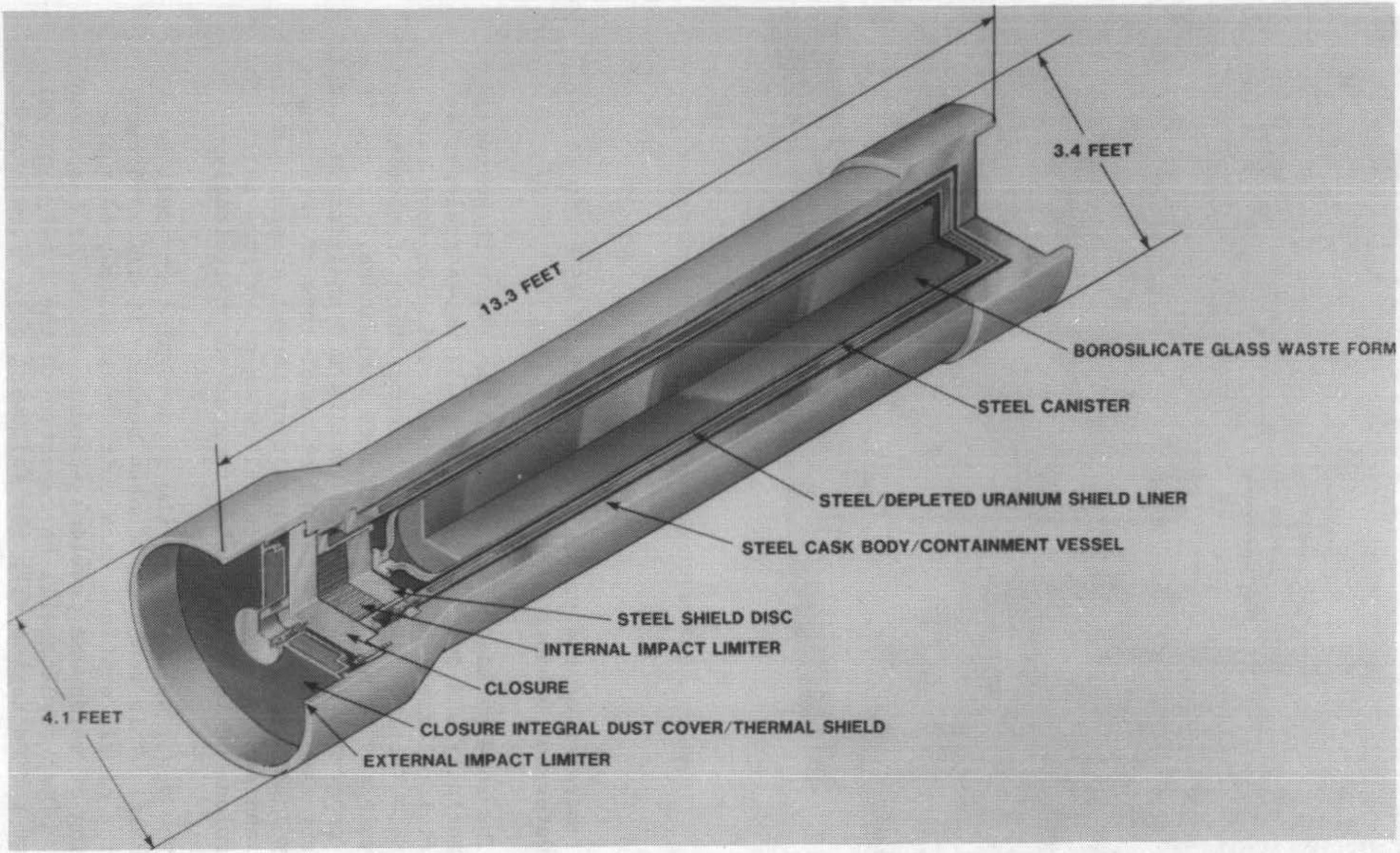

FIG. 2. DHLW truck cask (1 ft = 0.3048 m).

