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Title/Desc:

TEST & EVALUATION REPORT FOR WHC 1-L LIQUID
SHIPPER DOCKET 95-41-7A TYPE A CONTAINER

Pages: 131

ENGINEERING CHANGE NOTICE

Page 1 of 21. ECN **No 623795**Proj.
ECN

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Page 2 of 2

1. ECN (use no. from pg. 1)

623795

15. Design Verification Required ☐ Yes ☒ No	16. Cost Impact				17. Schedule Impact (days)	
	ENGINEERING		CONSTRUCTION			
	Additional	☐ \$	Additional	☐ \$		
	Savings	☐ \$	Savings	☐ \$	Improvement	☐
					Delay	☐

18. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 12. Enter the affected document number in Block 19.

SDD/DD		Change described in Block 12. Enter the affected document number in Block 19.	
Functional Design Criteria	☐	Seismic/Stress Analysis	☐
Operating Specification	☐	Stress/Design Report	☐
Criticality Specification	☐	Interface Control Drawing	☐
Conceptual Design Report	☐	Calibration Procedure	☐
Equipment Spec.	☐	Installation Procedure	☐
Const. Spec.	☐	Maintenance Procedure	☐
Procurement Spec.	☐	Engineering Procedure	☐
Vendor Information	☐	Operating Instruction	☐
OM Manual	☐	Operating Procedure	☐
FSAR/SAR	☐	Operational Safety Requirement	☐
Safety Equipment List	☐	IEFD Drawing	☐
Radiation Work Permit	☐	Cell Arrangement Drawing	☐
Environmental Impact Statement	☐	Essential Material Specification	☐
Environmental Report	☐	Fac. Proc. Samp. Schedule	☐
Environmental Permit	☐	Inspection Plan	☐
		Inventory Adjustment Request	☐
		Tank Calibration Manual	☐
		Health Physics Procedure	☐
		Spares Multiple Unit Listing	☐
		Test Procedures/Specification	☐
		Component Index	☐
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		Process Flow Chart	☐
		Purchase Requisition	☐
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19. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision

Document Number/Revision

Document Number Revision

20. Approvals

[illegible]

TEST AND EVALUATION REPORT FOR WESTINGHOUSE HANFORD COMPANY'S 1-L LIQUID SHIPPER, DOCKET 95-41-7A, TYPE A CONTAINER

D. L. Kelly

Westinghouse Hanford Company, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-87RL10930

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Abstract: This report incorporates the U.S. Department of Energy, Office of Facility Safety Analysis (DOE/EH-32) approval letter for packaging use. This report documents the U.S. Department of Transportation Specification 7A Type A (DOT-7A) compliance test results of the 1-L Liquid Shipper packaging. The approved packaging system is designed to ship Type A quantities of radioactive materials, normal form. Contents may be liquid or solid form. Liquid contents must have a specific gravity ≤ 2 . Solid materials are limited in weight, to include packaging, to the gross weight of the as-tested liquids and bottles.

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United States Government

Department of Energy

memorandum

DATE: FEB 23 1996
REPLY TO: EM-76:Wangler:3-5078
ATTN OF:
SUBJECT: APPROVAL OF 1-L LIQUID SHIPPER AS A SPECIFICATION 7A PACKAGING

TO: T. Teynor, Director, Waste Programs Division, Richland Operations Office

The Westinghouse Hanford Company (WHC) 1-L Liquid Shipper (docket 95-41-7A) is hereby approved for use as a Department of Transportation Specification 7A Type A packaging. This is based upon our review of the Final Evaluation Report documenting the performance testing conducted on the packaging, as well as our observation of the testing at WHC. The Final Evaluation Report and information pages prepared by WHC are also approved.

If you need additional information, please contact me at 301-903-5078 or Ashok Kapoor at 301-903-6838.

Michael E. Wangler
Headquarters Certifying Official
Office of Transportation, Emergency
Management and Analytical Services, EM-76

cc: see next page

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TEST AND EVALUATION REPORT FOR WESTINGHOUSE HANFORD COMPANY'S
1-L LIQUID SHIPPER, DOCKET 95-41-7A
TYPE A CONTAINER

1.0 INTRODUCTION

1.1 BACKGROUND

This report documents the U.S. Department of Transportation Specification 7A Type A (DOT-7A) compliance test results of the Westinghouse Hanford Company (WHC) 1-L Liquid Shipper. The 1-L Liquid Shipper packaging configurations were evaluated and tested in August 1995 at the U.S. Department of Energy (DOE) approved test facility located at the Hanford site, in Richland, Washington. Because WHC conducted the tests, an independent observer, representing the DOE, Office of Facility Safety Analysis (EH-32), was present during testing.

The packaging configurations tested utilize the 3M SafeSend¹ Reusable Super Pack Shipping System (SP-RIL Kit). Two different types of 1-L internal bottles were tested. This packaging system was provided by WHC. The 3M SafeSend SP-RIL Kit assembly is manufactured by the 3M Company and available through various packaging vendors such as Labelmaster.² The SafeSend SP-RIL Kit consists of a polyethylene canister base and cap with integral sorbent material, a quad ring gasket, two plastic bags, and six foam inserts. Eight fiberboard shippers are included in the kit. The packaging configurations tested utilized two different types of internal, 1-L bottles. The internal bottles must be supplied by the user and must remain intact and not break or leak.

The two different internal bottle types tested were as follows:

1. A 1-L, narrow-mouth, Teflon,³ fluorinated ethylene propylene (FEP) bottle with a Tefzel⁴ ethylene-tetrafluoroethylene (ETFE) screw closure (lid). The nominal diameter of the cap is 3.96875-cm (1.5625-in). The bottle, including the content weight, had an average weight of 2167.5 g (4.78 lb).

NOTE: THIS BOTTLE IS APPROVED FOR USE INSIDE THE 1-L LIQUID SHIPPER.

¹SafeSend is a trademark of the 3M Company.

²Labelmaster is an American Labelmark Company.

³Teflon is a trademark of E.I. du Pont de Nemours & Company.

⁴Tefzel is a trademark of E.I. du Pont de Nemours & Company.

2. A 1-L, wide-mouth, fluorinated high density polyethylene (FLPE) bottle with a fluorinated polypropylene (PP) screw closure (lid). The nominal diameter of the cap is 6.6675-cm (2.625-in). The bottle, including the content weight, had an average weight of 2108.85 g (4.65 lb).

NOTE: THIS BOTTLE IS NOT APPROVED FOR USE INSIDE THE 1-L LIQUID SHIPPER.

The packaging configurations tested were as follows:

1. The 1-L, narrow-mouth Teflon bottle with a Tefzel lid. The internal bottle was filled with simulated contents. The average internal bottle content weight was 2000 g (4.4 lb). The average bottle weight, including simulated contents, was 2167.5 g (4.78 lb). Six foam inserts were placed around the bottle according to the opening, loading, and closure instructions provided by the test sponsor (see Appendix B). These items were placed into a plastic bag, that was placed inside the SafeSend canister. The SafeSend was then placed inside a fiberboard shipper.

NOTE: THIS CONFIGURATION IS NOT APPROVED FOR USE.

2. The 1-L, wide-mouth FLPE bottle with PP lid. The internal bottle was filled with simulated contents. The average internal bottle content weight was 2000 g (4.4 lb). The average bottle weight, including simulated contents, was 2108.85 g (4.65 lb). Six foam inserts were placed around the bottle according to the opening, loading, and closure instructions provided by the test sponsor (see Appendix B). These items were placed into a plastic bag, that was placed inside the SafeSend canister. The SafeSend was then placed inside a fiberboard shipper.

NOTE: THIS CONFIGURATION IS NOT APPROVED FOR USE.

3. The 1-L, narrow-mouth Teflon bottle with a Tefzel lid. The internal bottle was filled with simulated contents. The average internal bottle content weight was 2000 g (4.4 lb). The average bottle weight, including simulated contents, was 2167.5 g (4.78 lb). Six foam inserts were placed around the bottle according to the opening, loading, and closure instructions provided by the test sponsor (see Appendix B). These items were placed into a plastic bag, that was placed inside the SafeSend canister.

NOTE: THIS CONFIGURATION IS APPROVED FOR USE.

4. The 1-L, wide-mouth FLPE bottle with PP lid. The internal bottle was filled with simulated contents. The average internal bottle content weight was 2000 g (4.4 lb). The average bottle weight, including simulated contents, was 2108.85 g (4.65 lb). Six foam inserts were placed around the bottle according to the opening, loading, and closure instructions provided by the test sponsor (see Appendix B). These items were placed into a plastic bag, that was placed inside the SafeSend canister.

NOTE: THIS CONFIGURATION IS NOT APPROVED FOR USE.

The nominal gross weight of the assembled packaging is 3830.5 g (8.4 lb). Use of the external fiberboard shipper for this packaging configuration is not authorized. The tested, 1-L internal bottle that is approved for use is as follows:

1. The 1-L, narrow-mouth, Teflon bottle with the Tefzel lid. The nominal diameter of the cap is 3.96875-cm (1.5625-in). The internal bottle contents cannot exceed 2000 g (4.4 lb). Total bottle weight, including contents, cannot exceed 2167.5 g (4.78 lb).

Bottles used other than the approved, as-tested type must be tested and evaluated prior to use to ensure that its performance is equal to the approved, as-tested bottle. The internal bottle must remain intact and not break or leak. The nominal diameter of the internal bottle lid must be no more than 3.96875-cm (1.5625-in), so as to ensure that the lid of the SafeSend canister would not be pushed outward if it were drop tested as described in this evaluation report (refer to Section 5.2.2 of this report).

The approved packaging system described in this report is designed to ship Type A quantities of radioactive materials, normal form. Contents may be liquid or solid form. Liquid contents must have a specific gravity ≤ 2 . Solid materials are limited in weight, to include packaging, to the gross weight of the as-tested liquids and bottles.

The approved packaging configuration described in this report may be transported by air. As such, the approved configuration described meets the International Air Transport Association (IATA) *Dangerous Goods Regulations* (IATA 1995) for transportation of Type A liquids or solids. The IATA *Dangerous Goods Regulations* are published by the IATA Dangerous Goods Board pursuant to IATA Resolutions 618 and 619 (IATA 1995) and constitute a manual of industry carrier regulations to be followed by all IATA member airlines. The 36th edition of the IATA *Dangerous Goods Regulations* is based on the requirements of Annex 18 to the 1944 Convention on International Civil Aviation held in Chicago, and the 1995-96 edition of the associated *Technical Instructions for the Safe Transport of Dangerous Goods by Air*, DOC 9284-AN/905, adopted and published by the Council of International Civil Aviation Organization (ICAO 1995).

All DOT-7A Type A requirements of 49 CFR are addressed whether the requirement is applicable to the tested package configuration. Type A tests performed using the external fiberboard shipper included the vibration; water

spray; penetration bar drops (1.0 m [3.3 ft] and 1.7 m [5.5 ft]); compression; and 0.3 m [1 ft] drop onto each corner. Because of the negative results from the water spray test (see Section 5.2.1.b of this report), and the failure of the package during the 0.3 m (1 ft) drop onto each corner (see Section 5.2.1.c.4 of this report), Type A tests were performed without the use of the external fiberboard shipper. These tests included the vibration; water spray; penetration bar drops (1.0 m [3.3 ft] and 1.7 m [5.5 ft]); compression; 1.2 m [4 ft] drop test, and 9 m [30 ft] drop test.

The SafeSend container was manufacturer-tested by TEN-E Packaging Services, Inc., for the 3M Company, to a pressure of 100 kPa (14.5 psig) pressure differential. No further containment boundary verification was conducted by the DOE-approved test facility.

Documentation is provided by this report to satisfy the requirements of 49 CFR 173.415(a), "Authorized Type A Packages," which states:

"U.S. Department of Transportation (DOT) Specification 7A (178.350 of this subchapter) Type A general packaging. Each shipper of a Specification 7A must maintain on file for at least one year after the latest shipment, and shall provide to DOT on request, a complete documentation of tests and an engineering evaluation or comparative data showing that the construction methods, packaging design, and materials of construction comply with that specification. Specification 7A packagings designed in accordance with the requirements of 178.350 in effect on June 30, 1983, and constructed prior to July 1, 1985, may continue to be used. Packagings either designed or constructed after June 30, 1985, must meet the requirements of 178.350 applicable at the time of their design or construction."

This document will serve to meet the above-stated requirements when the packaging is used as prescribed. In addition, a description of the packaging is provided with an illustration and/or drawings to allow the user/shipper to obtain the packaging and verify that the packaging hardware complies with all of the specifications of the tested packaging.

By itself, this document does not ensure total compliance with all documentation necessary for making a shipment of radioactive material. In addition to documentation of tests, the shipper must maintain on file other appropriate documentation such as comparison of the physical properties of the actual contents to be shipped with those of the simulated payload used in testing to demonstrate equivalency. Also, implementation and documentation of a quality control program are required.

1.2 PURPOSE AND SCOPE

A design verification procedure (Kelly 1995a) was used to document that the packaging meets the design requirements of 49 CFR 173.24, 173.24a, 173.24b, 173.411, 173.412, and 173.462. Testing was performed to demonstrate that the approved packaging configuration noted in Sections 1.1 and 2.0 of this report meet the requirements for a DOT-7A Type A packaging (Kelly 1995b).

Testing was performed in accordance with 49 CFR 173.465 and 173.466 using *DOT-7A Packaging Test Procedure* (Kelly 1995c).

A comparison and evaluation of the IATA/ICAO regulations, Section 6, "Radioactive Material" (IATA 1995), as applicable for air transportation of Type A materials, also was made. The IATA/ICAO regulations, as they compare to 49 CFR, are identified in the applicable sections of this report.

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2.0 PACKAGING DESCRIPTION

2.1 DESIGN

The 3M SafeSend SP-R1L Kit assembly is manufactured by the 3M Company and available through various packaging vendors such as Labelmaster. The SafeSend SP-R1L Kit consists of a polyethylene canister base and cap with integral sorbent material, a quad ring gasket, two plastic bags, and six foam inserts. Eight fiberboard shippers are included in the kit. The original design of the 1-L Liquid Shipper called for the use of the outer fiberboard shipper. However, due to the negative results that occurred during the water spray test (see Section 5.2.1.b of this report) and during the 0.3-m (1-ft) drop test onto each corner (see Section 5.2.1.c.4 of this report), the fiberboard shipper is not authorized for use in the approved packaging configuration.

The packaging configurations tested also utilized two different types of internal, 1-L bottles. The internal bottles must be supplied by the user and must remain intact and not break or leak. Due to the leakage that occurred in the wide-mouth FLPE bottle with a PP lid during the 9-m (30-ft) drop tests, and due to the lid of the SafeSend being pushed outward during this same drop testing, this bottle is not authorized for use in this packaging configuration (see Section 5.2.2 of this report).

Refer to Section 2.1.2 and Appendix A of this evaluation report for the approved 1-L Liquid Shipper configuration. Loading of the approved test packaging weight may be found in Table 2-1. Packaging dimensions can be found in Table 2-2. Design measurements noted for this packaging are provided in English units and converted to metric units. Measurements are nominal (1 in = 2.54 cm).

Table 2-1. Approved Packaging Loading.

Item	Description	Nominal Weight g (lb)
SafeSend SP-R1L kit	Includes SafeSend ^a canister and lid; 6 foam inserts; and plastic bag.	1663.0 (3.66)
1-L internal bottle (Type #1)	Narrow-mouth, Teflon ^b FEP bottle with a Tefzel ^c ETFE lid, including product fill weight.	2167.5 (4.78)
Gross weight	Assembled package.	3830.5 (8.4)

^aSafeSend is a trademark of the 3M Company.

^bTeflon is a trademark of E.I. du Pont de Nemours & Company.

^cTefzel is a trademark of E.I. du Pont de Nemours & Company.

ETFE = ethylene tetrafluoroethylene

FEP = fluorinated ethylene propylene

Table 2-2. Dimensions.

Item	Measurements cm (in.)
Foam inserts	2.54-cm (1-in.) thick 12.7-cm (5-in.) diameter
SafeSend* cap	6.16-cm (2.43-in.) height 12.1-cm (4.75-in.) inside diameter 13.75-cm (5.41-in.) outside diameter
SafeSend canister base	31.5-cm (12.4-in.) height 12.40-cm (4.88-in.) inside diameter 18.1-cm (7.125-in.) outside diameter
Quad ring gasket	12.34-cm (4.86-in.) outside diameter 0.356-cm (0.140-in.) (nominal) thick
1-L internal bottle (Type #1)	20.0-cm (7.875-in) height 8.57-cm (3.375-in) base diameter 3.96875-cm (1.5625-in) lid diameter (nominal)

*SafeSend is a trademark of the 3M Company.

2.1.1 Materials/Method of Construction

Refer to Table 2-3 for the 1-L Liquid Shipper materials/method of construction information. The packaging configuration was tested as described in Section 1.1 of this report.

Table 2-3. Materials/Method of Construction.

