TEST AND EVALUATION DOCUMENT FOR U.S. DEPARTMENT OF TRANSPORTATION SPECIFICATION 7A TYPE A PACKAGING

(DOE/RL-96-57, VOLUME 2, REV. 0-D)

Note: This is a living document, new information will be added to this document as it becomes available.

PREFACE

The U.S. Department of Energy (DOE) has been conducting, through several of its operating contractors, an evaluation and testing program to qualify Type A radioactive material packagings per U.S. Department of Transportation Specification 7A (DOT-7A) of the Code of Federal Regulations, Title 49, Part 178, Section 178.350[(1)] (49 CFR 178.350). This program is called the DOT-7A Program. The DOT-7A Program is currently administered by the DOE, Office of Safety, Health and Security, DOE/EM-05, at DOE Headquarters in Germantown, Maryland.

Two volumes of DOE's Test and Evaluation Document (DOE/RL-96-57) exist. **Volume 1** was released in August 1996, and is identified as formerly being WHC-EP-0558, Rev. 3 (WHC 1992). Volume 1 contains approximately 300 different packagings that have been determined to meet requirements for DOT-7A Type A packaging since 1987. All packagings presented in Volume 1 were tested and/or evaluated to be in compliance with DOT-7A packaging requirements in effect after June 30, 1983.

Volume 2 was developed because of regulatory changes within 49 CFR, and due to the extreme size of the Volume 1 document. Volume 2 contains packagings that have been tested and evaluated through DOE's DOT-7A Program since 1996 as meeting the requirements of 49 CFR 178.350. All packagings presented in Volume 2 were tested and/or evaluated to be in compliance with DOT-7A packaging requirements in effect after April 1, 1996.

The specific packaging data contained in this document will serve to meet the requirements of 49 CFR 173.415(a) for "...documentation of tests ..." when the packagings are used as prescribed herein. However, shippers are cautioned that additional documentation will be needed to fulfill all of the requirements for a particular shipment; most importantly that the contents to be shipped have been evaluated for compatibility with the packaging and that their characteristics have been bounded by the simulated contents used in qualification testing.

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LIST OF TERMS

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CFR	Code of Federal Regulations
cm	centimeters
DOE	U.S. Department of Energy
DOE-HQ	U.S. Department of Energy-Headquarters
DOT	U.S. Department of Transportation
DOT-7A	DOT Specification 7A
F	Fahrenheit
ft	foot/feet
HDPE	high-density polyethylene
in.	inch
kg	kilogram
kPa	kilopascal (1 atmosphere=14.7 psig=1 bar=100kPa)
lb	pound
m	meter
mm	millimeter
NRC	U.S. Nuclear Regulatory Commission
psia	pounds per square inch absolute
psig	pounds per square inch gauge
RFP	request for proposal
RL	Richland Operations Office
WHC	Westinghouse Hanford Company
WMNW	Waste Management Federal Services, Inc., Northwest Operations
WMTS	Waste Management Technical Services

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1. DOT, 1998, "Transportation," Title 49, Code of Federal Regulations, Part 178, U.S. Department of Transportation, Washington, D.C.

DOE/RL-96-57, Rev. 0-F, Vol. 1

TEST AND EVALUATION DOCUMENT FOR THE U.S. DEPARTMENT OF TRANSPORTATION SPECIFICATION 7A TYPE A PACKAGING

(Formerly WHC-EP-0558, Rev. 3)

PREFACE

The U.S. Department of Energy (DOE) has been conducting, through several of its operating contractors, an evaluation and testing program to qualify Type A radioactive material packagings per U.S. Department of Transportation Specification 7A (DOT-7A) of the Code of Federal Regulations, Title 49, Part 178, Section 178.350[(1)] (49 CFR 178.350). This program is called the DOT-7A Program. The DOT-7A Program is administered by the DOE, Office of Transportation, Emergency Management, and Analytical Services, DOE/EM-76, at DOE Headquarters in Germantown, Maryland.