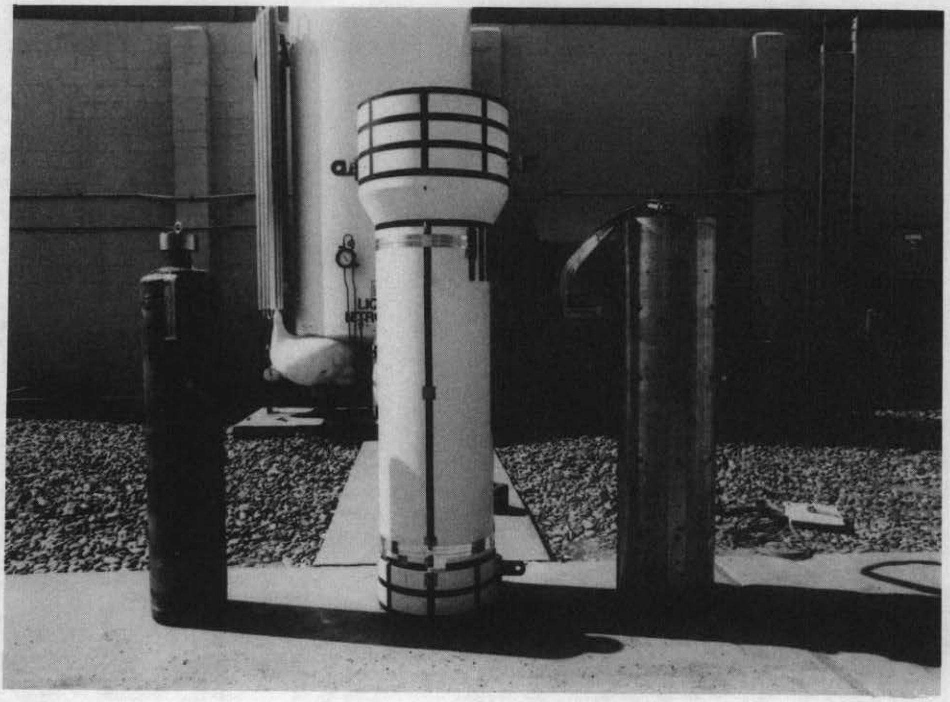

FIG. 3. DHLW half-scale model canister, cask and shielding liner.

4) Immersion of the package to a depth of 15 m (50 ft) in water for 8 hours.

The same packaging must undergo the first three tests sequentially and survive by meeting allowable radioactive material release limits and external radiation dose rate limits. Testing, analysis, or a combination of testing and analysis may be used to demonstrate compliance. In the DHLW cask program a combination of testing and analysis is used to satisfy the hypothetical accident conditions of impacting a fully loaded cask onto an unyielding target after a 9 m free fall and onto a puncture pin following a 1 m free fall. The immersion and thermal events are treated analytically.

The scale selected for the structural test model is one-half. This scale was chosen because it allows direct scaling of all critical cask components, allows adequate scaling of welds and provides adequate space for instrumentation. Test results will be reported in the Safety Analysis Report for Packaging with the following objectives that help verify the reference design:

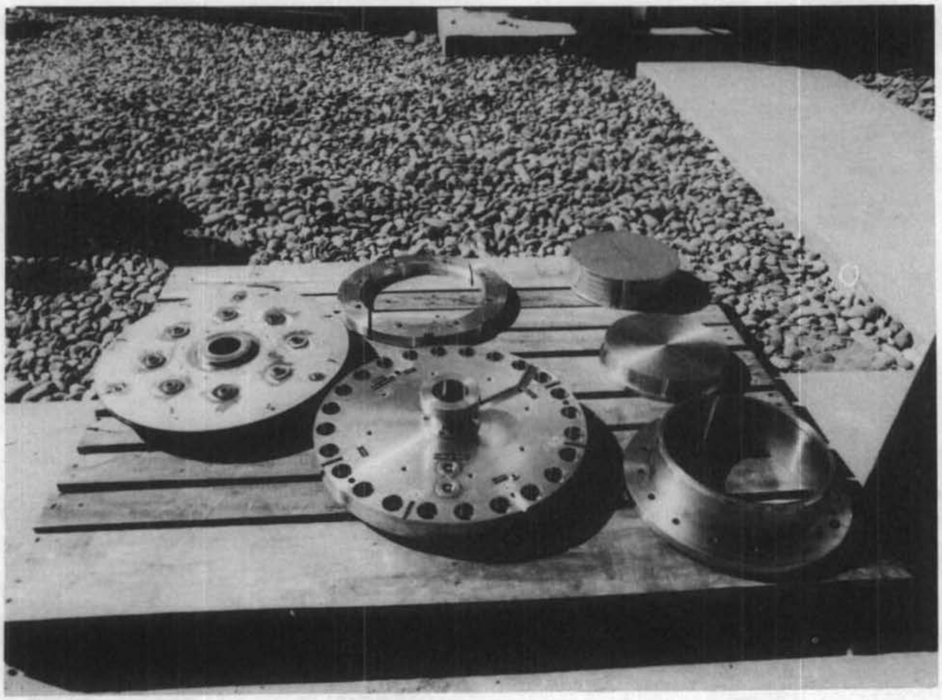

FIG. 4. DHLW half-scale model components (from upper right, clockwise) internal impact limiter, shield disc, internal impact limiter holder, closure plate, thermal shield and shear ring.

1) Correlate test and analytical results to establish the validity of using computer non-linear analysis to demonstrate compliance with regulations
2) Verify post-accident shielding effectiveness
3) Confirm the design for drop orientations that were analyzed with approximate calculations
4) Obtain seal deformation data
5) Confirm the acceptability of components that cannot fully be evaluated by analysis (welds, bolts, etc.).

To meet these objectives the following test sequence is being performed at the SNL Coyote Aerial Cable Facility:

1) 9 m cask bottom end flat drop
2) 9 m cask closure end flat drop
3) 1 m gas sample port puncture drop
4) 9 m cask side drop
5) 1 m closure puncture drop
6) 9 m cask center of gravity over bottom corner drop
7) 9 m cask center of gravity over closure corner drop

The scale model is shown in Figs. 3 and 4. Fig. 5 shows the model rigged above the target for the bottom end drop.