Item/component	Description
SafeSend ^a SP-R1L kit	Labelmaster ^b Catalog Part No. KSP-1LR.
Canister	High-density polyethylene, two-piece welded assembly. Canister incorporates an integral sorbent material that is 300 g (0.66 lb) of microwebs, powersorb, universal white with surfactant.
Lid	High-density polyethylene that incorporates an integral sorbent material that is 97 g (0.21 lb) of microwebs, powersorb, universal white with surfactant.
Quad-ring gasket	Teflon ^c -coated ethylene propylene. The ring has a thin film of Dow Corning ^d #7 Silicone Paste Lubricant used on the bottom surface.
Snap latch	Acetal. The application torque range of the lid is 5-6 N·m (45-55 in·lb).
Bag	Gusseted, polyethylene.
Foam inserts	Open cell, urethane foam.
1-L internal bottle (Type #1)	Narrow-mouth, Teflon, FEP bottle with a ETFE lid. Nalgene ^e Part Number: 1600-0032 (Fisher ^f Part Number: 02-923-30D).

^aSafeSend is a trademark of the 3M Company.

^bLabelmaster Industrial Compliance Products, 1994 General Catalog, No. G-800, Chicago, Illinois. Labelmaster is an American Labelmark Company.

^cTeflon is a trademark of E. I. du Pont de Nemours & Company.

^dDow Corning #7 Silicone Paste Lubricant is a trademark of the Dow Corning Corporation.

^eNalgene is a trademark of Sybron Corporation.

^fFisher is a trademark of Fisher Scientific.

ETFE =ethylene-tetrafluorethylene

FEP =fluorinated ethylene propylene

2.1.2 Authorized Configuration

The authorized configuration consists of the 3M SafeSend polyethylene canister base and cap with integral sorbent material, a quad ring gasket, a plastic bag, and six foam inserts. A 1-L, narrow-mouth, Teflon bottle with the Tefzel lid holds the contents, and is placed inside the SafeSend container. The internal bottle content weight cannot exceed 2000 g (4.4 lb). Total bottle weight, including contents, cannot exceed 2167.5 g (4.78 lb).

Bottles used other than the approved, as-tested type must be tested and evaluated prior to use to ensure that its performance is equal to the approved, as-tested bottle. The internal bottle must remain intact and not break or leak. The nominal diameter of the internal bottle lid must be no more than 3.96875-cm (1.5625-in), so as to ensure that the lid of the SafeSend would not be pushed outward if it were drop tested as described in this evaluation report (refer to Section 5.2.2 of this report).

The nominal gross weight of the assembled packaging is to be no more than 3830.5 g (8.4 lb). Use of the external fiberboard shipper for this packaging configuration is not authorized.

2.2 CONTAINMENT SYSTEM

The 1-L Liquid Shipper provides two levels of containment. The primary containment boundary consists of the internal 1-L bottle and lid. The secondary containment boundary is provided by the SafeSend canister base, cap, and gasket.

2.3 AUTHORIZED CONTENTS

The approved packaging system described in this report is designed to ship Type A quantities of radioactive materials, normal form. Contents may be liquid or solid form. Liquid contents must have a specific gravity ≤ 2 . Solid materials are limited in weight, to include packaging, to the gross weight of the as-tested liquid and bottle.

The simulated payload used for testing purposes was water and carbon steel shot to equal a liquid with a specific gravity of 2. Fluorescein was added as a tracer material.

3.0 EVALUATION CRITERIA

NOTE: The box placed around the following text identifies the IATA requirements that are applicable to, and evaluated against, 49 CFR test criteria.

3.1 TEST CRITERIA

When subjected to the tests specified in 49 CFR 173.465 and 173.466, the packaging will prevent the following:

- Loss or dispersal of the radioactive contents
- Any significant increase in the radiation levels recorded or calculated at the external surfaces as compared to the condition before the test.

For air transport, if the package were subjected to the tests specified in IATA 6.9.4, "Tests for Demonstrating Ability to Withstand Normal Conditions of Transport," it would prevent:

1. Loss of shielding integrity which should result in more than a 20% increase in the radiation level at any external surface of the package; and
2. Loss or dispersal of the radioactive contents.

3.2 PASS/FAIL CRITERIA

For all tests, except where otherwise indicated, the packages tested were considered to fail if there was significant damage to the packaging and/or loss of the simulated load. Rupture or leakage from any of the packages constitutes failure.

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4.0 PREPARATION OF SPECIMENS FOR TESTING

NOTE: The bolded text identifies the applicable Type A regulations outlined in 49 CFR. Boxes placed around text identify the IATA requirements that are applicable to, and evaluated against, the appropriate sections in 49 CFR.

4.1 PRELOADING INSPECTION - 49 CFR 173.462

- a. Each packaging was examined before testing to identify and record any faults or damage, including:

1. Divergence from the specifications or drawings.

The packaging components were as specified.

The original packaging configuration was modified during testing. Due to the damage that occurred to the fiberboard shipper during the water spray test (see Section 5.2.1.b of this report) and 0.3-m (1-ft) drop test onto each corner (see Section 5.2.1.c.4 of this report), the fiberboard shipper is not authorized for use. Per the sponsor's request, the lid on the SafeSend containers had two small holes drilled, opposite the lid locking mechanism. A tamper wire was then inserted through these two holes. This tamper wire was added to all test units, with the exception of 41-TU-18 and 41-TU-19.

This also complies with IATA 6.9.1.7, "Demonstration of Compliance."

2. Defects in construction.

No defects in construction were found on any test units.

This also complies with IATA 6.9.1.7, "Demonstration of Compliance."

3. Corrosion or other deterioration.

No corrosion or other deterioration was found.

This also complies with IATA 6.9.1.7, "Demonstration of Compliance."

4. Distortion of features.

There were no observable distortions of features.

This also complies with IATA 6.9.1.7, "Demonstration of Compliance."

- b. Any deviation found under paragraph (a) of this section from the specified design shall be corrected or suitably taken into account in the subsequent evaluation.

As stated in paragraph (a) of this section, the original packaging configuration was modified during testing, per the sponsor's request. The removal of the fiberboard shipper and the addition of the tamper wire was taken into account during testing activities. There was no negative impact or effect on the performance of the 1-L Liquid Shipper test units, or on the testing conducted.

No IATA counterpart identified.

- c. The containment system of the packaging shall be clearly specified.

Primary containment is provided by the internal 1-L bottle and lid. Secondary containment is provided by the SafeSend canister base, cap, and gasket.

This also complies with IATA 6.9.1.8, "Demonstration of Compliance."

- d. The external features of the packaging shall be clearly identified so that reference may be made to any part of it.

The external features of the packaging are clearly identifiable. The outer container, the SafeSend canister, has identification numbers located on the label of the body of the SafeSend and located in the right corner of the red label on the cap. These numbers must be identical. Operating instructions (Jones 1995) state the packaging is not to be used if these numbers are not identical.

This also complies with IATA 6.9.1.8, "Demonstration of Compliance."

4.2 TEST CONTENTS

The simulated payload that was used for testing was a 1-L inner bottle, filled with water and carbon steel shot to equal a liquid with a specific gravity ≤ 2 . Fluorescein was added as a tracer material.

The two different internal bottle types tested were as follows:

1. A 1-L, narrow-mouth, Teflon, FEP bottle with a Tefzel, ETFE lid. The nominal diameter of the cap is 3.96875-cm (1.5625-in). The internal bottle content weight averaged 2000 g (4.4 lb). Total bottle weight, including contents, averaged 2167.5 g (4.78 lb).

The test units incorporating this bottle type were marked as follows:

41-TU-01 through 41-TU-05, 41-TU-11, and 41-TU-19

NOTE: THIS BOTTLE IS APPROVED FOR USE INSIDE THE 1-L LIQUID SHIPPER.

2. A 1-L, wide-mouth, FLPE bottle with a PP lid. The nominal diameter of the cap is 6.6675-cm (2.625-in). The internal bottle contents weight averaged 2000 g (4.4 lb). Total bottle weight, including contents, averaged 2108.85 g (4.65 lb).

NOTE: THIS BOTTLE IS NOT APPROVED FOR USE INSIDE THE 1-L LIQUID SHIPPER.

The test units incorporating this bottle type were marked as follows:

41-TU-06 through 41-TU-10; and 41-TU-12 through 41-TU-18

4.3 LOADING, ASSEMBLY, AND CLOSURE

A diagram of the approved packaging configuration is provided in Appendix A, Figure A-1, of this report. The packagings were assembled, loaded, and closed in accordance with the test instructions as outlined in Appendix B of this report.

The 1-L Liquid Shipper consists of the 3M SafeSend SP-R1L Kit and an internal 1-L bottle. The SafeSend SP-R1L Kit consists of a polyethylene canister base and cap with integral sorbent material, a quad ring gasket, two plastic bags, and six foam inserts. Eight fiberboard shippers are included in the kit. The original design of the 1-L Liquid Shipper called for the use of the outer fiberboard shipper. However, due to the negative results that occurred during the water spray test (see Section 5.2.1.b of this report) and during the 0.3-m (1-ft) drop test onto each corner (see Section 5.2.1.c.4 of

this report), the fiberboard shipper is not authorized for use in the approved packaging configuration.

The packaging configurations tested also utilized two different types of internal, 1-L bottles. The internal bottles must be supplied by the user. Bottles used other than the approved, as-tested type must be tested and evaluated prior to use to ensure that its performance is equal to the approved, as-tested bottle. The internal bottle must remain intact and not break or leak. The nominal diameter of the internal bottle lid must be no more than 3.96875-cm (1.5625-in), so as to ensure that the lid of the SafeSend would not be pushed outward if it were drop tested as described in this evaluation report (see Section 5.2.2 of this report).

Due to the leakage that occurred in the wide-mouth, FLPE bottle with a PP lid during the 9-m (30-ft) drop tests, and due to the lid of the SafeSend being pushed outward during this same drop testing, this bottle is not authorized for use in this packaging configuration (see Section 5.2.2 of this report).

5.0 PACKAGING EVALUATION RESULTS

The following list shows the primary sections of 49 CFR applicable to Type A packaging:

NOTE: This list highlights the performance requirements and is not intended to present an all-encompassing list.

- 173.24 General Requirements for Packagings and Packages
- 173.24a Additional General Requirements for Non-Bulk Packagings and Packages
- 173.24b Additional General Requirements for Bulk Packagings
- 173.411 General Design Requirements
- 173.412 Additional Design Requirements for Type A Packages
- 173.415(a) Authorized Type A Packages
- 173.442 Thermal Limitations
- 173.461 Demonstration of Compliance with Tests
- 173.462 Preparations of Specimens for Testing
- 173.463 Packaging and Shielding - Testing for Integrity
- 173.465 Type A Packaging Tests
- 173.466 Additional Tests for Type A Packagings Designed for Liquids and Gases
- 173.474 Quality Control for Construction of Packaging
- 173.475 Quality Control Requirements Prior to Each Shipment of Radioactive Material
- 178.3 Marking of Packagings
- 178.350 Specification 7A; General Packaging, Type A
- 178.608 Vibration Standards

As the packaging configuration is also approved for transportation by aircraft, Section 6, "Radioactive Material," of the IATA regulations is also applicable. The primary section of 49 CFR applicable to air transport follows:

- 173.27 General Requirements for Transportation by Aircraft

5.1 DESIGN EVALUATION

NOTE: The bolded text identifies the applicable Type A regulations outlined in 49 CFR. Boxes placed around text identify the IATA requirements that are applicable to, and evaluated against, the appropriate sections in 49 CFR.

Following is an evaluation of the ability of the packaging configuration to meet performance-related regulations. Compliance with all the indicated regulations will signify that the packagings have met the design and performance testing requirements for a DOT-7A Type A packaging. Additionally, the IATA/ICAO requirements are identified, and the results of the evaluated compliance are indicated.

5.1.1 49 CFR 173.24 - General Requirements for Packages and Packagings

- a. **Applicability.** Except as otherwise provided in this subchapter, the provisions of this section apply to--

- (1) Bulk and non-bulk packagings;
- (2) New packagings and packagings which are reused; and
- (3) Specification and non-specification packagings.

The approved packaging configuration (see Sections 1.1 and 2.1.2 of this report) has been tested and/or evaluated by WHC, and meets DOT-7A Type A packaging criteria.

- b. Each package used for shipment of hazardous materials under this subchapter shall be designed, constructed, maintained, filled, its contents so limited, and closed so that under conditions normally incident to transportation--

- (1) Except as otherwise provided in this subchapter, there will be no identifiable (without the use of instruments) release of hazardous materials to the environment;

The approved packaging configuration (see Sections 1.1 and 2.1.2 of this report) meets the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.411, .412, .465, and .466 as demonstrated in this report.

- (2) The effectiveness of the package will not be substantially reduced; for example, impact resistance, strength, packaging compatibility, etc. must be maintained for the minimum and maximum temperatures encountered during transportation;

The approved packaging configuration (see Sections 1.1 and 2.1.2 of this report) meets the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.411, .412, .465, and .466 as demonstrated in this report.

- (3) There will be no mixture of gases or vapors in the package which could, through any credible spontaneous increase of heat or pressure, significantly reduce the effectiveness of the packaging.

Use of the SafeSend packaging with incompatible materials may cause leakage of contents, posing such risks as serious physical injury or property damage. Incompatible materials include the following:

- (1) Those having a vapor pressure of greater than 130 kP (18.8 lbf/in²) at 55 °C (130 °F)
- (2) Those which in combination could increase heat or vapor pressure
- (3) Materials that may chemically attack this packaging or its components.

It is the responsibility of the shipper to ensure that the payload will remain stable during transport.

- c. Authorized packagings. A packaging is authorized for a hazardous material only if--

- (1) The packaging is prescribed or permitted for the hazardous material in a packaging section specified for that material in Column 8 of the section 172.101 Table and conforms to applicable requirements in the special provisions of Column 7 of the section 172.101 Table and, for specification packagings (including U.N. standard packagings), the specification requirements in parts 178 and 179 of this subchapter; or
- (2) The packaging is permitted under, and conforms to, provisions contained in sections 171.11, 171.12, 171.12a, 173.3, 173.4, 173.5, 173.7, 173.27, or 176.11 of this subchapter.

The approved packaging configuration, as documented herein, has been qualified to meet Specification 7A packaging requirements in accordance with 49 CFR 178.350. It is the responsibility of the shipper to ensure that the packagings used are in compliance with the design discussed in this report.

- d. DOT specification and U.N. standard packagings. For DOT specification packagings (including U.N. standard packagings, conformance to the applicable specifications in parts 178 and 179 of this subchapter is required in all details. For performance-oriented packagings covered by subpart L of part 178 of this subchapter, each packaging must be capable of meeting the performance test requirements specified in subpart M of part 178 of this subchapter for the applicable packing group shown in Column 5 of the section 172.101 Table.

The approved packaging configuration, as documented herein, has been qualified to meet Specification 7A packaging requirements in accordance with 49 CFR 178.350. It is the responsibility of the shipper to ensure that the packagings used are in compliance with the design discussed in this report.

e. **Compatibility.**

- (1) Even though certain packagings are specified in this part, it is, nevertheless, the responsibility of the person offering a hazardous material for transportation to ensure that such packagings are compatible with their lading. This particularly applies to corrosivity, permeability, softening, premature aging and embrittlement.

It is the responsibility of the shipper to ensure that these design requirements have been properly addressed by the designer and fabricator. The operating instructions (Jones 1995) specify steps that must be taken to prevent incompatible materials from being shipped in this packaging. The approved packaging configuration tested and/or evaluated meets this requirement.

- (2) Packaging materials and contents must be such that there will be no significant chemical or galvanic reaction between the materials and contents of the package.

Use of the SafeSend packaging with incompatible materials may cause leakage of contents, posing such risks as serious physical injury or property damage. Incompatible materials include the following:

- (1) Those having a vapor pressure of greater than 130 kPa (18.8 lbf/in²) at 55 °C (130 °F)
- (2) Those which in combination could increase heat or vapor pressure
- (3) Materials that may chemically attack this packaging or its components.

It is the responsibility of the shipper to ensure that the contents will not react adversely with the packaging.

- (3) **Plastic packagings and receptacles.**

- (i) Plastic used in packagings and receptacles must be of a type compatible with the lading and may not be permeable to an extent that a hazardous condition is likely to occur during transportation, handling or refilling.
 - (ii) Each plastic packaging or receptacle which is used for liquid hazardous materials must be capable of withstanding without failure the procedure specified in Appendix B of

this part ("Procedure for Testing Chemical Compatibility and Rate of Permeation in Plastic Packagings and Receptacles"). The procedure specified in Appendix B of this part must be performed on each plastic packaging or receptacle used for Packing Group I materials. The maximum rate of permeation of hazardous lading through or into the plastic packaging or receptacles may not exceed 0.5 percent for materials meeting the definition of a Division 6.1 material according to section 173.132 and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than--

- (A) 18 °C (64 °F) for 180 days in accordance with Test Method 1 in Appendix B of this part;
 - (B) 50 °C (122 °F) for 28 days in accordance with Test Method 2 in Appendix B of this part; or
 - (C) 60 °C (140 °F) for 14 days in accordance with Test Method 3 in Appendix B of this part.
- (iii) Alternative procedures or rates of permeation are permitted if they yield a level of safety equivalent to or greater than that provided by paragraph (e)(3)(ii) of this section and are specifically approved by the Associate Administrator for Hazardous Materials Safety.