This document presents approximately 300 different packagings that have been determined to meet the requirements for a DOT-7A, Type A packaging per 49 CFR 178.350. The original program document was prepared in 1987 by Monsanto Research Corporation - Mound Laboratory for the DOE's Security Evaluation Program to facilitate the regulation changes implemented by HM-169. The Mound document has commonly been called the "Red Book."

In September 1989, the program was transferred to Westinghouse Hanford Company (WHC), located at the Hanford Site near Richland, Washington. In 1992, the "Red Book" was replaced in its entirety by a new program document, WHC-EP-0558, or the "Blue Book." Revision 3 was the last issued revision of the WHC document. In fiscal year 1996, the Hanford Site began undergoing contractual changes. In June 1996, it was decided at that the next revision to the *Test and Evaluation Document for DOT Specification 7A Type A Packagings* would be identified as a DOE, Richland Operations (RL) document. This RL document (DOE/RL-96-57, Rev. 0, Volume 1) incorporates all the packagings that were included in the WHC document (WHC-EP-0558, Rev. 3), as well as three additionally approved, tested, and evaluated packagings.

The specific packaging data contained in this document will serve to meet the requirements of 49 CFR 173.415(a) for "...documentation of tests ..." when the packagings are used as prescribed herein. However, shippers are cautioned that additional documentation will be needed to fulfill all of the requirements for a particular shipment; most importantly that the contents to be shipped have been evaluated for compatibility with the packaging and that their characteristics have been bounded by the simulated contents used in qualification testing.

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LIST OF TERMS

ACGLF	adjustable center of gravity lift fixture
AE	Argonne National Laboratory - East
ANL-E	Argonne National Laboratory - East
ANL-W	Argonne National Laboratory - West

ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
AW	Argonne National Laboratory - West
Battelle	Battelle Columbus Laboratory
Btu	British thermal unit
C	Celsius
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
DOE-HQ	U.S. Department of Energy-Headquarters
DOT	U.S. Department of Transportation
DOT-7A	DOT Specification 7A
EPDM	Ethylene/Propylene/Diene
ETFE	ethylene-tetrafluorethylene
F	Fahrenheit
FEMA	Federal Emergency Management Agency
FEP	fluorinated ethylene propylene
FKM	Fluorocarbon Rubber
FM	Feed Materials Production Center
FMPC	Feed Materials Production Center
gal	gallon
HDPE	high-density polyethylene
HEPA	high-efficiency particulate air
HF	Hanford, Richland, Washington
INEL	Idaho National Engineering Laboratory
kg	kilogram
kPa	kilopascal (1 atmosphere=14.7 psig=1 bar=100kPa)
L	liter
LANL	Los Alamos National Laboratory
LL	Lawrence Livermore National Laboratory
LLNL	Lawrence Livermore National Laboratory
MD	Mound Laboratory
mil	0.001 inches
mL	milliliter
MLM	Mound Laboratory
MMES	Martin Marietta Energy Systems
MS	military specification
NDE	nondestructive examination
NFTI	Nuclear Filter Technology, Inc.
NLO	National Lead Corporation
NPT	National Pipe Thread
NRC	U.S. Nuclear Regulatory Commission
OR	Oak Ridge National Laboratory
ORNL	Oak Ridge National Laboratory
Pa	pascal

psi	pounds per square inch
psia	pounds per square inch absolute
psig	pounds per square inch gauge
PVC	polyvinylchloride
RF	Rocky Flats Plant
RFP	request for proposal
RH	Hanford, Richland, Washington
RTV	room temperature vulcanizing
SNR	Schenectady Naval Reactors Office
Spec	specification
SR	Savannah River Plant and Laboratory
SRP	Savannah River Plant and Laboratory
SWB	standard waste box
TDOP	Ten-Drum Overpack
TRUPACT	transuranic package transporter
UN	United Nations
UV	ultraviolet
Westinghouse	Hanford Westinghouse Hanford Company
WHC	Westinghouse Hanford Company
WIPP	Waste Isolation Pilot Plant
WMCO	Westinghouse Materials Company of Ohio
WRAP-1	Waste Receiving and Processing Facility, Module 1
WVNS	West Valley Nuclear Services

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1. DOT, 1995, "Transportation," Title 49, Code of Federal Regulations, Part 178, U.S. Department of Transportation, Washington, D.C.