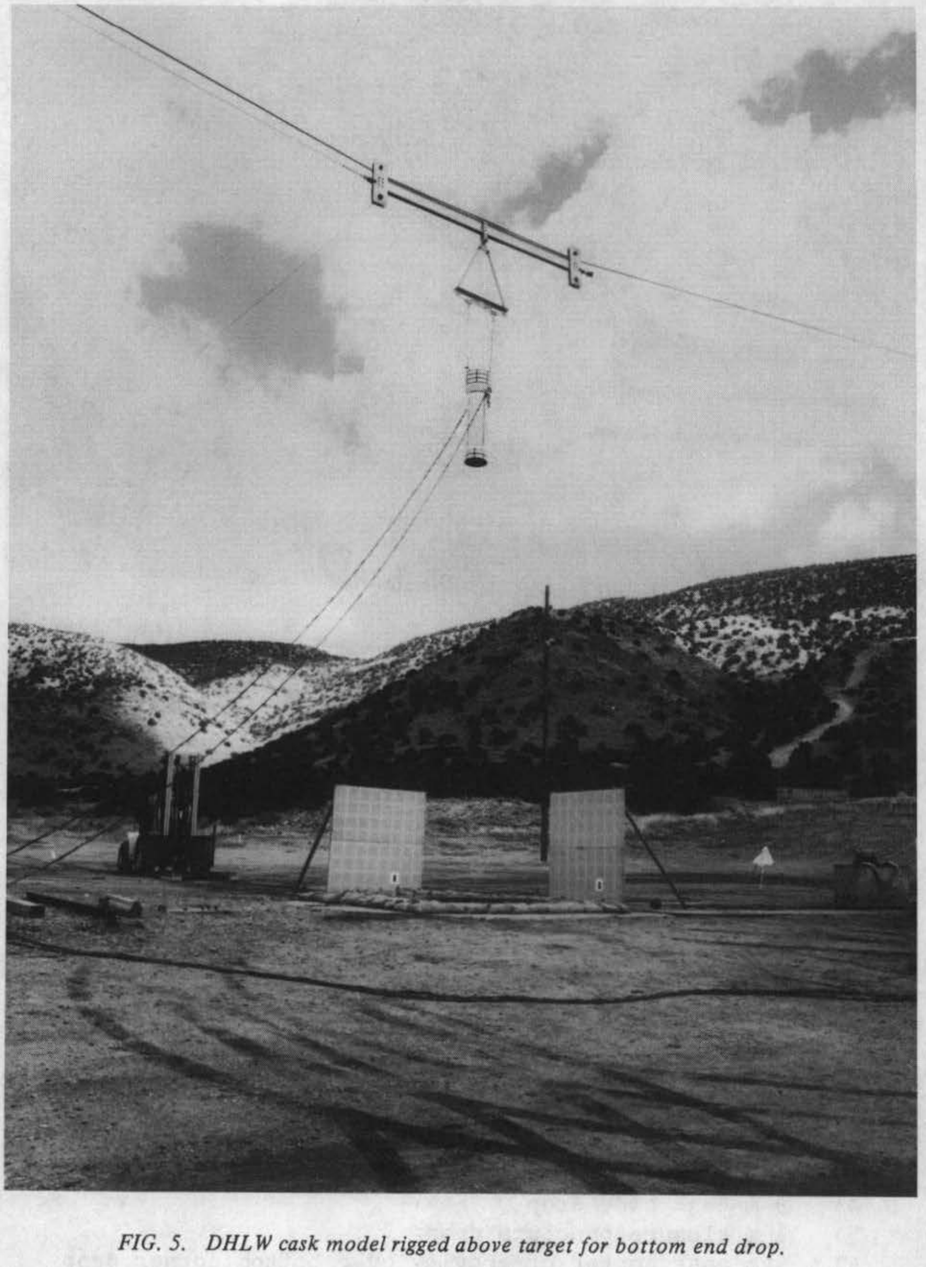

FIG. 5. DHLW cask model rigged above target for bottom end drop.

Table I. Full-Scale Closure Seal Leak Testing

Normal Conditions

Method	Leak Rate (atm-cm^3/sec)
Pressure Rise	2×10^{-4}
He Mass Spectrometer	5×10^{-9}

Hypothetical Accident Conditions

Method	O-Ring Decompression cm	in	Leak Rate (atm-cm^3/sec)
He Mass Spectrometer	0.0	(0.0)	No Detectable
He Mass Spectrometer	.025	(0.01)	2×10^{-8}
He Mass Spectrometer	.050	(0.02)	3×10^{-7}
He Mass Spectrometer	.060	(0.03)	8×10^{-7}
He Mass Spectrometer	.080	(0.04)	9×10^{-4}

Instrumentation for post-test evaluation includes strain gages, strain-gaged bolts, accelerometers and displacement transducers. Post-test data are also collected from radiographs of the depleted uranium and welds, cask body and closure seal leak tests, mechanical inspections and seal deformations. Photographic records of all aspects of the test are maintained.

In addition to the one-half scale structural tests, full scale tests on the containment sealing system have been performed. Since scaling relationships for closure seal performance have not been developed it was necessary to perform these tests on a full-scale version. Testing was performed on a full-scale mock-up with a prototype closure and closure interface that was designed and fabricated by Hanford Engineering Development Laboratory (HEDL) for remote handling demonstration.

The objective of this testing is to demonstrate that the double o-ring seals satisfy the leakage criteria during normal conditions of transport and hypothetical accident conditions. The test procedure follows American National Standard Institute N14.5 - 1977(4) and is performed with a leak sensitivity of at least 10^{-7} atm-cm^3/sec based on dry air at 25°C for a pressure differential of 1 atmosphere against a vacuum of 10^{-2} atm or less. Pressure rise and helium mass spectrometer tests that were conducted are reported in Table I. The accident condition is simulated by a partial reduction in o-ring