The approved packaging configuration, as described herein, is authorized for transportation of liquids and/or solids. It is the responsibility of the shipper to ensure that the contents will not react adversely with the container.

- (4) Mixed contents. Hazardous materials may not be packed or mixed together in the same outer packaging with other hazardous or nonhazardous materials if such materials are capable of reacting dangerously with each other and causing--
- (i) Combustion or dangerous evolution of heat;
 - (ii) Evolution of flammable or poisonous gases; or
 - (iii) Formation of unstable or corrosive materials.

Hazardous and/or nonhazardous materials will not be packed or mixed together so as to cause a reaction. The approved packaging configuration, as documented herein, has been qualified to meet Specification 7A packaging requirements in accordance with 49 CFR 178.350. It is the responsibility of the shipper to ensure that materials will not be combined so as to cause a reaction.

- (5) Packagings used for solids, which may become liquid at temperatures likely to be encountered during transportation, must be capable of containing the hazardous material in the liquid state.

The approved packaging configuration (see Sections 1.1 and 2.1.2 of this report) is authorized for liquids and solids.

Primary containment for the 1-L Liquid Shipper is provided by the internal 1-L bottle. The bottle must remain intact and not break or leak. The as-tested bottle that is approved for use is a 1-L, narrow-mouth, Teflon bottle with the Tefzel lid. Bottles used other than the approved, as-tested type must be tested and evaluated prior to use to ensure that its performance is equal to the approved, as-tested bottle. The nominal diameter of the internal bottle lid must be no more than 3.96875-cm (1.5625-in), so as to ensure that the lid of the SafeSend would not be pushed outward if it were drop tested as described in this evaluation report (see Section 5.2.2 of this report).

Secondary containment is provided by the SafeSend container, consisting of a threaded lid, a Teflon-coated ethylene propylene O-ring, and a positive locking mechanism. The SafeSend container contains sorbent material that is capable of absorbing liquids up to twice its 1-L capacity. A fluid indicator is incorporated into the sorbent cylinder lining the canister. Any appearance other than a uniform blue color indicates leakage or breakage of contents. The presence of a uniform blue color does not ensure contents are intact.

It is the responsibility of the shipper to ensure that the packagings used are in compliance with the design discussed in this report.

f. Closures.

- (1) Closures on packagings shall be so designed and closed that under conditions (including the effects of temperature and vibration) normally incident to transportation--
- (i) Except as provided in paragraph (g) of this section, there is no identifiable release of hazardous materials to the environment from the opening to which the closure is applied; and
 - (ii) The closure is secure and leakproof.
- (2) Except as otherwise provided in this subchapter, a closure (including gaskets or other closure components, if any) used on a specification packaging must conform to all applicable requirements of the specification.

Testing and evaluation of the approved packaging design indicates this requirement to be satisfied. The internal bottle lids are hand tightened. When properly locked into place, the lid locking mechanism on the SafeSend container is designed to prevent loosening due to acceleration, vibration, or vibration resonance resulting from normal conditions of transportation.

The initial packaging design included the use of the fiberboard shipper. Vibration testing was conducted for 1 hour on six test units filled with the actual simulated contents, and the fiberboard shipper. Three test units included the narrow-mouth Teflon bottle (41-TU-01 through 41-TU-03); and three test units included the wide-mouth FLPE bottle (41-TU-06 through 41-TU-08). The packagings were checked after the vibration test, and none were damaged or observed to have leakage of simulated contents.

Because of the negative results of the water spray test (see Section 5.2.1.b of this report) and the 0.3-m (1-ft) drop test onto each corner (see Section 5.2.1.c.4 of this report), the external fiberboard shipper was removed, and the vibration test was conducted a second time on these same test units. Per the sponsor's request and prior to conducting the second vibration test, the lid of the SafeSend containers had two small holes drilled opposite the lid locking mechanism, and a tamper wire added through these two holes. The packagings were checked after the vibration test, and none were damaged or observed to have leakage of simulated contents.

- g. Venting. Venting of packagings, to reduce internal pressure which may develop by the evolution of gas from the contents, is permitted only when--
- (1) Transportation by aircraft is not involved;
 - (2) Except as otherwise provided in this subchapter, the evolved gases are not poisonous, likely to create a flammable mixture with air or be an asphyxiant under normal conditions of transportation;
 - (3) The packaging is designed so as to preclude an unintentional release of hazardous materials from the receptacle; and
 - (4) For shipments in bulk packagings, venting is authorized for the specific hazardous material by a special provision in the section 172.101 Table or by the applicable bulk packaging specification in part 178 of this subchapter.

This packaging has no provision for venting. The approved packaging configuration described and tested is authorized for transportation by aircraft. The SafeSend container was manufacturer-tested and cannot be used for contents that would produce an internal pressure in excess of 100 kPa (14.5 psi). The vapor pressure should never exceed 130 kPa/18.8 psi at 55 °C (130 °F).

h. Outage and filling limits--

- (1) *General*. When filling packagings and receptacles for liquids, sufficient ullage (outage) must be left to ensure that neither leakage nor permanent distortion of the packaging or receptacle will occur as a result of an expansion of the liquid caused by temperatures likely to be encountered during transportation. Requirements for outage and filling limits for non-bulk and bulk packaging are specified in section 173.24a(d) and 173.24b(a), respectively.
- (2) *Compressed gases and cryogenic liquids*. Filling limits for compressed gases and cryogenic liquids are specified in sections 173.301 through 173.306 for cylinders and sections 173.314 through 173.319 for bulk packagings.

The approved packaging configuration described and tested is authorized for transportation of liquids by aircraft. Primary containment is provided by the internal 1-L bottle and lid. The internal bottle will have an ullage of approximately 10 percent for liquid transport. The bottle must remain intact and not break or leak. The as-tested bottle that is approved for use is a 1-L, narrow-mouth, Teflon bottle with the Tefzel lid. Bottles used other than the approved, as-tested type must be tested and evaluated prior to use to ensure that its performance is equal to the approved, as-tested bottle. The nominal diameter of the internal bottle lid must be no more than 3.96875-cm (1.5625-in), so as to ensure that the lid of the SafeSend would not be pushed outward if it were drop tested as described in this evaluation report (see Section 5.2.2 of this report).

The SafeSend was manufacturer-tested to an internal pressure of 100 kPa (14.5 psi). The vapor pressure should never exceed 130 kPa/18.8 psi at 55 °C (130 °F).

The 1-L Liquid Shipper will not transport compressed gasses or cryogenic liquids.

IATA 6.8.4.14, "Requirements for Type A Packages," applies and is met as the packaging configuration described is authorized for transportation of liquids by aircraft.

- i. *Air transportation*. Packages offered or intended for transportation by aircraft must conform to the general requirements for transportation by aircraft in section 171.11 of this subchapter.

The approved packaging configuration described and tested is authorized for transportation of liquids by aircraft. Primary containment is provided by the internal 1-L bottle and lid. The internal bottle will have an ullage of approximately 10 percent for liquid transport. The bottle must remain intact and not break or leak. The as-tested bottle that is approved for use is a 1-L,

narrow-mouth, Teflon bottle with the Tefzel lid. Bottles used other than the approved, as-tested type must be tested and evaluated prior to use to ensure that its performance is equal to the approved, as-tested bottle. The nominal diameter of the internal bottle lid must be no more than 3.96875-cm (1.5625-in), so as to ensure that the lid of the SafeSend would not be pushed outward if it were drop tested as described in this evaluation report (see Section 5.2.2 of this report).

The SafeSend was manufacturer-tested to an internal pressure of 100 kPa (14.5 psi). The vapor pressure should never exceed 130 kPa/18.8 psi at 55 °C (130 °F).

IATA 6.8.2.12, "General Requirements," and 6.8.4.14, "Requirements for Type A Packages," apply as the packaging configuration is authorized for transportation by aircraft.

5.1.2 49 CFR 173.24a - Additional General Requirements for Non-Bulk Packagings and Packages

a. Packaging design. Except as provided in section 172.312 of this subchapter:

- (1) *Inner packaging closures.* A combination packaging containing liquid hazardous materials must be packed so that closures on inner packagings are upright.

The approved packaging configuration described and tested is authorized for transporting liquids or solids. The internal bottles, containing the material to be transported, shall be packed in the SafeSend in an upright position in accordance with the operating instructions (Jones 1995).

- (2) *Friction.* The nature and thickness of the outer packaging must be such that friction during transportation is not likely to generate an amount of heat sufficient to alter dangerously the chemical stability of the contents.

The nature and thickness of the approved packaging configuration is such that friction during transport will not generate any heating that would adversely affect the contents.

- (3) *Securing and cushioning.* Inner packagings of combination packagings must be so packed, secured and cushioned to prevent their breakage or leakage and to control their movement within the outer packaging under conditions normally incident to transportation. Cushioning material must not be capable of reacting dangerously with the contents of the inner packagings.

The operating instruction (Jones 1995) describes how to pack the 1-L Liquid Shipper packaging. The bottle must remain

intact and not break or leak. The as-tested bottle that is approved for use is a 1-L, narrow-mouth, Teflon bottle with the Tefzel lid. Bottles used other than the approved, as-tested type must be tested and evaluated prior to use to ensure that its performance is equal to the approved, as-tested bottle. The nominal diameter of the internal bottle lid must be no more than 3.96875-cm (1.5625-in), so as to ensure that the lid of the SafeSend would not be pushed outward if it were drop tested as described in this evaluation report (see Section 5.2.2 of this report).

It is the responsibility of the shipper to ensure that cushioning material is compatible with contents.

- (4) *Metallic devices.* Nails, staples and other metallic devices shall not protrude into the interior of the outer packaging in such a manner as to be likely to damage inner packagings or receptacles.

Although a tamper wire is to be added prior to transport, it is unlikely that this metallic device or protrusion could cause damage to the packaging.

- (5) *Vibration.* Each non-bulk package must be capable of withstanding, without rupture or leakage, the vibration test procedure specified in section 178.608 of this subchapter.

The approved packaging configuration was judged to pass this requirement. Type A packagings are required "to withstand the effects of any acceleration, vibration, or vibration resonance that may arise during normal transportation" [see 49 CFR 173.412 (e)]. The test identified in this section was applied to support the ability of the packaging to meet the requirement. Visual examination of the packaging identified no rupture or leakage.

The internal bottle lids are hand tightened. When properly locked into place, the lid locking mechanism on the SafeSend container is designed to prevent loosening due to acceleration, vibration, or vibration resonance resulting from normal conditions of transportation.

The initial packaging design included the use of the fiberboard shipper. Vibration testing was conducted for 1 hour on six test units filled with the actual simulated contents, and the fiberboard shipper. Three test units included the narrow-mouth Teflon bottle (41-TU-01 through 41-TU-03); and three test units included the wide-mouth FLPE bottle (41-TU-06 through 41-TU-08). The packagings were checked after the vibration test, and none were damaged or observed to have leakage of simulated contents.

Because of the negative results of the water spray test (see Section 5.2.1.b of this report) and the 0.3-m (1-ft) drop test

onto each corner (see Section 5.2.1.c.4 of this report), the external fiberboard shipper was removed, and the vibration test was conducted a second time on these same test units. Per the sponsor's request and prior to conducting the second vibration test, the lid of the SafeSend containers had two small holes drilled opposite the lid locking mechanism, and a tamper wire added through these two holes. The packagings were checked after the vibration test, and none were damaged or observed to have leakage of simulated contents.

b. Non-bulk packaging filling limits.

(1) A single or composite non-bulk packaging may be filled with a liquid hazardous material only when the specific gravity of the material does not exceed that marked on the packaging, or a specific gravity of 1.2 if not marked, except as follows:

- (i) A Packing Group I packaging may be used for a Packing Group II material with a specific gravity not exceeding the greater of 1.8, or 1.5 times the specific gravity marked on the packaging, provided all the performance criteria can still be met with the higher specific gravity material;
- (ii) A Packing Group I packaging may be used for a Packing Group III material with a specific gravity not exceeding the greater of 2.7, or 2.25 times the specific gravity marked on the packaging, provided all the performance criteria can still be met with the higher specific gravity material; and
- (iii) A Packing Group II packaging may be used for a Packing Group III material with a specific gravity not exceeding the greater of 1.8, or 1.5 times the specific gravity marked on the packaging, provided all the performance criteria can still be met with the higher specific gravity material.

This is not applicable to a Type A packaging as Type A packaging does not incorporate packing groups. The liquid contents must have a maximum specific gravity ≤ 2 . The solid materials are limited in weight, to include packaging, to the gross weight of the as-tested liquids and bottles. Refer to Table 2-1 for the approved packaging loading weights.

(2) Except as otherwise provided in this section, a single or composite non-bulk packaging may not be filled with a solid hazardous material to a gross mass greater than the maximum gross mass marked on the packaging.

This is not applicable to a Type A packaging as the gross mass is not required to be marked on the packaging by the manufacturer.

- (3) A single or composite non-bulk packaging which is tested and marked for liquid hazardous materials may be filled with a solid hazardous material to a gross mass, in kilograms, not exceeding the rated capacity of the packaging in liters, multiplied by the specific gravity marked on the packaging, or 1.2 if not marked. In addition:
- (i) A single or composite non-bulk packaging which is tested and marked for Packing Group I liquid hazardous materials may be filled with a solid Packing Group II hazardous material to a gross mass, in kilograms, not exceeding the rated capacity of the packaging in liters, multiplied by 1.5, multiplied by the specific gravity marked on the packaging, or 1.2 if not marked.
 - (ii) A single or composite non-bulk packaging which is tested and marked for Packing Group I liquid hazardous materials may be filled with a solid Packing Group III hazardous material to a gross mass, in kilograms, not exceeding the rated capacity of the packaging in liters, multiplied by 2.25, multiplied by the specific gravity marked on the packaging, or 1.2 if not marked.
 - (iii) A single or composite non-bulk packaging which is tested and marked for Packing Group II liquid hazardous materials may be filled with a solid Packing Group III hazardous material to a gross mass, in kilograms, not exceeding the rated capacity of the packaging in liters, multiplied by 1.5, multiplied by the specific gravity marked on the packaging, or 1.2 if not marked.

This is not applicable to a Type A packaging as Type A packaging does not incorporate packing groups. The liquid contents must have a maximum specific gravity ≤ 2 . The solid materials are limited in weight, to include packaging, to the gross weight of the as-tested liquids and bottles. Refer to Table 2-1 for the approved packaging loading weights.

- (4) Packagings tested as prescribed in section 178.605 of this subchapter and marked with the hydrostatic test pressure as prescribed in section 178.503(a)(5) of this subchapter may be used for liquids only when the vapor pressure of the liquid conforms to one of the following:
- (i) The vapor pressure must be such that the total pressure in the packaging [i.e., the vapor pressure of the liquid plus the partial pressure of air or other inert gases, less 100 kPa (15 psi) at 55 °C (131 °F), determined on the basis of a maximum degree of filling in accordance with paragraph (b)(1) of this section and a filling temperature of 15 °C (59 °F)], will not exceed two-thirds of the marked test pressure;

- (ii) The vapor pressure at 50 °C (122 °F) must be less than four-sevenths of the sum of the marked test pressure plus 100 kPa (15 psi); or
- (iii) The vapor pressure at 55 °C (131 °F) must be less than two-thirds of the sum of the marked test pressure plus 100 kPa (15 psi).

This is not applicable to Type A packaging as Section 178.605 does not pertain to specification packagings. The approved packaging configuration described and tested is authorized for transportation of liquids or solids by aircraft.

Primary containment is provided by the internal 1-L bottle and lid. The internal bottles will have an ullage of approximately 10 percent for liquid transport. The bottle must remain intact and not break or leak. The as-tested bottle that is approved for use is a 1-L, narrow-mouth, Teflon bottle with the Tefzel lid. Bottles used other than the approved, as-tested type must be tested and evaluated prior to use to ensure that its performance is equal to the approved, as-tested bottle. The nominal diameter of the internal bottle lid must be no more than 3.96875-cm (1.5625-in), so as to ensure that the lid of the SafeSend would not be pushed outward if it were drop tested as described in this evaluation report (see Section 5.2.2 of this report).

The SafeSend is designed and constructed to prevent leakage that may be caused by changes in altitude and temperature that may be encountered during air transport. The SafeSend was manufacturer-tested to an internal pressure of 100 kPa (14.5 psi). The vapor pressure should never exceed 130 kPa/18.8 psi at 55 °C (130 °F).

<p>The packaging configuration meets IATA 6.8.2.10 and 6.8.2.11, "General Requirements." IATA 6.8.2.12 applies and is met.</p>
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- (5) No hazardous material may remain on the outside of a package after filling.

The level of non-fixed (removable) radioactive contamination on the external surfaces of each package offered for shipment shall be kept as low as practicable (49 CFR 173.443). It is the responsibility of the shipper to ensure compliance with this requirement.

c. Mixed contents.