Privacy & Security Notice

TEST AND EVALUATION DOCUMENT FOR U.S. DEPARTMENT OF TRANSPORTATION SPECIFICATION 7A TYPE A PACKAGING (VOLUME 2)

1.0 INTRODUCTION

The U.S. Department of Energy (DOE) has been conducting, through several of its operating contractors, an evaluation and testing program to qualify Type A radioactive material packagings per U.S. Department of Transportation (DOT) Specification 7A (DOT-7A) of the Code of Federal Regulations (CFR), Title 49, Part 178 (49 CFR 178). The program is currently administered by the DOE, Office of Safety, Health, and Security, DOE/EM-05, at DOE-Headquarters (DOE-HQ) in Germantown, Maryland.

This document (Vol. 2) summarizes the evaluation and testing performed for all of the packagings successfully qualified in this program since 1996.

Two volumes of DOE's Test and Evaluation Document (DOE/RL-96-57) exist. **Volume 1** was released in August 1996, and is identified as formerly being WHC-EP-0558, Rev. 3. Volume 1 contains approximately 300 different packagings that have been determined to meet requirements for DOT-7A Type A packaging per 49 CFR 178.350 since 1987.

Volume 2 was developed because of regulatory changes within 49 CFR, and due to the extreme size of the Volume 1 document. Volume 2 contains packagings that have been tested and evaluated through DOE's DOT-7A Program since 1996.

Evaluation and testing activities on one DOE DOT-7A Program Docket resulted in the qualification of four new packaging configurations, which are incorporated herein and summarized in Table 1-1 below.

Table 1-1. New Packaging Configurations

1.1 PURPOSE AND SCOPE

The purpose of this document is to provide technical documentation of the evaluation and testing activities

successfully completed to qualify a number of packagings to the requirements of DOT-7A (49 CFR 178.350). The packagings described herein are considered acceptable for transport of Type A quantities of radioactive material subject to the applicable restrictions and specifications.

This document is not intended to supply all of the information necessary for the fabrication of the identified DOT-7A packagings. The drawings in the document are for illustrative purposes and are intended to assist the reader in selecting a packaging meeting the requirements for the material to be shipped. If one desires to fabricate one of the packagings in the document, the primary user or custodian of that packaging should be contacted for the information.

The specific packaging data contained in this document will serve to meet the requirements of 49 CFR 173.415(a) for ". . . documentation of tests . . ." when the packagings are used as prescribed. In addition to the documentation of tests, the shipper must maintain on file, other appropriate data applicable to the shipment, such as the following:

- Evaluation of the properties of the actual contents to be shipped for compatibility with the packaging
- The Quality Control Program and its implementation.

Therefore, it is apparent that this document does not "stand alone" for all the documentation needed when offering a package for transportation. The shipper is responsible in many areas for ensuring that the loaded package is acceptable.

Changes in technology and in the mission of the various DOE facilities and contractors will generate the need for new packaging designs on a continuing basis. If a new design is needed (i.e., not currently covered in this document), contact one of the DOT-7A Program administrative or technical contacts listed in Sections **1.1.1** and **1.1.2**, respectively, for assistance on qualifying a new packaging.

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1.1.1 Administrative Contacts

The DOT-7A Program is currently administered by the DOE, Office of Safety, Health, and Security, DOE/EM-05, at DOE-HQ in Germantown, Maryland. The responsible person is as follows:

M. E. Wangler
202-586-7976
e-mail: mike_wangler@em.doe.gov

Any organization wishing to have a packaging qualified in this program should contact one of the persons listed above.

1.1.2 Technical Contacts

Duratek Federal Services Inc., Northwest Operations Packaging Engineering, is currently conducting the evaluation and testing activities. The persons responsible for these activities are as follows:

J. A. Reeves
509-376-0781

D. L. Kelly
509-372-2276

Please contact one of the persons listed above with any technical questions or any questions regarding dockets that have been established in the program.

The program has a great deal of experience with designs and materials that adequately perform to the requirements.