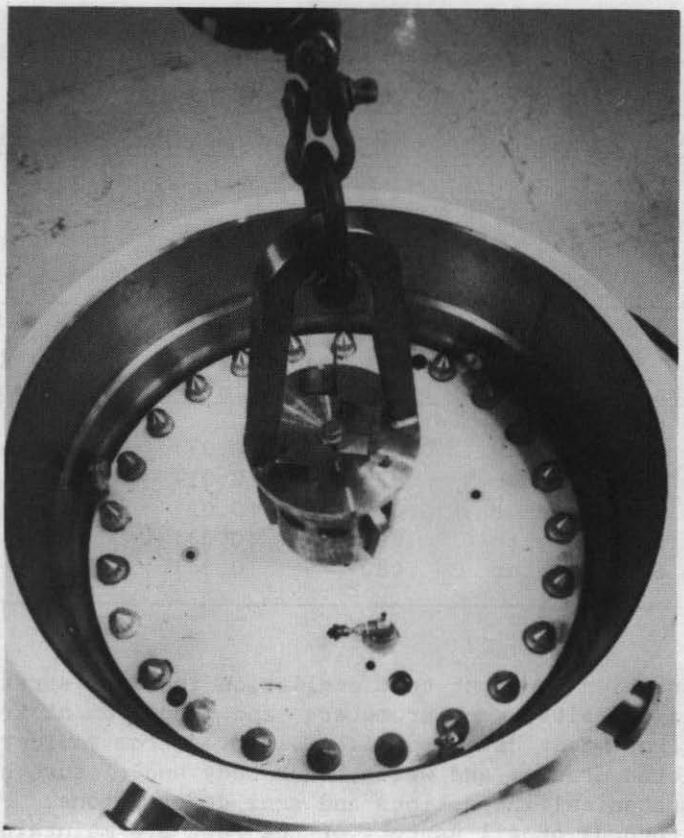

FIG. 6. DHLW full-scale mock-up of O-ring decompression.

compression as shown in Figs. 6 and 7. The o-ring compression and contact pressure on the seals is reduced in several incremental steps. Actual seal surface opening deformations during hypothetical accident conditions are recorded during the half-scale model tests. These deformations will be correlated with the full-scale mock-up leak test results as acceptance criteria to obtain the sealing capability of the closure seals.

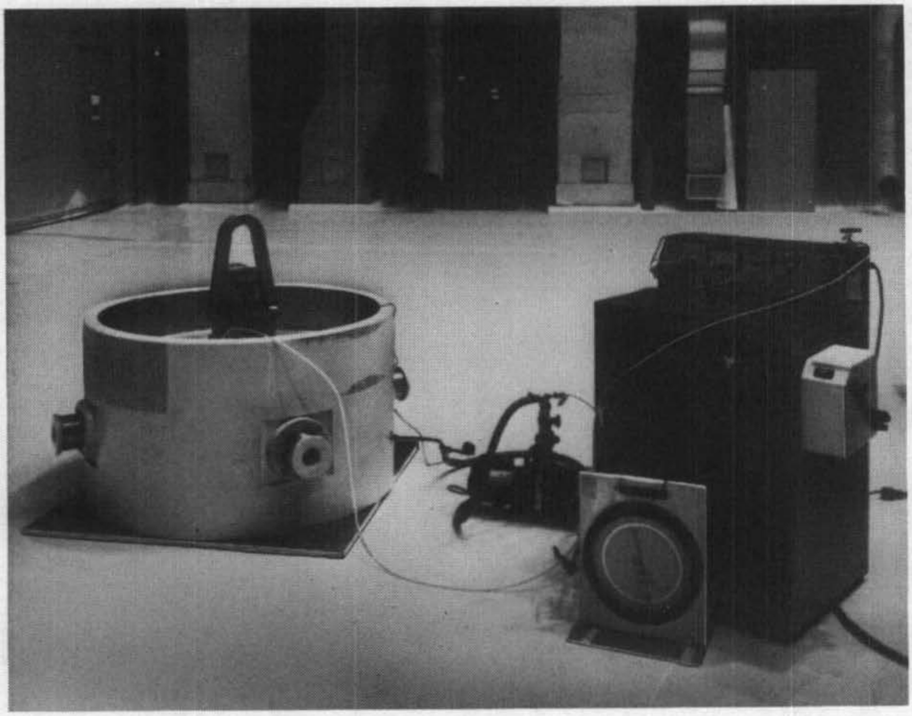

FIG. 7. DHLW full-scale mock-up leak test setup.

ACKNOWLEDGEMENT

The authors gratefully acknowledge that the full-scale mock-up leak testing was performed by D. L. Swannack, HEDL.

REFERENCES

(1) M. M. Madsen, A. Zimmer, "A Truck Cask Design for Shipping Defense High Level Waste", Proceedings of the American Nuclear Society International Topical Meeting on High Level Nuclear Waste Disposal, Pasco, WA, September 24-26, 1985, Published by Battelle Press, 505 King Avenue, Columbus, OH.

(2) Federal Register, Title 10, Code of Federal Regulations, Part 71, Office of the Federal Register, National Archives and Records Administration, Washington, DC.

(3) Department Of Energy Order 5480.3, dated July 9, 1985, "Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes."

(4) American National Standard Institute N14.5-1977, Leakage Tests on Packages for Shipment of Radioactive Materials, American National Standards Institute, 1430 Broadway, New York, NY 10018.