- (1) An outer non-bulk packaging may contain more than one hazardous material only when--

- (i) The inner and outer packagings used for each hazardous material conform to the relevant packaging sections of this part applicable to that hazardous material;
 - (ii) The package as prepared for shipment meets the performance tests prescribed in part 178 of this subchapter for the packing group indicating the highest order of hazard for the hazardous materials contained in the package;
 - (iii) Corrosive materials (except ORM-D) in bottles are further packed in securely closed inner receptacles before packing in outer packagings; and
 - (iv) For transportation by aircraft, the total net quantity does not exceed the lowest permitted maximum net quantity per package as shown in Column 9a or 9b, as appropriate, of the section 172.101 Table. The permitted maximum net quantity must be calculated in kilograms if a package contains both a liquid and a solid.
- (2) A packaging containing inner packagings of Division 6.2 materials may not contain other hazardous materials, except dry ice.

The package is designed and tested for radioactive material shipments only. It is the responsibility of the shipper to ensure that reactive hazardous components are not shipped together in a packaging, and that the package is in compliance with the above requirements.

- d. Liquids must not completely fill a receptacle at a temperature of 55 °C (131 °F) or less.

The operating instructions (Jones 1995) will address that the internal bottles shall have a minimum 10 percent ullage at standard temperature and pressure (STP).

5.1.3 49 CFR 173.24b – Additional General Requirements for Bulk Packagings

a. *Outage and filling limits.*

- (1) Liquids and liquefied gases must be so loaded that the outage is at least one percent of the total capacity of a cargo or portable tank, or compartment thereof, or at least one percent of the total capacity of the tank and dome for tank car and multi-unit tank car tanks at the reference temperature of 46 °C (115 °F) for uninsulated tanks and 41 °C (105 °F) for insulated tanks.
- (2) Hazardous materials may not be loaded into the dome of a tank car. If the dome of the tank car does not provide sufficient

outage, vacant space must be left in the shell to provide the required outage.

- (3) Bulk packagings for materials poisonous by inhalation. For a material which meets the definition of poisonous by inhalation (see section 171.8 of this subchapter), the outage in a bulk packaging must be at least five percent of the total capacity of the tank or compartment at the reference temperature of 46 °C (115 °F) for uninsulated tanks and 41 °C (105 °F) for insulated tanks.

The above items do not apply as this is not a bulk packaging.

- b. *Equivalent steel.* For the purposes of this section, stainless steel is steel with a guaranteed minimum tensile strength of 51.7 deka newtons per square millimeter (75,000 psi) and a guaranteed elongation of 40 percent or greater. Where the regulations permit steel other than stainless steel to be used in place of a specified stainless steel (for example, as in section 172.102 of this subchapter, special provision B30), the minimum thickness for the steel must be obtained from one of the following formulas, as appropriate:

Formula for metric units:

$$e_1 = (12.74e_0) / (Rm_1A_1)^{1/3}$$

Formula for non-metric units:

$$e_1 = (144.2e_0) / (Rm_1A_1)^{1/3}$$

Where:

e_0 = Required thickness of the reference stainless steel in millimeters or inches respectively;

e_1 = Equivalent thickness of the steel used in millimeters or inches respectively;

Rm_1 = Specified minimum tensile strength of the steel used in deka newtons per square millimeter or pounds per square inch respectively; and

A_1 = Specified minimum percentage elongation of the steel used multiplied by 100 (for example, 20 percent times 100 equals 20). Elongation values used must be determined from a 50 mm or 2 inch test specimen.

This requirement is not applicable as this is not a bulk packaging. Also, there are no metals used in the packaging.

- c. Air pressure in excess of ambient atmospheric pressure may not be used to load or unload any lading which may create an air-enriched mixture within the flammability range of the lading in the vapor space of the tank.

This requirement is not applicable as this is not a bulk packaging. Also, air pressure is not used in the loading and unloading process.

d. A bulk packaging may not be loaded with a hazardous material that:

- (1) Is at a temperature outside of the packaging's design temperature range; or
- (2) Exceeds the maximum weight of lading marked on the specification plate.

This requirement is not applicable as this is not a bulk packaging. Also, it is the responsibility of the shipper to ensure compliance with this requirement.

5.1.4 49 CFR 173.411 - General Design Requirements

Except for a package that contains a limited quantity or excepted instrument or article under Paragraphs 173.421 through 173.424, each package used for shipment of radioactive materials shall be designed so that:

- a. The package can be easily handled and properly secured in or on a conveyance during transport;

The approved packaging configuration tested meets this requirement. The maximum gross weight of the assembled packaging is 3830.5 g (8.4 lb). This packaging configuration is easily lifted, handled, and secured during transport. Use of the external fiberboard shipper is not authorized for use in the approved packaging configuration.

The packaging configuration tested also meets IATA 6.8.2.1, "General Requirements."

- b. A package with a gross weight exceeding 10 kilograms (22 pounds) and up to 50 kilograms (110 pounds) has a means for manual handling;

This requirement is not applicable as the packaging configuration tested has a gross weight less than 10 kg (22 lb). This packaging configuration is easily lifted and handled.

- c. A package with a gross weight of 50 kilograms (110 pounds) or more can be safely handled by mechanical means;

This requirement is not applicable as the packaging configuration tested has a gross weight less than 50 kg (110 lb).

- d. Each lifting attachment on the package, when used in the intended manner, with a minimum safety factor of three, does not impose an unsafe stress on the structure of the package. In addition, the lifting attachment shall be so designed that failure under excessive load would not impair the ability of the package to meet all other requirements of this subpart. Each attachment or other feature on

the outer surface of the packaging that could be used to lift the package must be removable or otherwise capable or being made inoperable for transport, or shall be designed with strength equivalent to that required for lifting attachments;

There are no lifting attachments; therefore, this requirement is not applicable.

As there are no lifting attachments, IATA 6.8.2.2 and 6.8.2.3, "General Requirements," are not applicable.

- e. The external surface, as far as practicable, may be easily decontaminated;

The approved packaging configuration tested meets the intent of this requirement. The external surface of the packaging is the SafeSend container. The outer surface of the SafeSend is made of high-density polyethylene; the internal bottles are made of Teflon with Tefzel lids. All of these materials have been shown to be easily decontaminated if no degradation of the material has occurred due to exposure to incompatible materials.

Protrusions and crevices exist on the SafeSend canister; however, the surface is smooth and this area can easily be decontaminated. It is the responsibility of the shipper to ensure that materials shipped in the container are compatible with each other and the container.

The packaging configuration tested meets IATA 6.8.2.4, "General Requirements."

- f. The outer layer of packaging will avoid, as far as practicable, pockets or crevices where water might collect; and

As the original design of the 1-L Liquid Shipper called for the use of the fiberboard shipper, testing began by conducting a water spray test on test units 41-TU-11 and 41-TU-12. These two test units were subjected to the water spray conditions for one hour with no loss of contents. The fiberboard shipper absorbed water, became saturated, and began to expand. The glue sealing the top and bottom flaps, and the side of the shipper held in place; however, the layers of fiberboard corrugation material began to separate from each other, on the side, and top and bottom flaps of the shipper. The fiberboard did not crack, rip, or tear (see Section 5.2.1.b of this report).

Because of the adverse effect that the water spray had on the fiberboard shipper, causing the ultimate packaging failure during the 0.3-m (1-ft) drop test onto each corner of the packaging (see Section 5.2.1.c.4 of this report), the design was changed to exclude

the use of the fiberboard shipper. Because of the configuration change, the lid on the SafeSend containers had two small holes drilled, opposite the lid locking mechanism. A tamper wire was then inserted through these two holes. This tamper wire was added to all test units, with the exception of 41-TU-18 and 41-TU-19.

The water spray test was then conducted on test units 41-TU-11 and 41-TU-17 without the fiberboard shipper (see Section 5.2.1.b of this report). A slight amount of water pooled around the SafeSend lid near the handhold area; however, this did not have any adverse effect on the performance of the SafeSend. The SafeSends were opened, and there was no inleakage of water. The test engineer determined that no further water spray tests were necessary on the remaining test units.

The packaging configuration also meets IATA 6.8.2.5, "General Requirements."

- g. Each feature that is added to the package at the time of transport, and that is not a part of the package, will not reduce the safety of the package.

No features are to be added at the time of transport. However, prior to shipment, tamper indication tape will be added to the internal bottle closure. A tamper wire will also be added to the lid of the SafeSend container. Instructions are included in the operating instructions (Jones 1995). The addition of tamper indication tape and the tamper wire will not reduce the safety of the package. It is the responsibility of the shipper to ensure that any features added to the package at time of transport do not reduce the safety of the packaging.

The packaging configuration described meets IATA 6.8.2.6, "General Requirements."

5.1.5 49 CFR 173.412 - Additional Design Requirements for Type A Packages

In addition to meeting the general design requirements prescribed in Paragraph 173.411, each Type A packaging shall be designed so that:

- a. The smallest overall external dimension of the package is not less than 10 centimeters (4 inches);

The external dimensions of the packaging exceed the minimum dimensional requirement.

IATA 6.8.4.2, "Requirements for Type A Packages," applies and is met.

- b. The outside of the packaging incorporates a feature, such as a seal, that is not readily breakable, and that, while intact, is evidence that the package has not been opened. In the case of packages shipped in exclusive use closed transport vehicles, the cargo compartment may be sealed instead of the individual packages;

Prior to shipment, tamper indication tape will be added to the internal bottle closure. A tamper wire will also be added to the lid of the SafeSend container. Instructions are included in the operating instructions (Jones 1995). It is the responsibility of the shipper to ensure that appropriate precautions are taken to seal the package in a manner that will provide evidence that the package has not been opened.

IATA 6.8.4.3, "Requirements for Type A Packages," applies and is met.

- c. As far as practicable, the external surfaces are free from protrusions and are designed and finished so that they can be easily decontaminated;

The approved tested packaging configuration meets this requirement. Protrusions exist on the outer surface of the SafeSend canister, which is made of high density polyethylene. The as-tested bottle that is approved for use is a 1-L, narrow-mouth, Teflon bottle with the Tefzel lid. Bottles used other than the approved, as-tested type must be tested and evaluated prior to use to ensure that its performance is equal to the approved, as-tested bottle.

All of the materials listed above have been shown to be easily decontaminated if no degradation of the material has occurred from exposure to incompatible materials.

IATA 6.8.2.4, "General Requirements," applies and is met.

- d. Containment and shielding would be maintained during transportation and storage in a temperature range of -40°C (-40°F) to 70°C (158°F) with account being taken of the possibility of brittle fracture;

No shielding is used for the approved packaging configuration. Primary containment is provided by the following: The as-tested narrow-mouth, 1-L Teflon bottle with a Tefzel lid. The operating temperature range for the Teflon bottle and lid is -105° to 150°C (-71.2° to 302°F) (Nalge Company Report). If other than the as-tested bottle and lid is used, the shipper must document equivalency either by evaluation or further testing. The nominal diameter of the internal bottle lid must be no more than 3.96875-cm (1.5625-in), so as to ensure that the lid of the SafeSend would not be pushed

outward if it were drop tested as described in this evaluation report (see Section 5.2.2 of this report).

Secondary containment is provided by the SafeSend canister base, cap, and gasket. The SafeSend system is made of high-density polyethylene plastic. Plastics do not show appreciable degradation of performance over the entire operation temperature range as shown in test data supplied by the 3M Company. The gasket material used in the SafeSend container is made from Teflon-coated ethylene propylene. This material has an operating range of -54° to 149°C (-65° to 300°F).

IATA 6.8.4.5, "Requirements for Type A Packages," applies and is met.

- e. It is able to withstand the effects of any acceleration, vibration, or vibration resonance that may arise during normal transportation, without any deterioration of the effectiveness of closing devices or of the integrity of the package as a whole and without loosening or unintentional release of nuts, bolts, or other securing devices even after repeated use;

The approved packaging configuration was judged to pass this requirement. The test identified in 49 CFR 178.608 was applied to support the ability of the packaging to meet the requirement. Visual examination of the packaging identified no rupture or leakage.

The internal bottle lids are hand tightened. When properly locked into place, the lid locking mechanism on the SafeSend container is designed to prevent loosening due to acceleration, vibration, or vibration resonance resulting from normal conditions of transportation.

The initial packaging design included the use of the fiberboard shipper. Vibration testing was conducted for 1 hour on six test units filled with the actual simulated contents, and the fiberboard shipper. Three test units included the narrow-mouth Teflon bottle (41-TU-01 through 41-TU-03); and three test units included the wide-mouth FLPE bottle (41-TU-06 through 41-TU-08). The packagings were checked after the vibration test, and none were damaged or observed to have leakage of simulated contents.

Because of the negative results of the water spray test (see Section 5.2.1.b of this report) and the 0.3-m (1-ft) drop test onto each corner (see Section 5.2.1.c.4 of this report), the external fiberboard shipper was removed, and the vibration test was conducted a second time on these same test units. Per the sponsor's request and prior to conducting the second vibration test, the lid of the SafeSend containers had two small holes drilled opposite the lid locking mechanism, and a tamper wire added through these two holes.

The packagings were checked after the vibration test, and none were damaged or observed to have leakage of simulated contents.

IATA 6.8.2.7, "General Requirements," also applies and is met.

- f. It includes a containment system securely closed by a positive fastening device that cannot be opened unintentionally or by pressure that may arise within the package during normal transport. Special form, as demonstrated in accordance with Paragraph 173.469 may be considered as a component of the containment system;

The containment system consists of the as-tested, approved, 1-L Teflon bottle and Tefzel lid, and the SafeSend canister base, cap, and gasket. The SafeSend includes a positive locking mechanism that will only lock if the lid is fully closed. The fiberboard shipper is not approved for use with this packaging configuration.

Primary containment is provided by the internal 1-L bottle and lid. The internal bottles will have an ullage of approximately 10 percent for liquid transport. The bottle must remain intact and not break or leak. The as-tested bottle that is approved for use is a 1-L, narrow-mouth, Teflon bottle with the Tefzel lid. Bottles used other than the approved, as-tested type must be tested and evaluated prior to use to ensure that its performance is equal to the approved, as-tested bottle. The nominal diameter of the internal bottle lid must be no more than 3.96875-cm (1.5625-in), so as to ensure that the lid of the SafeSend would not be pushed outward if it were drop tested as described in this evaluation report (see Section 5.2.2 of this report).

The SafeSend is designed and constructed to prevent leakage that may be caused by changes in altitude and temperature that may be encountered during air transport. The SafeSend was manufacturer-tested to an internal pressure of 100 kPa (14.5 psi). The vapor pressure should never exceed 130 kPa/18.8 psi at 55 °C (130 °F).

The packagings tested meet IATA 6.8.4.7, 6.8.4.8, and 6.8.4.9, "Requirements for Type A Packages."

- g. The materials of the packaging and any components or structures are physically and chemically compatible with each other and with the contents, taking into account the behavior of each under irradiation;

The materials of the approved packaging configuration are physically and chemically compatible with each other. It is the responsibility of the shipper to ensure that the contents are compatible with the packaging.

The packaging configuration tested meets IATA 6.8.2.8, "General Requirements."

- h. For each component of the containment system account is taken, where applicable, of radiolytic decomposition of materials and the generation of gas by chemical reaction and radiolysis;

It is the responsibility of the shipper to ensure that the effects of radiation from the payload will not degrade the performance of the packaging through gas generation, chemical reaction, or radiolysis.

IATA 6.8.4.10, "Requirements for Type A Packages," also applies.

- i. The containment system will retain its radioactive contents under the reduction of ambient pressure to .25 kilograms per square centimeter (3.5 pounds per square inch);

The containment system consists of the as-tested, approved, 1-L Teflon bottle and Tefzel lid, and the SafeSend canister base, cap, and gasket. The SafeSend includes a positive locking mechanism that will only lock if the lid is fully closed. The fiberboard shipper is not approved for use with this packaging configuration.

Primary containment is provided by the internal 1-L bottle and lid. The internal bottles will have an ullage of approximately 10 percent for liquid transport. The bottle must remain intact and not break or leak. The as-tested bottle that is approved for use is a 1-L, narrow-mouth, Teflon bottle with the Tefzel lid. Bottles used other than the approved, as-tested type must be tested and evaluated prior to use to ensure that its performance is equal to the approved, as-tested bottle. The nominal diameter of the internal bottle lid must be no more than 3.96875-cm (1.5625-in), so as to ensure that the lid of the SafeSend would not be pushed outward if it were drop tested as described in this evaluation report (see Section 5.2.2 of this report).

The SafeSend is designed and constructed to prevent leakage that may be caused by changes in altitude and temperature that may be encountered during air transport. The SafeSend was manufacturer-tested to an internal pressure of 100 kPa (14.5 psi). The vapor pressure should never exceed 130 kPa/18.8 psi at 55 °C (130 °F).

The approved packaging described in this report passed the required pressure conditions.

IATA 6.8.4.11, "Requirements for Type A Packages," applies and is met.