The normal approach to qualification of a new packaging design is to develop the design and operational documentation, review this documentation, and expose several test units to the Type A packaging tests (49 CFR 173.465 and 173.466). If the packaging performs adequately, it will be approved for use and included in this document at the next revision.

1.2 RESPONSIBILITIES

There are a number of specific functions that must be performed to ensure that a DOT-7A package is properly prepared for safe transport and in full compliance with the applicable regulations. The affiliation or the specific arrangements between the designer, manufacturer, and user should be adequately described and understood.

The following paragraphs discuss specific responsibilities.

1.2.1 The U.S. Department of Energy

The Packaging Certification Staff of DOE/EM-05 is responsible for the administration of the DOT-7A Program. This includes approval authority for all of the various program documents, requests for evaluation and testing of new packagings, and approval of their qualification. General programmatic direction is also under the control of DOE/EM-05.

1.2.2 Shipper

Shippers of Type A quantities of radioactive material are generally responsible for all aspects of the shipment. It is DOE policy to fully comply with the regulations for such shipments as established in 49 CFR 173. Normally the shipper will be able to locate an acceptable packaging, which places primary emphasis on ensuring compatibility with contents and correctness in operations.

1.2.3 Manufacturer

The manufacturer of a DOT-7A Type A packaging, which is covered in this document or otherwise authorized for use within the DOE system, is responsible for using materials, fabrication methods, manufacturing, and quality controls to ensure that the packaging is equivalent to the specified design. No design changes, substitutions, or changes in fabrication methods or controls are authorized without the approval of DOE/EM-05.

1.2.4 Testing Laboratory

The testing laboratory is responsible for evaluation and testing of new DOT-7A packaging designs based on the direction of DOE/EM-05. This process involves review of the applicants' design data, inspection of the test unit packages, performance of the Type A packaging tests, and documentation of the results. Duratek Federal Services Inc., Northwest Operations is currently performing this function for DOE/EM-05 in addition to maintaining and distributing the various DOT-7A Program documents.

1.3 APPLICABLE U.S. DEPARTMENT OF TRANSPORTATION REGULATIONS

The DOT regulations for shipping hazardous materials are located in 49 CFR, Parts 100-499. Copies of these regulations can be obtained from the Government Printing Office or other sources. The packagings described herein have been qualified to meet DOT-7A (49 CFR 178.350) for Type A packagings. Specification 7A is a general specification and invokes the applicable requirements of 49 CFR 173, Subparts A, B, and I.

Some of the important regulations affecting shipments of Type A quantities of radioactive material are summarized in the following paragraphs. The primary sections of 49 CFR applicable to Type A packaging requirements are as follows:

173.21	**Forbidden materials and packages**
173.22	**Shipper's responsibility**
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**
173.403	**Definitions**
173.410	**General design requirements**
173.412	**Additional design requirements for Type A packages**
173.415(a)	**Authorized Type A packages; DOT Specification 7A**
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 Class 7 (radioactive) materials**
178.3	**Marking of packagings**
178.350	**Specification 7A; general packaging, Type A**
178.608	**Vibration standard.**

1.3.1 Contents Characterization

Specification 7A packagings are qualified for transporting Type A quantities of radioactive material. Characterization of contents for compatibility with the selected packaging is an important aspect of any shipment and is primarily the responsibility of the shipper. The regulations address this area with a number of items, which are summarized in the following paragraphs.

1.3.1.1 Radiological. The following sections in 49 CFR 173, Subpart I address the radiological characteristics of the material to be shipped:

173.417	**Authorized fissile materials packages**
173.431	**Activity limits for Type A and Type B packages**
173.433	**Requirements for determining A_1 and A_2 values for radionuclides and**

	for the listing of radionuclides on shipping papers and labels
173.441	**Radiation level limitations**
173.453	**Fissile materials--exceptions**
173.459	**Mixing of fissile material packages.**

The shipper must characterize the payload as needed to determine compliance with these requirements.

CAUTION: Testing by the DOE-approved test facility is generally conducted by using a uniform distributed load. Therefore, no consideration is given to point sources being in the package. It is the responsibility of the shipper to use the damage information provided for each packaging configuration tested and documented herein to determine if a significant change in radiation level would result for a specific load. Note that point sources within the load require that the shipper use extreme caution.

NOTE: The shipper must ensure that the radiation level at any surface would not increase by more than 20 percent as a result of the decrease in distance to the center of the package load [TS-R-1 (ST-1, Revised)]. The internal load and shifting of contents needs to be considered and taken into account during transport.

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1.3.1.2 Physical Form**.** The physical form of the material has a direct and an indirect effect on the applicability of a number of requirements. For example, the form affects the density of the material, which will affect the gross weight, which affects the requirements invoked for package handling features. In the DOT-7A Program, solid materials are classed into one of three Material Forms (Forms) as follows:

- Form Number 1: Solids--any particle size

- A packaging qualified for these contents is expected to contain radioactive contents of any representative particulate size.

- Form Number 2: Solids--large particle size only (i.e., sand, concrete, debris, soil)

- Contents of a corresponding particulate size such as soil or construction debris. (Glass or plastic labware having fine particulate available for dispersion would not fit this category and would require a packaging qualified for fine particulate, Form Number 1.)

- Form Number 3: Solids--objects with no significant dispersible or removable contamination (for definition, see 49 CFR 173.443, "Contamination control").

- Metals with activation products

- Forms of metals/alloys/compounds of uranium, thorium

- Solid materials with the radioactive material firmly fixed in place, possibly by the application of a fixing media (i.e., paint)

- Solidified material.

NOTE: These are examples only and each form must be analyzed for compliance with the "no removable or dispersible contamination" criterion found in 49 CFR 173.443.

Packagings intended to transport liquids and gases must be designed to withstand more severe test conditions than those designed for solids.

1.3.1.3 Thermal**. The following sections in 49 CFR address the thermal limitations and requirements applicable to packagings:**

173.410(i)	**Air shipments, containment and shielding--temperature range**
173.412(c)	**Containment and shielding--temperature range**
173.442	**Thermal limitations**
173.448(b)	**Heat output.**

The thermal heat generation of the contents, for whatever reason, must not degrade the packaging. Normally, Type A quantities of radionuclides do not generate enough decay heat to be of concern. If there is any doubt, the decay heat should be calculated and the package design analyzed to ensure no problems.

1.3.1.4 Chemical**. The following sections of 49 CFR pertain to the chemical characteristics of the contents:**

173.21	**Forbidden materials and packages**
173.24(b)(3)	**Mixture, reaction**
173.24(e)(2)	**Reaction**
173.24(e)(3)	**Plastic compatibility/permeability**
173.24(f)	**Closures, gaskets**
173.410(g)	**Compatibility, behavior under irradiation**
173.412(e)	**Gas generation, radiolysis.**

The contents must not react with the packaging so as to degrade it and must not develop chemical conditions which could lead to an explosion. The basic chemical makeup of the nonradioactive constituents of the contents to be shipped must be understood in order to adequately design a packaging.

1.3.2 Packaging Design

The following sections of 49 CFR address the regulatory requirements primarily applicable to the design of a Type A packaging:

173.24(b)	**Design and construction**
173.24(e)(3)	**Plastic packagings and receptacles**
173.403	**Definitions**
173.410	**General design requirements**
173.412	**Additional design requirements for Type A packages**
173.462(c)	**Containment system . . . specified**
173.462(d)	**External features . . . clearly identified**
178.3	**Marking of packagings.**

The packagings identified in this document have been designed and qualified to meet these requirements for transporting contents as shown in the subsequent sections. The following paragraphs are intended to summarize the design-related requirements.

1.3.2.1 General Arrangement**.** The packaging design will generally fall into one of three basic configurations: (1) single packaging, (2) composite packaging, or (3) combination packaging (see definitions 49 CFR 171.8). Single packagings are generally recommended for solids meeting the definition of Form Number 2 or Form

Number 3, or gases. For packaging of solids classed as Form Number 1 and liquids, composite or combination packagings are recommended.