- j. Each valve through which the radioactive contents could otherwise escape is protected against damage and unauthorized operation and, except for a pressure relief device, has an enclosure to retain any leakage;

There are no valves used in this packaging configuration; therefore, this requirement is not applicable.

IATA 6.8.2.9, "General Requirements," and 6.8.4.12, "Requirements for Type A Packages," are not applicable.

- k. Any radiation shield that encloses a component of the packaging specified as part of the containment system will prevent the unintentional escape of that component from the shield;

The approved packaging configuration does not utilize shielding; therefore, this requirement is not applicable.

Primary containment is provided by the internal 1-L bottle. The bottle lid is hand tightened. The bottle is placed in an upright position within the SafeSend container. The as-tested bottle that is approved for use is a 1-L, narrow-mouth, Teflon bottle with the Tefzel lid. Bottles used other than the approved, as-tested type must be tested and evaluated prior to use to ensure that its performance is equal to the approved, as-tested bottle. The nominal diameter of the internal bottle lid must be no more than 3.96875-cm (1.5625-in), so as to ensure that the lid of the SafeSend would not be pushed outward if it were drop tested as described in this evaluation report (see Section 5.2.2 of this report).

The SafeSend container provides secondary containment, and has a self-locking mechanism on the lid that engages to the proper torque when the lid is screwed on.

IATA 6.8.4.13, "Requirements for Type A Packages," is not applicable.

- l. Failure of any tie down attachment of the packaging under excessive load will not impair the ability of the package to meet other requirements of this subpart;

There are no tie-down attachments on the packagings; therefore, this requirement is not applicable.

IATA 6.8.4.4, "Requirements for Type A Packages," is not applicable.

- m. When subjected to the tests specified in Paragraph 173.465 or evaluated against these tests by any of the methods authorized by Paragraph 173.461(a), the packaging will prevent:

- (1) Loss or dispersal of the radioactive contents; and
- (2) Any significant increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test.

The shipper must ensure that the radiation level at any surface of the packaging would not increase by more than 20% as a result of the decrease in distance to the center of the package load. Consideration of the internal load and breaking or leaking of the internal bottle (and possible release of contents) needs to be taken into account during transport.

Calculations were performed to determine if there is a greater than 20% increase in the radiation level at the surface of the SafeSend if the bottle were to break. The WHC Packaging Safety Engineering organization reported that the radiation levels for the liquid source term used increase as much as 66%, making the container unacceptable for Type A liquids if the bottle were to break.

The as-tested bottle that is approved for use is a 1-L, narrow-mouth, Teflon bottle with the Tefzel lid. Bottles used other than the approved, as-tested type must be tested and evaluated prior to use to ensure that its performance is equal to the approved, as-tested bottle. The nominal diameter of the internal bottle lid must be no more than 3.96875-cm (1.5625-in), so as to ensure that the lid of the SafeSend would not be pushed outward if it were drop tested as described in this evaluation report (see Section 5.2.2 of this report).

The approved, as-tested bottle remained intact and in position during testing.

IATA 6.8.4.15, "Requirements for Type A Packages," applies.

- n. Each packaging designed for liquids will:

- (1) Meet the conditions prescribed in paragraph (m) of this section when subjected to the tests specified in Paragraph 173.466 or evaluated against these tests by any of the methods authorized by Paragraph 173.461(a);
- (2) For any package with a liquid volume not exceeding 50 cubic centimeters (1.7 fluid ounces), have sufficient suitable absorbent material to absorb twice the volume of the liquid contents. The absorbent material shall be compatible with the package contents and suitably positioned to contact the liquid in the event of leakage; and

- (3) For any package with a liquid volume exceeding 50 cubic centimeters (1.7 fluid ounces), either:
- (i) Have sufficient absorbent material as prescribed in paragraph (n) (2) of this section; or
 - (ii) Have a containment system composed of primary inner and secondary outer containment components designed to assure retention of the liquid contents within the secondary outer components in the event that the primary inner components leak; and

Liquids are authorized for use in the approved packaging configuration. Primary containment is provided by the 1-L internal bottle. The as-tested bottle that is approved for use is a 1-L, narrow-mouth, Teflon bottle with the Tefzel lid. Bottles used other than the approved, as-tested type must be tested and evaluated prior to use to ensure that its performance is equal to the approved, as-tested bottle. The nominal diameter of the internal bottle lid must be no more than 3.96875-cm (1.5625-in), so as to ensure that the lid of the SafeSend would not be pushed outward if it were drop tested as described in this evaluation report (see Section 5.2.2 of this report).

The secondary containment, the SafeSend container, uses a high-performance liner material in its construction. This liner, which is integral to the polyethylene casing, provides a predefined, nonshifting envelope of protection for the primary container. The liner has three functional properties:

- Cushioning for the primary container
- Absorbency to contain leakage or liquid from breakage
- Reinforcement of the plastic casing.

The liner material is made up of ultra fine, plastic fibers, microns in diameter, which are chemically treated to render them wettable with a wide range of liquids. The base polymer (polypropylene) that makes up the fibers is essentially chemically inert and has no solvents at room temperature. Saturation capacity of the liner is approximately 2 L (0.53 gal). The rate of absorbency for water is 0.5 L/min (0.13 gal/min) when charged into the upright unit.

IATA 6.8.4.16, "Requirements for Type A Packages," applies and is met.

- o. Each package designed for compressed or uncompressed gases other than tritium or argon-37 not exceeding 200 curies will be able to prevent loss of contents when the package is subjected to the tests prescribed in 173.466 or evaluated against these tests by any of the methods authorized by Paragraph 173.461(a).

Compressed or uncompressed gases are not authorized for use in this packaging configuration.

IATA 6.8.4.17, "Requirements for Type A Packages," does not apply as compressed or uncompressed gases are not authorized for use in this packaging configuration.

5.1.6 49 CFR 173.442 - Thermal Limitations

Each package of radioactive material shall be designed, constructed, and loaded so that:

- a. The heat generated within the package because of the radioactive contents will not, at any time during transportation, affect the integrity of the package under conditions normally incident to transportation; and
- 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 °C (100 °F), exceed either;
 - (1) 50 °C (122 °F) in other than an exclusive use shipment; or
 - (2) 82 °C (180 °F) in an exclusive use shipment.

It is the responsibility of the shipper to ensure that the design and construction capabilities have been properly addressed by the designer and fabricator. The shipper is responsible to ensure that the contents of the package are properly loaded within the thermal design limitations.

IATA 6.8.2.10 and 6.8.2.11, "General Requirements," and 6.8.4.5, "Requirements for Type A Packages," apply for air transport.

5.1.7 49 CFR 178.3 - Marking of Packagings

- a. Each packaging manufactured to a DOT specification or a UN standard shall be marked as follows:
 - (1) In an unobstructed area with letters and numerals identifying the standards or specification (e.g., UN 1A1, DOT 4B240ET, etc.).
 - (2) Unless otherwise specified in this part, with the name and address or symbol of the manufacturer, or, for a UN standard packaging, the approval agency certifying compliance with the UN standard. Symbols, if used, must be registered with the Associate Administrator for Hazardous Materials Safety. Duplicate symbols are not authorized.

- (3) The markings must be stamped, embossed, burned, printed or otherwise marked on the packaging, to provide adequate accessibility, permanency, contrast, and legibility so as to be readily apparent and understood.
 - (4) Unless otherwise specified, letters and numerals must be at least 12.0 mm (0.47 inches) in height except that for packagings of less than or equal to 30 L (7.9 gallons) capacity for liquids or 30 kg (66 pounds) capacity for solids, the height must be at least 6.0 mm (0.2 inches).
- b. Packagings may be marked with the United Nations symbol and packaging identification code as provided in this subchapter, in the ICAO Technical Instructions or in Annex 1 to the IMDG Code, provided the person applying these marks has established that the packaging conforms to the applicable provisions of this subchapter, the ICAO Technical Instructions or Annex 1 to the IMDG Code, respectively.
- (1) If an indication of the State in whose territory the specified tests are carried out, or of the State authorizing the allocation of the mark, is required by this part (see paragraph 178.503 of this part), the letters "USA" shall be used if the manufacturing and testing occurs in the United States.
 - (2) If an indication of the name of the manufacturer or other identification of the packaging as specified by the competent authority is required, the name and address or symbol of the person making the mark shall be entered. Symbols, if used, must be registered with the Associate Administrator for hazardous Material Safety. Duplicate symbols are not authorized.
 - (3) Packagings manufactured to UN standards in accordance with this subchapter shall be marked as prescribed in paragraph 178.503 of this part.
- c. Where a packaging conforms to more than one UN standard or DOT specification, the packaging may bear more than one marking, provided the packaging meets all the requirements of each standard or specification. Where more than one marking appears on a packaging, each marking must appear in its entirety.

It is the responsibility of the shipper to ensure that the above requirements have been properly addressed by providing assurance that the packagings have been correctly marked as a Type A packaging, including identification of the manufacturer in accordance with the operating instructions (Jones 1995).

<p>For air transport, it is the shipper's responsibility to ensure that the IATA Section 6.3, "Marking," requirements are met.</p>
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5.2 COMPLIANCE TEST EVALUATION

5.2.1 49 CFR 173.465 - Type A Packaging Tests

- a. The proposed packaging with proposed contents must be capable of withstanding the tests prescribed in this section. One prototype may be used for all tests if the requirements of paragraph (b) of this section are complied with.
- b. **Water Spray Test.** The water spray test must precede each test or test sequence prescribed in this section. The water spray test shall simulate exposure to rainfall of approximately 5 centimeters (2 inches) per hour for at least one hour. The time interval between the end of the water spray test and the beginning of the next test shall be such that the water has soaked-in to the maximum extent without appreciable drying of the exterior of the specimen. In the absence of evidence to the contrary, this interval may be assumed to be two hours if the water spray is applied from four different directions simultaneously. However, no time interval may elapse if the water spray is applied from each of the four directions consecutively.

The water spray test was conducted on test units 41-TU-11 and 41-TU-12, and included the fiberboard shipper. These two test units were subjected to the water spray conditions for 1 hour with no loss of contents. The fiberboard shipper absorbed water, became saturated, and began to expand. The glue sealing the top and bottom flaps, and side of the shipper held in place; however, the layers of fiberboard corrugation material began to separate from each other on the top and bottom flaps, and side of the shipper. The fiberboard did not crack, rip, tear, or come unglued.

These two test units were left to sit for less than half-an-hour when drying began to occur to the outer fiberboard shipper. Test unit 41-TU-11 was then subjected to the penetration bar drop test (refer to Section 5.2.1.e of this report) and the compression test (refer to Section 5.2.1.d.2 of this report). Test unit 41-TU-12 was subjected to the 0.3-m (1-ft) drop test onto each corner (refer to Section 5.2.1.c.4 of this report). Because of the negative affect this drop test had on the fiberboard shipper, the sponsor decided that the shipper should be removed.

The water spray test was successfully performed on the modified design of test units 41-TU-11 and 41-TU-17 (without the fiberboard shipper). Prior to conducting this test, two small holes were drilled into the side of the SafeSend lid, opposite the lid locking mechanism, and a tamper wire added. These two test units were then subjected to the water spray conditions for 1 hour with no loss of contents. Water pooled in the top of the SafeSend lid around the handhold area; however there was no inleakage of water.

No further water spray tests were conducted as this test had no negative effect on the performance of the packaging.

The packagings as tested meet IATA 6.9.4.1, 6.9.4.2, and 6.9.4.3, "Tests for Demonstrating Ability to Withstand Normal Conditions of Transport."

- c. **Free Drop Test.** The free drop test consists of a fall onto the target in a manner that causes maximum damage to the safety features being tested, and:
1. For packages weighing 5,000 kilograms (11,000 pounds) or less, the distance of the fall measured from the lowest point of the packaging to the upper surface of the target shall not be less than 1.2 meters (4 feet).
 2. For packages weighing more than 5,000 kilograms (11,000 pounds), the distance of the fall shall not be less than the distance specified in Table 11, for the applicable packaging weight:

TABLE 11:
FREE-FALL DISTANCE FOR PACKAGING WEIGHING MORE THAN 5,000 KILOGRAMS.

PACKAGING WEIGHT		FREE-FALL DISTANCE	
KILOGRAMS	POUNDS	FEET	METERS
>5,000 TO 10,000...	>11,000 TO 22,000...	3	0.9
>10,000 TO 15,000...	>22,000 TO 33,000...	2	0.6
More than 15,000...	More than 33,000...	1	0.3

The vibration test, water spray test, penetration bar drops, compression, 0.3-m (1-ft) drop onto each corner of the fiberboard shipper were conducted prior to the 1.2-m (4-ft) drop test. Due to the failure of the fiberboard shipper during the 0.3-m (1-ft) drop test onto each corner (refer to Section 5.2.1.c.4 of this test plan), the design was modified, and the outer fiberboard shipper was not used for any further tests. Two small holes were drilled into the side of the SafeSend lid, opposite the lid locking mechanism, and a tamper wire was added to the test units noted in Table 5-1.

The vibration test, water spray test, and the 9-m (30-ft) drop test were then conducted on the modified packaging design prior to the 1.2-m (4-ft) drop test. The water spray test was conducted on test units 41-TU-11 and 41-TU-17 with no inleakage of water and no loss of contents. No further water spray tests were conducted as this had no negative effect on the performance of the packaging.

The Test Plan (Kelly 1995b) indicated that the 9-m (30-ft) drop test would be conducted prior to the 1.2-m (4-ft) drop test. The 9-m (30-ft) drop test included both inner bottle configurations. It had been

determined that the wide-mouth bottle was inferior to the narrow-mouth bottle. To save time and cost, the wide-mouth bottle configuration was chosen to undergo the 1.2-m (4-ft) drop test. The test results identified in Section 5.2.2 of this report (the 9-m [30-ft] drop test), proved and confirmed that the wide-mouth bottle was, in fact, inferior. As such, the 1.2 m (4 ft) drop test was only performed on the 1-L Liquid Shipper packaging containing the described wide-mouthed bottle (which is not approved for use in this packaging configuration). The as-tested, narrow-mouthed bottle passed by comparison.

The packagings shown in Table 5-1 were subjected to drop tests from a height of 1.2 m (4 ft).

IATA 6.9.4.4 and 6.9.4.5, "Tests for Demonstrating Ability to Withstand Normal Conditions of Transport," apply and are met.

Table 5-1. Drop Tests - 1.2 m (4 ft).

Package No.	Gross wt. g (lb)	Drop orientation
41-TU-13	3775.9 (8.3)	Flat onto SafeSend lid
41-TU-14	3782.1 (8.3)	Center of gravity (CG) to impact the top corner of the SafeSend at the locking mechanism
41-TU-15	3758.6 (8.3)	Flat onto bottom of SafeSend
41-TU-16	3788.2 (8.4)	CG to impact the bottom corner of the SafeSend
41-TU-17	3753.2 (8.3)	Flat onto side of SafeSend at the locking mechanism

Results

41-TU-13: This test unit did not utilize the fiberboard shipper. The lid of the SafeSend container had two small holes drilled into it per the sponsor's direction, and a tamper wire was added. This test unit was dropped flat onto the top lid of the SafeSend container, and utilized the wide-mouth bottle configuration (which is not authorized for use as an approved packaging). Internal contents (bottle, lid, and simulated contents) were loaded to 2104.4 (4.64 lb). The gross weight of the entire packaging was verified to be 3775.9 g (8.3 lb). There was no indication of damage to the exterior or interior of the SafeSend canister and lid, no tears or cracks to the internal absorbent material, and no breakage or leakage of the internal bottle. There was no evidence that the internal bottle shifted during impact. A blacklight was used to

confirm that there was no loss of contents (fluorescent water or steel shot). Pass.

41-TU-14: This test unit did not utilize the fiberboard shipper. The lid of the SafeSend container had two small holes drilled into it per the sponsor's direction, and a tamper wire was added. This test unit was dropped center of gravity to impact the top corner of the SafeSend at the locking mechanism (25° angle), and utilized the wide-mouth bottle configuration (which is not authorized for use as an approved packaging). Internal contents (bottle, lid, and simulated contents) were loaded to 2104.9 g (4.64 lb). The gross weight of the entire packaging was verified to be 3782.1 g (8.3 lb). There was no indication of damage to the exterior or interior of the SafeSend canister and lid, no tears or cracks to the internal absorbent material, and no breakage or leakage of the internal bottle. There was no evidence that the internal bottle shifted during impact. A blacklight was used to confirm that there was no loss of contents (fluorescent water or steel shot). Pass.

41-TU-15: This test unit did not utilize the fiberboard shipper. The lid of the SafeSend container had two small holes drilled into it per the sponsor's direction, and a tamper wire was added. This test unit was dropped flat onto the bottom of the SafeSend container, and utilized the wide-mouth bottle configuration (which is not authorized for use as an approved packaging). Internal contents (bottle, lid, and simulated contents) were loaded to 2106.6 g (4.64 lb). The gross weight of the entire packaging was verified to be 3758.6 g (8.3 lb). There was no indication of damage to the exterior or interior of the SafeSend canister and lid, no tears or cracks to the internal absorbent material, and no breakage or leakage of the internal bottle. There was no evidence that the internal bottle shifted during impact. A blacklight was used to confirm that there was no loss of contents (fluorescent water or steel shot). Pass.