1.3.2.2 Containment**.** The following sections of 49 CFR that pertain directly to containment of contents are as follows:

173.24(b)	**Design and construction**
173.24(e)(2)	**Reaction**
173.24(e)(3)	**Plastic packagings and receptacles**
173.24(f)	**Closures and gaskets**
173.410(i)	**Air shipments, containment and shielding--temperature range**
173.412(j)(1)	**Loss or dispersal**
173.462(c)	**Containment system . . . specified**
173.469(a)(4)	**Leaktightness.**

Basically, there can be "no significant release of the hazardous materials to the environment," and the packaging must remain effective when subjected to normal conditions of transport, with account being taken for any reactions between the contents and the packaging materials. In practice, "no significant release," implies no measurable leakage based on visual evaluation.

Containment is formed by those materials or components that are or may be in direct contact with the contents during shipment. The design process will involve choices of basic material, use of filters or other pressure relief devices, gaskets or other seal materials, closure mechanisms, and other features. Typical containment materials are high-density polyethylene (HDPE), polypropylene, glass, and steel.

1.3.2.3 Shielding**. The following sections of 49 CFR address shielding design of Type A packagings:**

173.412(c)	**Temperature (-40 to 70 °C [-40 to 158 °F]), brittle fracture**
173.412(h)	**Shielding/containment interface**
173.412(j)(2)	**Significant increase in radiation**
173.441	**Radiation level limitations.**

Shielding may be required for Type A quantities of radionuclides. Lead or steel are commonly used materials for shielding. The regulations require that the shielding and containment system remain intact and effective when subjected to normal conditions of transport.

1.3.2.4 Lifting and Handling**. The following sections of 49 CFR address the design of lifting and handling features of Type A packagings:**

173.410(a)	**Handling, securing**
173.410(b)	**Lifting attachments.**

The exterior design of the packaging shall meet the above requirements.

1.3.2.5 Tiedown**. The following sections of 49 CFR directly address the design of tiedown features of Type A packagings:**

173.410(a)	**Handling, securing**
173.412(i)	**Tiedown, failure.**

Package tiedown features and equipment shall be designed to comply with these requirements.

1.3.3 Package Qualification and Testing

Type A packagings must be designed to withstand the tests delineated in 49 CFR 173, Sections 173.465 and/or 173.466 as applicable. Section 173.461 addresses the methods by which compliance with these requirements may be addressed. The DOT-7A Program typically demonstrates acceptable performance by exposing several prototype test units to the test conditions. The tests that are performed are described briefly below.

1.3.3.1 Reduced Pressure Test [49 CFR 173.412(f)]**.** The reduced pressure test is intended to simulate the reduction of ambient (external) pressure to the package to 25.0 kPa (3.6 psia). This may be achieved by pressurizing the internal cavity of the packaging to 78.0 kPa (11.3 psig), or by placing an empty but closed packaging into a chamber that can be evacuated to 25.0 kPa (3.6 psia). In both cases, leak detection by visual identification of loss of material, gas pressure drop, gas bubble, soap bubble, or other method sensitive to 10^{-3} standard cubic centimeters per second will typically be used.

1.3.3.2 Water Spray Test [49 CFR 173.465(b)]**.** The water spray test simulates exposure to rainfall of approximately 5 cm (2 in.)/hour for at least one hour. This test must precede each of the other tests or test sequences described in 49 CFR 173.465. 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 package. The time interval is two hours if the spray is applied from four different directions simultaneously. Other tests will follow immediately if the spray is applied from each of the four directions consecutively.

1.3.3.3 Stacking Test [49 CFR 173.465(d)]**.** The stacking test lasts for a period of at least 24 hours. The compressive load is equivalent to either five times the weight of the actual package or 13 kPa (1.9 lb/in^2) multiplied by the vertically projected area of the package, whichever is greater. The load is applied uniformly to two opposite sides of the package, one of which must be the base on which the package would normally stand.

1.3.3.4 Penetration Test [49 CFR 173.465(e) and 173.466(a)(2)]. The package is placed on a rigid, flat, horizontal surface. A bar (penetration bar) 3.2 cm (1.25 in.) in diameter with a hemispherical end, weighing 6 kg (13.2 lb), with its longitudinal axis vertical, is dropped onto the center of the weakest part of the package, so that, if it penetrates far enough, it will hit the containment system. The bar must not be deformed by the test.