41-TU-16: This test unit did not utilize the fiberboard shipper. The lid of the SafeSend container had two small holes drilled into it per the sponsor's direction, and a tamper wire was added. This test unit was dropped center of gravity to impact the bottom corner of the SafeSend (25° angle), and utilized the wide-mouth bottle configuration (which is not authorized for use as an approved packaging). Internal contents (bottle, lid, and simulated contents) were loaded to 2111.0 g (4.65 lb). The gross weight of the entire packaging was verified to be 3788.2 g (8.4 lb). There was no indication of damage to the exterior or interior of the SafeSend canister and lid, no tears or cracks to the internal absorbent material, and no breakage or leakage of the internal bottle. There was no evidence that the internal bottle shifted during impact. A blacklight was used to confirm that there was no loss of contents (fluorescent water or steel shot). Pass.

41-TU-17: This test unit did not utilize the fiberboard shipper. The lid of the SafeSend container had two small holes drilled into it per the sponsor's direction, and a tamper wire was added. This test unit was dropped flat onto the side of the SafeSend container at the locking mechanism, and utilized the wide-mouth bottle configuration (which is not authorized for use as an approved packaging). Internal contents (bottle,

lid, and simulated contents) were loaded to 2111.8 g (4.66 lb). The gross weight of the entire packaging was verified to be 3753.2 g (8.3 lb). There was no indication of damage to the exterior or interior of the SafeSend canister and lid, no tears or cracks to the internal absorbent material, and no breakage or leakage of the internal bottle. There was no evidence that the internal bottle shifted during impact. Although a slight amount of fluorescent dye was evident within the threaded lid area of the inner bottle, a blacklight was used to confirm that there was no loss of contents (fluorescent water or steel shot). Pass.

3. For Fissile Class II packagings, the free drop specified in subparagraph (1) or (2) of this paragraph shall be preceded by a drop from a height of 0.3 meter (1 foot) on each corner. For cylindrical packagings, the 0.3 meter (1 foot) drop shall be onto each of the quarters of each rim.

The packaging configuration will not be authorized for Fissile Class II materials; therefore, this requirement is not applicable.

IATA 6.9.4.6, "Tests for Demonstrating Ability to Withstand Normal Conditions of Transport," does not apply.

4. For fiberboard or wood rectangular packages not exceeding 50 kilograms (110 pounds) in weight, a separate specimen of the proposed packaging shall be subjected to a free drop onto each corner from a height of 0.3 meter (1 foot).

The original design of this packaging incorporated the use of an outer fiberboard shipper. As such, one test unit, 41-TU-12, was used for this test. The SafeSend container did not have two holes drilled into the lid area or tamper wire added. Internal contents (wide-mouthed bottle, lid, and simulated contents) were loaded to 2111.3 g (4.7 lb). The gross weight of the entire packaging, including the fiberboard shipper, was verified to be 4115.3 g (9.1 lb).

This test unit underwent the water spray test prior to this test. Immediately after the water spray test was conducted and before the packaging could dry (about a half-hour duration), the subject test unit was dropped a total of eight times, center of gravity (25° angle), once onto each corner of the fiberboard shipper. The side seam of the fiberboard shipper came unglued, exposing the SafeSend container. The SafeSend container did not eject from the fiberboard shipper. The top and bottom flaps of the fiberboard shipper did not come unglued; however, the layers of the corrugated fiberboard material separated from each other, both on the top and bottom flaps. Upon impact, the corners of the fiberboard shipper crumpled in an accordion fashion.

The fiberboard shipper was opened, and the packaging was then observed for any further damage. There was no indication of damage to the exterior or interior of the SafeSend canister and lid, no tears or cracks to the internal absorbent material, and no breakage or leakage of the internal bottle. A black light was used to confirm that there was no loss of contents (fluorescent water or steel shot).

NOTE: The packaging configuration, incorporating the fiberboard shipper, failed this test and is not authorized for use.

NOTE: Because the design of the 1-L Liquid shipper was modified to no longer incorporate the use of the external fiberboard shipper, this requirement does not apply.

IATA 6.9.4.7, "Tests for Demonstrating Ability to Withstand Normal Conditions of Transport," was not met, and does not apply due to the design modification made to the approved configuration for the 1-L Liquid Shipper.

5. For fiberboard cylindrical packages weighing not more than 100 kilograms (220 pounds) a separate specimen of the proposed packaging shall be subjected to a free drop onto each of the quarters of each rim from a height of 0.3 meter (1 foot).

This requirement is not applicable.

IATA 6.9.4.8, "Tests for Demonstrating Ability to Withstand Normal Conditions of Transport," is not applicable.

6. The target shall have a flat, horizontal surface of such mass and rigidity that any increase in its resistance to displacement or deformation upon impact by the specimen would not significantly increase the damage to the specimen.

The test pad used meets this requirement.

The DOE-approved test facility, located at the Hanford site, utilized a test pad located in the 305 Building, 300 Area. This pad is an 11,868-kg (26,165-lb), 2.1-m (84-in) square, indoor test pad consisting of a 5-cm (2-in) thick steel top plate, a 10-cm (4-in) thick steel intermediate plate, and a 61-cm (2-ft) thick reinforced concrete base. The pad is located in a 4.6-m (15-ft) deep pit with a 3.0 by 3.7-m (10 by 12-ft) opening.

IATA 6.9.3, "Target for Drop Tests," applies and is met.

- d. **Compression Test.** The compression test shall last for a period of at least 24 hours and consists of a compressive load equivalent to the greater of the following:
1. Five times the weight of the actual package; or
 2. 1300 kilograms per square meter (265 pounds per square foot) multiplied by the vertically projected area of the package. The compressive load shall be applied uniformly to two opposite sides of the packaging specimen, one of which must be the base on which the package would normally stand.

The original design of this packaging incorporated the use of an outer fiberboard shipper. As such, one test unit, 41-TU-11, was used for this test. Internal contents (narrow-mouthed bottle, lid, and simulated contents) were loaded to 2168.3 g (4.8 lb). The gross weight of the entire packaging, including the fiberboard shipper, was verified to be 4190.9 g (9.2 lb).

The water spray and penetration (1-m [3.3-ft] and 1.7-m [5.5-ft]) tests were conducted prior to conducting the compression test. The compressive load was determined by calculating the vertically projected area of the package as this exceeds five times the estimated weight of the package. A load of 51 kg (112 lb) was applied uniformly to two opposite sides of test unit 41-TU-11, one of which was the base on which the package would normally stand. Because of the failure of test unit 41-TU-12 during the 0.3-m (1-ft) drop onto each corner (see Section 5.2.1.c.4 of this report), this test was stopped.

The design of the 1-L Liquid Shipper was modified. The outer fiberboard shipper was removed, and two holes were drilled into the lid of the SafeSend container and tamper wire added. Test unit 41-TU-11 was modified in this manner. Internal contents (narrow-mouthed bottle, lid, and simulated contents) remained loaded at 2168.6 g (4.8 lb). The gross weight of the entire packaging, without the fiberboard shipper, was verified to be 3872.8 g (8.5 lb).

The water spray and penetration (1-m [3.3-ft] and 1.7-m [5.5-ft]) tests were then conducted on this modified test unit prior to conducting the compression test (without the fiberboard shipper). The compressive load was determined by calculating the vertically projected area of the package as this exceeds five times the estimated weight of the package. A load of 51 kg (112 lb) was applied uniformly to two opposite sides of test unit 41-TU-11, one of which was the base on which the package would normally stand.

The compression test was successfully conducted on the modified design by using test unit 41-TU-11. There was no deformation to the SafeSend canister or lid, or breakage of the internal, narrow-mouthed bottle.

IATA 6.9.4.9 and 6.9.4.10, "Tests for Demonstrating Ability to Withstand Normal Conditions of Transport," apply and are met.

- e. **Penetration Test.** For the penetration test the packaging specimen shall be placed on a rigid, flat, horizontal surface that will not move while the test is being performed. The test shall consist of:
1. A bar of 3.2 centimeters (1.25 inches) in diameter with a hemispherical end weighing 6 kilograms (13.2 pounds) being dropped with its longitudinal axis vertical, onto the center of the weakest part of the packaging specimen, so that, if it penetrates far enough, it will hit the containment system. The bar must not be deformed by the test; and
 2. The distance of the fall of the bar measured from its lower end to the upper surface of the packaging specimen shall not be less than 1 meter (3.3 feet).

The original design of this packaging incorporated the use of an outer fiberboard shipper. As such, one test unit, 41-TU-11, was used for this test. Internal contents (narrow-mouthed bottle, lid, and simulated contents) were loaded to 2168.3 g (4.8 lb). The gross weight of the entire packaging, including the fiberboard shipper, was verified to be 4190.9 g (9.2 lb).

The water spray test was conducted on test unit 41-TU-11 prior to conducting this test. Immediately after the water spray test was conducted and before the packaging could dry (about a half-hour duration), the subject test unit underwent the 1 m (3.3 ft) penetration test. The package was laid horizontally onto its side. The penetration bar was dropped onto the fiberboard shipper, and at the center of the package. The point of impact caused the fiberboard shipper to indent 1.9-cm (0.75-in.) deep and 3.81-cm (1.5-in.) across.

Because of the failure of test unit 41-TU-12 during the 0.3-m (1-ft) drop onto each corner (see Section 5.2.1.c.4 of this report), the design of the 1-L Liquid Shipper was modified, and the penetration test was repeated. The outer fiberboard shipper was removed from test unit 41-TU-11, and two holes were drilled into the lid of the SafeSend container and tamper wire added per the sponsor's instructions. Internal contents (narrow-mouthed bottle, lid, and simulated contents) remained loaded at 2168.6 g (4.8 lb). The gross weight of the entire packaging, without the fiberboard shipper, was verified to be 3872.8 g (8.5 lb).

The water spray test was conducted on test unit 41-TU-11, without the fiberboard shipper, prior to conducting this test. Immediately after the water spray test was conducted and before the packaging could dry, the subject test unit underwent the 1 m (3.3 ft) penetration test. The SafeSend container was laid on its horizontal side, and the penetration bar was dropped to hit the locking

mechanism on the SafeSend lid. The point of impact caused the locking mechanism to break off and shatter. A slight indentation occurred to the outside rim of the SafeSend lid at this point of impact. The SafeSend lid did not loosen, and there was no further damage. This penetration test was successfully conducted on test unit 41-TU-11, without the fiberboard shipper.

IATA 6.9.4.11, "Tests for Demonstrating Ability to Withstand Normal Conditions of Transport," applies and is met.

5.2.2 49 CFR 173.466 - Additional Tests for Type A Packagings Designed for Liquids and Gases

In addition to the tests prescribed in 173.465, Type A packaging designed for liquids and gases shall be capable of withstanding the following tests:

1. **Free Drop Test.** The packaging specimen shall fall onto the target in a manner which will cause it to suffer the maximum damage to its containment. The distance of the fall measured from the lowest part of the packaging specimen shall not be less than 9 meters (30 feet).

The vibration, water spray, and penetration tests were conducted prior to the 9-m (30-ft) drop test, and did not include the fiberboard shipper. Due to the failure of test unit 41-TU-12 during the 0.3-m (1-ft) drop test onto each corner (see Section 5.2.1.c.4), the outer fiberboard shipper was removed from the tested packaging configuration. Two holes were drilled into the SafeSend lid and tamper wire added per the sponsors instructions to the test units noted in Table 5-2, with the exception of test units 41-TU-18 and 41-TU-19.

The water spray test was conducted on test units 41-TU-11 and 41-TU-17 with no inleakage of water and no loss of contents. No further water spray tests were conducted as this test had no negative effect on the performance of the packaging.

The packagings shown in Table 5-2 were subjected to drop tests from a height of 9 m (30 ft).

IATA 6.9.5.2, "Additional Tests for Type A Packages Designed for Liquids and Gases," applies and is met.

Table 5-2. Drop Tests - 9 m (30 ft).

Package no.	Gross wt. g (lb)	Drop orientation
41-TU-01	3761.8 (8.3)	Flat onto SafeSend lid
41-TU-02	3841.4 (8.5)	CG to impact the top corner of the SafeSend at the locking mechanism
41-TU-03	3833.1 (8.5)	Flat onto bottom of SafeSend
41-TU-04	3812.8 (8.4)	CG to impact bottom corner of the SafeSend
41-TU-05	3884.5 (8.6)	Flat onto side of SafeSend at locking mechanism
41-TU-06	3699.0 (8.2)	Flat onto SafeSend lid
41-TU-07	3755.9 (8.3)	CG to impact the top corner of the SafeSend at the locking mechanism
41-TU-08	3802.6 (8.4)	Flat onto bottom of SafeSend
41-TU-09	3790.9 (8.4)	CG to impact bottom corner of the SafeSend
41-TU-10	3768.6 (8.3)	Flat onto side of SafeSend at locking mechanism
41-TU-12	3797.4 (8.4)	Flat onto side of SafeSend at locking mechanism
41-TU-18	3778.4 (8.3)	Flat onto side of SafeSend at locking mechanism
41-TU-19	3821.6 (8.4)	Flat onto side of SafeSend at locking mechanism

Results

41-TU-01: This test unit did not utilize the fiberboard shipper. The lid of the SafeSend container had two small holes drilled into it per the sponsor's direction, and a tamper wire was added. This test unit was dropped flat onto the lid of the SafeSend container, and utilized the narrow-mouth bottle configuration (which is authorized for use as an approved packaging). Internal contents (bottle, lid, and simulated contents) were loaded to 2164.8 g (4.8 lb). The gross weight of the entire packaging was verified to be 3761.8 g (8.3 lb). There was no indication of damage to the exterior or interior of the SafeSend canister and lid, no tears or

cracks to the internal absorbent material, and no breakage or leakage of the internal bottle. There was no evidence that the internal bottle shifted during impact. Although a slight amount of fluorescent dye was evident within the threaded lid area of the inner bottle, a blacklight was used to confirm that there was no loss of contents (fluorescent water or steel shot). Pass.

41-TU-02: This test unit did not utilize the fiberboard shipper. The lid of the SafeSend container had two small holes drilled into it per the sponsor's direction, and a tamper wire was added. This test unit was dropped center of gravity (25° angle) to impact the top corner of the SafeSend container at the locking mechanism, and utilized the narrow-mouth bottle configuration (which is authorized for use as an approved packaging). Internal contents (bottle, lid, and simulated contents) were loaded to 2169.8 g (4.8 lb). The gross weight of the entire packaging was verified to be 3841.4 g (8.5 lb). The SafeSend locking mechanism broke off, and a slight dent occurred in the top of the SafeSend at the point of impact. There was no indication of damage to the interior of the SafeSend canister and lid, no tears or cracks to the internal absorbent material, and no breakage or leakage of the internal bottle. There was no evidence that the internal bottle shifted during impact. A blacklight was used to confirm that there was no loss of contents (fluorescent water or steel shot). Pass.

41-TU-03: This test unit did not utilize the fiberboard shipper. The lid of the SafeSend container had two small holes drilled into it per the sponsor's direction, and a tamper wire was added. This test unit was dropped flat onto the bottom of the SafeSend container, and utilized the narrow-mouth bottle configuration (which is authorized for use as an approved packaging). Internal contents (bottle, lid, and simulated contents) were loaded to 2173.4 g (4.8 lb). The gross weight of the entire packaging was verified to be 3833.1 g (8.5 lb). There was no indication of damage to the exterior of the SafeSend canister and lid. Upon removal of the SafeSend lid, the inner absorbent material had pushed outward from the lid a distance of 2.54-cm (1-in). This lifting curved across the entire diameter of the lid. The maximum distance of this curve toward the center of the lid measured 4.45-cm (1.75-in). There was no indication of damage to the interior of the SafeSend canister, no tears or cracks to the internal absorbent material, and no breakage or leakage of the internal bottle. There was no evidence that the internal bottle shifted during impact. It was observed that the inner bottle had indented slightly along the wall that received the impact. A blacklight was used to confirm that there was no loss of contents (fluorescent water or steel shot). Pass.

41-TU-04: This test unit did not utilize the fiberboard shipper. The lid of the SafeSend container had two small holes drilled into it per the sponsor's direction, and a tamper wire was added. This test unit was dropped center of gravity (25° angle) to impact the bottom corner of the SafeSend container, and utilized the narrow-mouth bottle configuration (which is authorized for use as an approved packaging). Internal contents (bottle, lid, and simulated

contents) were loaded to 2161.9 g (4.8 lb). The gross weight of the entire packaging was verified to be 3812.8 g (8.4 lb). Slight dimpling [3.175-cm (1.25-in)] occurred across the exterior base of the SafeSend canister at the point of impact. This dimpling was located on a side bumper. There was no damage noted to the exterior of the SafeSend lid. There was no indication of damage to the interior of the SafeSend canister, no tears or cracks to the internal absorbent material, and no breakage or leakage of the internal bottle. There was no evidence that the internal bottle shifted during impact. It was observed that the inner bottle had a slight deformation along the area that received the impact. A blacklight was used to confirm that there was no loss of contents (fluorescent water or steel shot). Pass.