The distance of the fall of the bar is measured from its lower end to the upper surface of the package. The determination of this distance depends on the basic physical form of the contents for which the packaging is designed. The penetration drop height for packagings designed to contain only solids is 1 m (3.3 ft). This distance is 1.7 m (5.5 ft) for packagings designed to contain liquids and/or gases.

1.3.3.5 Free Drop Test [49 CFR 173.465(c) and 173.466(a)(1)]**.** The free drop test consists of a free-fall onto a flat, horizontal, rigid surface. The orientation of the test package is such that the fall will cause maximum damage to the package and its safety features. The distance of the fall will be measured from the lowest part of the packaging to the upper surface of the target. The distance of the fall is determined by the gross weight of the packaging, packaging material type, and material form to be shipped.

1.3.3.6 Vibration Standard [49 CFR 178.608]**.** Three randomly selected sample packagings are filled and

closed as for shipment. The sample packagings are placed on a vibrating platform that has a vertical or rotary double-amplitude (peak-to-peak displacement) of 2.54 cm (1 in.). The packages should be constrained horizontally to prevent them from falling off the platform, but must be free to move vertically, bounce, and rotate.

The test must be performed for at least one hour at a frequency that causes the package to be raised from the vibrating platform so that a piece of material of approximately 1.6-mm (0.063-in.) thickness can be passed between the bottom of any package and the platform.

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.

1.3.3.7 Demonstration of Compliance With Tests**.** Following the test sequences, which expose the prototypes to the applicable tests, the performance of the packaging is evaluated. If determined acceptable, the packaging is approved for use by DOE/EM-05 and included in this document.

1.4 USE OF TYPE B PACKAGINGS

The U.S. Nuclear Regulatory Commission (NRC)-approved Type B packagings may be used to transport Type A quantities of radioactive materials provided applicable requirements are met. The NRC provided some clarification regarding such use of NRC-approved Type B packagings in Information Notice 90-82 dated December 31, 1990 (NRC 1990). This information is summarized in the following paragraphs.

The NRC and DOT share primary responsibility for approving package designs for transportation of radioactive materials within the United States. The NRC regulations for the transportation of radioactive materials are codified in 10 CFR Part 71, "Packaging and Transportation of Radioactive Material." The DOT's hazardous materials regulations, which include radioactive material, are codified in 49 CFR Parts 100-199. Requirements for shippers of radioactive materials are given in 49 CFR 173.400 through 173.478. In addition, a provision in the NRC regulations, 10 CFR 71.5, requires that NRC licensees comply with DOT's hazardous materials regulations.

In general, pursuant to 10 CFR Part 71, the NRC approves package designs for shipment of fissile and greater-than-Type A quantities of radioactive material. The design for packages up to Type A quantities is subject to the requirements of DOT in 49 CFR Part 173.

In authorizing the use of NRC-approved packages for transportation of Type A quantities of radioactive material, DOT regulations specify, in 49 CFR 173.415, that certain conditions be met. One condition (49 CFR 173.471) is that the shipment of the package be made in compliance with the terms of the NRC certificate of compliance (certificate). For example, a radiographic source changer authorized for a Type B quantity of a specific radionuclide in special form is also authorized for a Type A quantity of the same specific radionuclide in special form, provided that all the terms and conditions of the certificate are met. Note that NRC approvals include the type and form of material, the maximum quantity of material per package, and the operating instructions and maintenance procedures for the package.

Alternately, an NRC-approved package may be shipped under the provisions of 49 CFR 173.415(a) as a DOT-7A package. In this instance, the shipper (if requested) must provide DOT with 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 DOT-7A. The shipper is required to maintain this documentation on file for at least one year after the latest shipment. Thus, a radiographic source changer approved by NRC for shipment of a specific radionuclide in special form could be used to ship a

Type A quantity of a different nuclide, provided that the package is re-evaluated under the provisions of 49 CFR 173.415(a).