41-TU-05: This test unit did not utilize the fiberboard shipper. The lid of the SafeSend container had two small holes drilled into it per the sponsor's direction, and a tamper wire was added. This test unit was dropped flat onto the side of the SafeSend to impact the locking mechanism, and utilized the narrow-mouth bottle configuration (which is authorized for use as an approved packaging). Internal contents (bottle, lid, and simulated contents) were loaded to 2171.4 g (4.8 lb). The gross weight of the entire packaging was verified to be 3884.5 g (8.6 lb). A slight deformation to the exterior SafeSend lid occurred at the point of impact. Although the locking mechanism on the SafeSend broke off, the lid did not loosen. There was no damage noted to the exterior of the SafeSend body. There was no indication of damage to the interior of the SafeSend canister, no tears or cracks to the internal absorbent material, and no breakage or leakage of the internal bottle. There was no evidence that the internal bottle shifted during impact. Although a slight amount of fluorescent dye was evident within the threaded lid area of the inner bottle, a blacklight was used to confirm that there was no loss of contents (fluorescent water or steel shot). Pass.

41-TU-06: This test unit did not utilize the fiberboard shipper. The lid of the SafeSend container had two small holes drilled into it per the sponsor's direction, and a tamper wire was added. This test unit was dropped flat onto the lid of the SafeSend, and utilized the wide-mouth bottle configuration (which is not authorized for use as an approved packaging). Internal contents (bottle, lid, and simulated contents) were loaded to 2106.0 g (4.6 lb). The gross weight of the entire packaging was verified to be 3699.0 g (8.2 lb). The internal bottle shifted during impact. It was noted that the lid to the SafeSend container was pushed outward, away from the SafeSend body, a distance of 0.3175-cm (0.125-in). Although the SafeSend lid pushed outward, the pin/locking mechanism did not break. The handhold area of the SafeSend lid compressed inward slightly, and a slight outward curvature of the lid was noted in the area of the handhold. There was no indication of damage to the interior of the SafeSend canister, no tears or cracks to the internal absorbent material, and no breakage or leakage of the internal bottle. A blacklight was

used to confirm that there was no loss of contents (fluorescent water or steel shot). Marginal pass.

41-TU-07: This test unit did not utilize the fiberboard shipper. The lid of the SafeSend container had two small holes drilled into it per the sponsor's direction, and a tamper wire was added. This test unit was dropped center of gravity (25° angle) to impact the locking mechanism on the top corner of the SafeSend lid, and utilized the wide-mouth bottle configuration (which is not authorized for use as an approved packaging). Internal contents (bottle, lid, and simulated contents) were loaded to 2110.4 g (4.7 lb). The gross weight of the entire packaging was verified to be 3755.9 g (8.3 lb). The internal bottle shifted during impact. It was noted that the lid to the SafeSend container was pushed outward, away from the SafeSend body, a distance of 0.3175-cm (0.125-in). The SafeSend pin/locking mechanism broke. The handhold area of the SafeSend lid compressed inward slightly, and a slight outward curvature of the lid was noted in the area of the handhold. There was no indication of damage to the interior of the SafeSend canister, no tears or cracks to the internal absorbent material, and no breakage or leakage of the internal bottle. Although a slight amount of fluorescent dye was evident within the threaded lid area of the inner bottle, a blacklight was used to confirm that there was no loss of contents (fluorescent water or steel shot). Marginal pass.

41-TU-08: This test unit did not utilize the fiberboard shipper. The lid of the SafeSend container had two small holes drilled into it per the sponsor's direction, and a tamper wire was added. This test unit was dropped flat onto the bottom of the SafeSend container, and utilized the wide-mouth bottle configuration (which is not authorized for use as an approved packaging). Internal contents (bottle, lid, and simulated contents) were loaded to 2107.8 g (4.6 lb). The gross weight of the entire packaging was verified to be 3802.6 g (8.4 lb). There was no indication of damage to the exterior or interior of the SafeSend canister or lid, no tears or cracks to the internal absorbent material, and no breakage or leakage of the internal bottle. There was no evidence that the internal bottle shifted during impact. Although a slight amount of fluorescent dye was evident within the threaded lid area of the inner bottle, a blacklight was used to confirm that there was no loss of contents (fluorescent water or steel shot). Pass.

41-TU-09: This test unit did not utilize the fiberboard shipper. The lid of the SafeSend container had two small holes drilled into it per the sponsor's direction, and a tamper wire was added. This test unit was dropped center of gravity (25° angle) to impact the bottom corner of the SafeSend container, and utilized the wide-mouth bottle configuration (which is not authorized for use as an approved packaging). Internal contents (bottle, lid, and simulated contents) were loaded to 2109.4 g (4.7 lb). The gross weight of the entire packaging was verified to be 3790.9 g (8.4 lb). Slight denting measured 13.97-cm (5.50-in) across the SafeSend sidewall at the point of impact. The underside of the SafeSend base dented

slightly, and measured 11.43-cm (4.50-in) across. There was no indication of damage to the interior of the SafeSend canister, no tears or cracks to the internal absorbent material, and no breakage or leakage of the internal bottle. There was no evidence that the internal bottle shifted during impact. Although a slight amount of fluorescent dye was evident within the threaded lid area of the inner bottle, a blacklight was used to confirm that there was no loss of contents (fluorescent water or steel shot). Pass.

41-TU-10: This test unit did not utilize the fiberboard shipper. The lid of the SafeSend container had two small holes drilled into it per the sponsor's direction, and a tamper wire was added. This test unit was dropped flat onto the side of the SafeSend container, and utilized the wide-mouth bottle configuration (which is not authorized for use as an approved packaging). Internal contents (bottle, lid, and simulated contents) were loaded to 2110.2 g (4.7 lb). The gross weight of the entire packaging was verified to be 3768.6 g (8.3 lb). There was no damage noted to the exterior of the SafeSend lid or canister. There was no indication of damage to the interior of the SafeSend canister, and no tears or cracks to the internal absorbent material. There was no evidence that the internal bottle shifted during impact. The top three foam spacers were removed from around the inner bottle, and they showed significant traces of fluorescent liquid. The inner bottle did not break; however, leakage had occurred around the bottle's threaded lid area. A blacklight was used to confirm the loss of liquid contents.

NOTE: Because of the failure of test unit 41-TU-10 during the 9.0-m (30-ft) drop test, it was decided that another test unit should be dropped in this same configuration and orientation, to confirm the performance of the wide-mouth inner bottle. Therefore, the following test was conducted:

41-TU-12: Prior to conducting the 9.0-m (30-ft) drop test on this test unit, this packaging originally utilized the fiberboard shipper, and underwent the water spray test and 0.3-m (1-ft) drop, center of gravity (25° angle) onto each corner of the fiberboard shipper. As this test unit failed the later test (see Section 5.2.1.c.4 of this report), the fiberboard shipper was removed, and this test unit was utilized for further use.

In conducting the 9.0-m (30-ft) drop test, this test unit did not utilize the fiberboard shipper. The lid of the SafeSend container had two small holes drilled into it per the sponsor's direction, and a tamper wire was added. The intent was to repeat the drop orientation specified for 41-TU-10, and to drop this test unit flat onto the side of the SafeSend container to impact the locking mechanism. This test unit utilized the wide-mouth bottle configuration (which is not authorized for use as an approved packaging). Internal contents (bottle, lid, and simulated contents) were loaded to 2111.3 g (4.7 lb). The gross weight of the entire packaging was verified to be 3797.4 g (8.4 lb).

When the package was dropped, it impacted at a slight angle. Slight denting measured 12.7-cm (5.0-in) across the bottom of the SafeSend sidewall at the point of impact. The underside of the SafeSend base dented slightly, and measured 12.06-cm (4.75-in) across. There was no indication of damage to the interior of the SafeSend canister, no tears or cracks to the internal absorbent material, and no breakage or leakage of the internal bottle. There was no evidence that the internal bottle shifted during impact. A blacklight was used to confirm that there was no loss of contents (fluorescent water or steel shot).

NOTE: Because test unit 41-TU-12 did not drop flat onto its side during this test, it was decided that another test unit should be dropped in the required configuration and orientation, to confirm the performance of the wide-mouth inner bottle. Therefore, the following test was conducted:

41-TU-18: This test unit did not utilize the fiberboard shipper. The lid of the SafeSend container did not have the two small holes drilled into it, and no tamper wire was added. The intent was to repeat the drop orientation specified for 41-TU-10, and to drop this test unit flat onto the side of the SafeSend container to impact the locking mechanism. This test unit utilized the wide-mouth bottle configuration (which is not authorized for use as an approved packaging). Internal contents (bottle, lid, and simulated contents) were loaded to 2112.4 g (4.7 lb). The gross weight of the entire packaging was verified to be 3778.4 g (8.3 lb). There was no damage noted to the exterior of the SafeSend lid or canister. There was no indication of damage to the interior of the SafeSend canister, and no tears or cracks to the internal absorbent material. There was no evidence that the internal bottle shifted during impact. The top three foam spacers were removed from around the inner bottle, and they showed significant traces of fluorescent liquid. The inner bottle did not break; however, leakage had occurred around the bottle's threaded lid area. A blacklight was used to confirm the loss of liquid contents.

NOTE: Because of the failure of test unit 41-TU-10 and 41-TU-18 during the 9.0-m (30-ft) drop test, and using the wide-mouthed inner bottle, it was decided that another test unit should be dropped in this same orientation, using the narrow-mouth bottle. The purpose of this additional testing was to confirm the performance of the narrow-mouth inner bottle. Therefore, the following test was conducted:

41-TU-19: This test unit did not utilize the fiberboard shipper. The lid of the SafeSend container did not have two small holes drilled into it, and no tamper wire was added. This test unit was dropped flat onto the side of the SafeSend to impact the locking mechanism, and utilized the narrow-mouth bottle configuration (which is authorized for use as an approved packaging). Internal contents (bottle, lid, and simulated contents) were loaded to 2163.2 g (4.8 lb). The gross weight of the entire packaging was verified to be 3821.6 g (8.4 lb). There was no damage noted to the exterior of

the SafeSend body or lid. There was no indication of damage to the interior of the SafeSend canister, no tears or cracks to the internal absorbent material, and no breakage or leakage of the internal bottle. There was no evidence that the internal bottle shifted during impact. Although a slight amount of fluorescent dye was evident within the threaded lid area of the inner bottle, a blacklight was used to confirm that there was no loss of contents (fluorescent water or steel shot). Pass.

2. **Penetration Test.** The specimen must be subjected to the test specified in 173.465(e) except that the distance of the fall shall be 1.7 meters (5.5 feet).

The original design of this packaging incorporated the use of an outer fiberboard shipper. As such, one test unit, 41-TU-11, was used for this test. Internal contents (narrow-mouthed bottle, lid, and simulated contents) were loaded to 2168.3 g (4.8 lb). The gross weight of the entire packaging, including the fiberboard shipper, was verified to be 4190.9 g (9.2 lb).

The water spray test was conducted on test unit 41-TU-11 prior to conducting this test. Immediately after the water spray test was conducted and before the packaging could dry, the subject test unit was laid horizontally onto its side, and underwent the 1 m (3.3 ft) penetration test as described in Section 5.2.1.e of this report. This test unit was then rotated 180° for the 1.7 m (5.5 ft) penetration test. The penetration bar was dropped onto test unit 41-TU-11 to impact the fiberboard shipper, and at the center of the package. The point of impact caused the fiberboard shipper to indent 1.9-cm (0.75-in.) deep and 3.81-cm (1.5-in.) across.

Because of the failure of test unit 41-TU-12 during the 0.3-m (1-ft) drop onto each corner (see Section 5.2.1.c.4 of this report), the design of the 1-L Liquid Shipper was modified, and this test was repeated. The outer fiberboard shipper was removed from test unit 41-TU-11, and two holes were drilled into the lid of the SafeSend container and tamper wire added. Internal contents (narrow-mouthed bottle, lid, and simulated contents) remained loaded at 2168.3 g (4.8 lb). The gross weight of the entire packaging, without the fiberboard shipper, was verified to be 3872.8 g (8.5 lb).

The water spray test was conducted on this packaging, without the fiberboard shipper, prior to conducting this test. Immediately after the water spray test was conducted and before the packaging could dry, the subject test unit underwent the 1 m (3.3 ft) penetration test as described in Section 5.2.1.e of this report. Test unit 41-TU-11 was then used for the 1.7 m (5.5 ft) penetration test. The SafeSend was laid on its horizontal side, and the penetration bar was dropped to impact the center of the SafeSend. A slight indentation measuring 0.3175-cm (0.125-in) deep and 3.81-cm (1.50-in) across occurred to the outside of the SafeSend at the point of impact.

IATA 6.9.5.3, "Additional Tests for Type A Packages Designed for Liquids and Gases," applies and is met.

5.2.3 49 CFR 178.608 - Vibration Standards

- a. Each packaging must be capable of withstanding, without rupture or leakage, the vibration test procedure outlined in this section.
- b. Test method.
 - (1) Three sample packagings must be filled and closed as for shipment.
 - (2) The three samples must be placed on a vibrating platform that has a vertical or rotary double-amplitude (peak-to-peak displacement) of one inch. The packages should be constrained horizontally to prevent them from falling off the platform, but must be left free to move vertically, bounce, and rotate.
 - (3) The test must be performed for one hour at a frequency that causes the package to be raised from the vibrating platform to such a degree that a piece of material of approximately 1.6 mm (0.063 inch [1/16 inch]) thickness (such as steel strapping or paperboard) can be passed between the bottom of any package and the platform.
 - (4) Immediately following the period of vibration, each package must be removed from the platform, turned on its side, and observed for any evidence of leakage.
 - (5) Other methods, at least equally effective, may be used, if approved by the Associate Administrator for Hazardous Material Safety.
- c. Criteria for passing the test. A packaging passes the vibration test if there is no rupture or leakage from any of the packages. No test sample should show any deterioration which could adversely affect transportation safety or any distortion liable to reduce packaging strength.

The approved packaging configuration was judged to pass this requirement. Visual examination of the packaging identified no rupture or leakage. Type A packagings are required "to withstand the effects of any acceleration, vibration, or vibration resonance that may arise during normal transportation" [49 CFR 173.412 (e)]. The test identified in this section was applied to support the ability of the packaging to meet the requirement.

The initial packaging design included the use of the fiberboard shipper. Vibration testing was conducted for 1 hour on six test units filled with the actual simulated contents, and the fiberboard

shipper. Three test units included the narrow-mouth Teflon bottle (41-TU-01 through 41-TU-03); and three test units included the wide-mouth FLPE bottle (41-TU-06 through 41-TU-08). The packagings were checked after the vibration test, and none were damaged or observed to have leakage of simulated contents.

Because of the negative results of the water spray test (see Section 5.2.1.b of this report) and the 0.3-m (1-ft) drop test onto each corner (see Section 5.2.1.c.4 of this report), the external fiberboard shipper was removed, and the vibration test was conducted a second time on these same test units. Per the sponsor's request and prior to conducting the second vibration test, the lid of the SafeSend containers had two small holes drilled opposite the lid locking mechanism, and a tamper wire added through these two holes. The packagings were checked after the vibration test, and none were damaged or observed to have leakage of simulated contents.

IATA 6.8.2.7, "General Requirements," will be met based on prior use of this packaging as a Performance-Oriented Packaging for shipment by air and the ability of this packaging to pass the DOT vibration test as stated above.

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6.0 CONCLUSION

The evaluation and testing indicates that the packaging configuration identified without the use of the fiberboard shipper, and the inner container consisting of the 1-L, narrow-mouth, Teflon FEP bottle with a Tefzel ETFE lid, meets applicable DOT-7A Type A design and compliance test requirements, and where applicable, meets IATA/ICAO design and compliance test requirements for transportation by aircraft. The packagings should be loaded, assembled, and closed as described in this document (see Section 4.3 and Appendix B). Deviations from the approved, tested packaging system configuration will require retesting or approval by the U.S. Department of Energy. The following restrictions/ specifications shall be observed:

1. The packagings are approved for shipping liquids having a specific gravity ≤ 2 , and solids. The solid versions would allow the shipment of normal or special form solids. The solid materials are limited in weight--to include packaging--to the gross weight of the approved, as-tested liquid and bottle. The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing/analysis must be conducted and documented to demonstrate Specification 7A compliance with the actual contents.
2. A fluid indicator is incorporated into the sorbent cylinder lining of the SafeSend. Any appearance other than a uniform blue color indicates leakage or breakage of contents. The presence of a uniform blue color does not ensure that contents are intact.
3. Use of the packaging configuration with incompatible materials may cause leakage of contents, posing such risks as serious physical injury or property damage. Incompatible materials for the SafeSend include the following:
 - Those having a vapor pressure of greater than 130 kPa (18.8 lbf/in²) at 55 °C (130 °F)
 - Those which in combination could increase heat or vapor pressure
 - Materials that may chemically attack this packaging or its components.
4. A vapor pressure of 130 kPa (18.8 psi) at 55 °C (130 °F) should never be exceeded.
5. Improper tightening of the SafeSend canister may cause leakage or breakage of contents. To ensure a proper seal for transporting the internal packaging, the SafeSend cap must be tightened until the latch snaps into place. The canister or latch should not be used if damaged.
6. The SafeSend identification numbers, located on the label on the body of the SafeSend and in the right corner of the red label on the cap, must be identical. Do not use if they are not identical.

7. When storing the SafeSend container, unscrew the cap one full turn from the latched position.
 8. Bottles used other than the approved, as-tested type (1-L, narrow-mouth, Teflon FEP bottle with a Tefzel ETFE lid) must be tested and evaluated prior to use to ensure that its performance is equal to the approved, as-tested bottle. The internal bottle must remain intact and not break or leak. The nominal diameter of the internal bottle lid must be no more than 3.96875-cm (1.5625-in), so as to ensure that the lid of the SafeSend would not be pushed outward if it were drop tested as described in this evaluation report (see Section 5.2.2).
- NOTE:** The 1-L, wide-mouth FLPE bottle with PP lid is not approved for use in this packaging configuration.
9. The 1-L inner bottle shall be inserted into the SafeSend container in an upright position.
 10. The shipper shall ensure that the radiation level at any surface would not increase by more than 20%.
 11. The maximum gross weight for the packaging configuration is shown in Table 6-1.

The shipper is the organization that actually uses the packagings and therefore is responsible to make sure they are used in accordance with their designs. The shipper shall ensure that the design is suitable in all respects for the contents to be shipped. If it is not suitable, testing/analysis must be conducted and documented to demonstrate Specification 7A compliance with the actual contents. The design will dictate many of the limits placed on the contents, such as mass and physical form.

The manufacturer(s) of the packaging described herein is responsible for using materials, processes, and controls in the packaging fabrication that are equivalent to those used in the fabrication of the test unit packagings.

Table 6-1. Maximum Gross Weight for 1-L Liquid Shipper.

Item	Description	Nominal Weight g (lb)
SafeSend SP-R1L kit	Includes SafeSend ^a canister and lid; 6 foam inserts; and plastic bag.	1663.0 (3.66)
1-L internal bottle (Type #1)	Narrow-mouth, Teflon ^b FEP bottle with a Tefzel ^c ETFE lid, including product fill weight.	2167.5 (4.78)
Gross weight	Assembled package.	3830.5 (8.4)

^aSafeSend is a trademark of the 3M Company.

^bTeflon is a trademark of E.I. du Pont de Nemours & Company.

^cTefzel is a trademark of E.I. du Pont de Nemours & Company.

ETFE = ethylene tetrafluoroethylene

FEP = fluorinated ethylene propylene

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7.0 QUALITY ASSURANCE PROGRAM

The quality assurance program implemented by the shipper's organization must implement actions to provide adequate confidence that the shipment will comply with the regulations. The following regulatory requirements address quality control applicable to Type A packaging.

Paragraphs 173.474 and 173.475 that are restated below provide the quality control elements prescribed in 49 CFR. These requirements must be met for all shipments.

173.474. Quality Control for Construction of Packaging

- a. Prior to the first use of any packaging for the shipment of radioactive material, the shipper shall determine that:
 - 1. The packaging meets the quality of design and construction requirements as specified in this subchapter; and
 - 2. The effectiveness of the shielding, containment, and, when required heat transfer characteristics of the package, are within the limits specified for the package design.

173.475. Quality Control Requirements Prior to Each Shipment of Radioactive Materials

Before each shipment of any radioactive materials package, the shipper shall ensure by examination or appropriate tests, that:

- a. The packaging is proper for the contents to be shipped;
- b. The packaging is in unimpaired physical condition, except for superficial marks;
- c. Each closure device of the packaging, including any required gasket, is properly installed, secured, and free of defects;
- d. For fissile material, each moderator and neutron absorber, if required, is present and in proper condition;
- e. Each special instruction for filling, closing, and preparation of the packaging for shipment has been followed;
- f. Each closure, valve, or other opening of the containment system through which the radioactive content might escape is properly closed and sealed;
- g. Each packaging containing liquid in excess of an A₂ quantity and intended for air shipment has been tested to show that it will not leak under an ambient atmospheric pressure of not more than 0.25 atmosphere, absolute, (0.25 kilograms per square centimeter or 3.6 pisa). The test must be conducted on the entire containment

system, or on any receptacle or vessel within the containment system, to determine compliance with this requirement.

- h. The internal pressure of the containment system will not exceed the design pressure during transportation; and
- i. External radiation and contamination levels are within the allowable limits specified in this subchapter.

It is critical that controls are in place to ensure that the packaging hardware to be used complies with the specifications given for the packaging hardware tested, described, and evaluated in this document. Each shipper must have a documented program that describes how this is achieved, and the degree of certainty, in addition to documentation (audit trail) that demonstrates compliance. The quality assurance program is mandated in DOE Order 5480.3, *Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes* (DOE 1985).

8.0 PRIMARY USER/MANUFACTURER

Site/Contact/Phone

W. Scott Edwards
(509) 376-2522

Address

Westinghouse Hanford Company
P.O. Box 1970
Richland, Washington 99352

Suppliers

3M SafeSend SP-R1L Kit

Labelmaster Catalog Part Number: KSP-1LR (Labelmaster 1994)

1-L Narrow-mouth Teflon, FEP Bottle with Tefzel ETFE Lid

Nalgene Part Number: 1600-0032

Fisher Part Number: 02-923-30D (Fisher 1994)

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9.0 REFERENCES

49 CFR, "Transportation," Parts 100 to 177 and Parts 178 to 199, *Code of Federal Regulations*, as amended.

DOE, 1985, *Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes*, DOE Order 5480.3, U.S. Department of Energy, Washington, D.C.

Jones, S. R, 1995, *Operating and Maintenance Instructions for the 1-L Liquid Shipper Package*, WHC-SD-TP-OMM-003, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Fisher, 1994, *The Fisher Catalog*, 1993/94, Fisher Scientific, Pittsburgh, Pennsylvania.

IATA, 1995, *Dangerous Goods Regulations*, 36th edition, Resolutions 618 and 619, IATA Dangerous Goods Board, International Air Transport Association, Montreal, Canada.

ICAO, 1995, *Technical Instructions for the Safe Transport of Dangerous Goods by Air*, 1995-96 edition, DOC 9284-AN/905, International Civil Aviation Organization, Montreal, Canada.

Kelly, D. L., 1995a, *DOT-7A Type A Packaging Design Guide*, WHC-SD-TP-RPT-017, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Kelly, D. L., 1995b, *Test Plan for Westinghouse Hanford Company's 1-L Liquid Shipper, Docket 95-41-7A, Type A Container*, WHC-SD-WM-OTP-003, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Kelly, D. L. 1995c, *DOT-7A Packaging Test Procedure*, WHC-SD-TP-RPT-018, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Labelmaster, 1994, *Labelmaster Industrial Compliance Products*, 1994 General Catalog, No. G-800, Labelmaster is an American Labelmark Company, Chicago, Illinois.

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10.0 BIBLIOGRAPHY

Cruse, J. M., 1992, *Test and Evaluation Document for DOT Specification 7A Type A Packaging*, WHC-EP-0558, Rev. 3, Westinghouse Hanford Company, Richland, Washington.

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11.0 GLOSSARY

ABBREVIATIONS AND ACRONYMS

CG	center of gravity
DOT	U.S. Department of Transportation
DOT-7A	U.S. Department of Transportation Specification 7A Type A
ETFE	ethylene-tetrafluoroethylene
FEP	fluorinated ethylene propylene
FLPE	fluorinated high density polyethylene
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
PP	fluorinated polypropylene
STP	standard temperature and pressure
WHC	Westinghouse Hanford Company

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APPENDIX A

WESTINGHOUSE HANFORD COMPANY 1-L LIQUID SHIPPER

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Figure A-1. Approved 1-L Liquid Shipper Configuration.

DOT 7A Type A
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S9509055.1

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APPENDIX B

OPENING, LOADING, AND CLOSURE PROCEDURE FOR TESTING

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APPENDIX B

OPENING, LOADING, AND CLOSURE PROCEDURE FOR TESTING

B1.0 GENERAL INFORMATION

Please note that although the following procedure was used for opening, loading, and closing of the 1-L Liquid Shipper, a design modification was made to the packaging configuration during testing. The external fiberboard shipper is not authorized for use in the approved packaging configuration. Also, the 1-L, wide-mouth, bottle (Type #2 noted below) is not authorized for use in the approved packaging configuration.

Refer to Appendix A for the Westinghouse Hanford Company (WHC) 1-L Liquid Shipper configuration. The packaging to be tested consists of an outer fiberboard shipper, a SafeSend¹ container and lid, a 1-L internal bottle and lid, six foam inserts, and a plastic bag. Two different 1-L internal bottle types will be tested as noted below. For testing purposes, all internal bottles will be filled with simulated contents of water and carbon steel shot to simulate a liquid with a specific gravity of 2. Fluorescein will be added inside the bottles for ease of any leak detection.

Bottle Types:

- #1: A 1-L, narrow-mouth, Teflon², fluorinated ethylene propylene (FEP) bottle with a Tefzel³ ethylene-tetrafluoroethylene (ETFE) lid.
- #2: A 1-L, wide-mouth, fluorinated high density polyethylene (FLPE) bottle with a fluorinated polypropylene (PP) lid.

B2.0 SAFESEND CONTAINER

NOTE: The 3M SafeSend SP-R1L Kit comes with one SafeSend container, two plastic bags, and six foam inserts. In addition, the kit contains eight fiberboard shippers. Refer to the configuration in Appendix A when assembling the packagings to be tested.

¹SafeSend is a trademark of the 3M Company.

²Teflon is a trademark of E.I. du Pont de Nemours & Company.

³Tefzel is a trademark of E.I. du Pont de Nemours & Company.

NOTE: The SafeSend container has identification numbers located on the label to the right of the 3M instruction book and in the right corner of the red label on the cap. These numbers must be identical. Do not use if they are not identical.

B2.1 SAFESSEND CONTAINER - OPENING INSTRUCTIONS

1. Unlatch the SafeSend canister cap by pressing on the left side of the black latch. Unscrew the cap counterclockwise. Remove the plastic bag and foam inserts from inside the SafeSend canister.
2. Gather the appropriate number of foam inserts to be used for the appropriate configuration to be tested and place into the plastic bag supplied.
3. Set the SafeSend container, plastic bag, foam inserts, and a fiberboard shipper aside in a clean, dry location.

NOTE: For general storage of the SafeSend container, follow the manufacturer's supplied information. The lid of the SafeSend container should not be tightened such that the lid locking mechanism is engaged.

B2.2 SAFESSEND CONTAINER - CLOSURE INSTRUCTIONS

NOTE: For general storage of the SafeSend container, follow the manufacturer's supplied information. The lid of the SafeSend container should not be tightened such that the lid locking mechanism is engaged.

NOTE: The SafeSend container has identification numbers located on the label to the right of the 3M instruction book and in the right corner of the red label on the cap. These numbers must be identical. Do not use if they are not identical.

1. Thoroughly wipe the threaded area of the SafeSend canister base and lid with a lint-free cloth to remove any debris.
2. Screw the cap on the SafeSend canister clockwise until the latch can be seen and heard to lock into place. Do not force the lid beyond the locked position.

B3.0 INTERNAL BOTTLES

Two different 1-L bottles will be used for testing:

Type #1: A 1-L, narrow-mouth, Teflon, FEP bottle with a Tefzel ETFE lid.

Type #2: A 1-L, wide-mouth, FLPE bottle with a PP lid.

B3.1 BOTTLES - OPENING INSTRUCTIONS

1. Turn the lid counterclockwise until it can be removed.

B3.2 BOTTLES - CLOSURE INSTRUCTIONS

1. Wipe the bottle and lid with a dust-free cloth.
2. Place the lid onto the bottle.
3. Turn the lid clockwise until hand-tight.

B4.0 ASSEMBLY INSTRUCTIONS

B4.1 INTERNAL BOTTLES

1. Open bottle.
2. Fill the appropriate bottle to be used with the simulated contents as shown below.

Simulated Contents:

1 L	Fill each bottle with enough steel shot and water so that the total content weight is equal to 2000 g, leaving a 10 percent ullage. Add fluorescein for leak detection purposes.
3. Close the bottle until the lid is hand-tight.

B4.2 FINAL ASSEMBLY

1. Assemble one of the plastic bags, six foam inserts, and the closed 1-L bottle that has been filled with the simulated contents. Refer to Appendix A for this particular configuration.
2. Place one foam insert, flat side down, into the plastic bag. Four foam inserts are placed around the sides of the 1-L bottle in an interlocking pattern as shown in Figure B-1. Place this assembly on top of the existing foam insert that is in the bag. Place one foam insert on top of the lid of the bottle, inside the bag, with the flat side facing up.
3. Insert bag with contents assembled into the SafeSend canister.
4. Roll and tuck the end of the bag down into the SafeSend canister. Be careful to keep the bag away from threaded sealing area.

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5. Close the SafeSend container in accordance with the appropriate instructions.
6. Construct the fiberboard shipper box by folding the bottom box flaps in the sequence printed on the flaps, flap #1 first, and so on.
7. Use the tape on flap #3 to seal the box bottom, Remove liner from tape, located on top face of flap #3; and then close flap #4 on to flap #3, pressing firmly where the tape is located.
8. Place SafeSend canister in 3M fiberboard shipper box and fold the top box flap in the sequence printed on the flaps, flap #1 first, and so on.
9. Seal box cover as in Step #7 above.

Figure B-1. Foam Placement for 1-L Bottle.

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B5.0 GLOSSARY

ABBREVIATIONS AND ACRONYMS

ETFE	ethylene-tetrafluoroethylene
FEP	fluorinated ethylene propylene
FLPE	fluorinated high density polyethylene
PP	fluorinated polypropylene
WHC	Westinghouse Hanford Company

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APPENDIX C

PHOTOGRAPHS

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Photo C-1. Vibration Testing, Including Fiberboard Shipper.

Photo C-2. Water Spray Test, Including Fiberboard Shipper.
(41-TU-11 and 41-TU-12)

Photo C-3. Penetration Bar Drop, Including Fiberboard Shipper.
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Photo C-4. Fiberboard Shipper Delamination.

Photo C-5. 0.3-m (1-ft) Drop onto Each Corner of Fiberboard Shipper, CG.
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Photo C-7. Compression Test with Fiberboard Shipper.
(41-TU-11, 51-kg [112-lb])

Photo C-8. Vibration Test without Fiberboard Shipper.

Photo C-9. Water Spray Test without Fiberboard Shipper.
(41-TU-11 and 41-TU-17)

Photo C-10. Penetration Bar Drop (1-m [3.3-ft]) onto Locking Mechanism.
(41-TU-11)

Photo C-11. Penetration Bar Drop (1-m [3.3-ft]) onto Locking Mechanism.
(41-TU-11)

Photo C-12. Penetration Bar Drop (1.7-m [5.5-ft]) onto Center of Package.
(41-TU-11)

Photo C-13. Compression Test without Fiberboard Shipper.
(41-TU-11, 51-kg [112-lb])

Photo C-14. 1.2-m (4-ft) Drop.
(41-TU-15, Flat onto Bottom of SafeSend)

Photo C-15. 9-m (30-ft) Drop.
(41-TU-01, Flat onto Top of SafeSend)

Photo C-16. 9-m (30-ft) Drop.
(41-TU-03, Flat onto Bottom of SafeSend)

Photo C-17. 9-m (30-ft) Drop.
(41-TU-05, Flat onto Side at Locking Mechanism)

Photo C-18. 9-m (30-ft) Drop.
(41-TU-06, Flat onto Lid of SafeSend)

Photo C-19. 9-m (30-ft) Drop.
(41-TU-06, Flat onto Lid of SafeSend)

Photo C-20. 9-m (30-ft) Drop.
(41-TU-07, Top Corner at Locking Mechanism, CG)

Photo C-21. 9-m (30-ft) Drop.
(41-TU-07, Top Corner at Locking Mechanism, CG)

Photo C-22. 9-m (30-ft) Drop.
(41-TU-07, Wide-mouth Bottle)

Photo C-23. 9-m (30-ft) Drop.
(41-TU-09, Bottom Corner, CG)

Photo C-24. 9-m (30-ft) Drop.
(41-TU-10, Drop Flat onto Side of SafeSend; Wide-mouth Bottle)

Photo C-25. 9-m (30-ft) Drop.
(41-TU-10, Wide-mouth Bottle)

Photo C-26. 9-m (30-ft) Drop.
(41-TU-18, Drop Flat onto Side of SafeSend; Wide-mouth Bottle)

Photo C-27. 9-m (30-ft) Drop.
(41-TU-18, Drop Flat onto Side of SafeSend; Narrow-mouth Bottle)

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