When an NRC-approved package is used as a DOT-7A package, the NRC package identification marking should be covered and new markings ("USA DOT-7A TYPE A" and "radioactive material") affixed to the package, pursuant to 49 CFR 173.415(a).

Users of the NRC-approved packages should be aware of the requirements for using NRC-approved packages for low-level radioactive materials exempted under 10 CFR 71.10. In particular, users of NRC-approved packages should:

- Determine what provision of 49 CFR 173.415 applies
- Comply with all requirements in 49 CFR 173.415(a) and 49 CFR 178.350 when the shipment is made pursuant to 49 CFR 173.415(a). Note that the use of an NRC-approved package pursuant to 49 CFR 173.415(a) requires that the package be re-evaluated as a DOT-7A Type A package, and that the shipper maintain the evaluation on file for one year after the last shipment
- Comply with all terms and conditions in the NRC certificate when the shipment is made pursuant to 49 CFR 173.415(c).

1.5 PROCUREMENT

Normally DOE shippers will procure complete packagings or components of packagings from commercial suppliers to satisfy shipment needs. The DOE/EM-05 recommends that any packaging procurement be conducted in two basic steps:

1. Obtain from the packaging supplier the documentation that will demonstrate compliance with the requirements (i.e., drawings, specifications, etc.) and perform a technical review.
2. Upon acceptance of the documentation (i.e., all comments satisfactorily resolved), release the supplier to manufacture the packagings or components.

Procurement of the packagings identified herein or their components will involve preparation of a technical specification followed by execution of the normal process used for procuring equipment or components. The following paragraphs summarize this process.

1.5.1 Specification Development

The shipper should prepare a technical specification for the packaging or component to be supplied that includes, as a minimum, any technical requirements specified in this document. The specification should also identify any other deliverables desired and the requirements applicable to each. When the specification is complete, the shipper normally will prepare a purchase requisition, which will accompany the specification, to initiate the formal procurement process.

1.5.2 Request for Proposals

The first formal step in the procurement process is preparation of a purchase requisition and the subsequent issuance of a request for proposal (RFP). The procurement package will include the completed specification, schedule requirements, and other pertinent technical information such as technical evaluation criteria, technical proposal instructions to bidders, etc. Upon completion and management approval of the purchase requisition and the specification, the shipper should contact the purchasing organization at the site or facility

to coordinate the RFP process. The buyer who is the cognizant purchasing representative will become the focal point in the process of negotiating with potential suppliers.

1.5.3 Order Placement

Normally several or more suppliers will respond to the RFP. This will initiate a selection process for determining the candidate who will supply acceptable deliverables for the lowest cost. The selection process will normally involve the shipper's technical review of each of the proposals and procurement department review including cost and price analysis. Upon completion of the reviews, a supplier (the seller) will be selected and the order placed.

1.5.4 Documentation Review and Approval

The next major action for the shipper will be to review any seller-provided documentation such as drawings, specifications, analyses, manufacturing processing instructions, and quality control processes. Upon acceptance of this data, the supplier will be released to manufacture the components or packagings per the purchase order.

1.5.5 Packaging Manufacturing and Delivery

The seller will manufacture the fleet packagings as specified in the purchase order when released by the buyer. When complete, the packagings will be delivered to the shipper's facility for receiving inspection and use.

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1.6 PACKAGING OPERATIONS

Packaging operations involve assembling the packaging, loading the contents, closing the package, and preparing for shipment. The operating instructions for a packaging are the primary vehicle for the shipper to maintain control on the assembly, loading, and closure processes for a packaging and its preparation for shipment and other items. Accordingly, shippers are requested to ensure that the operating instructions for the packaging system to be used implement the operational requirements discussed in the following paragraphs.

The operating instructions should consist of the following primary elements:

- Packaging description
- Authorized contents
- Preloading inspections
- Loading procedure
- Preparation for shipment
- Preshipment inspections
- Shipment requirements
- Unloading procedure
- Reuse/reconditioning (if applicable).

The packaging description and authorized contents sections should be similar to the material for a packaging included herein.

The shipper should determine, per the requirements identified by 49 CFR, the preloading inspections to be performed and the acceptance criteria considered necessary to ensure that the packaging complies and that

adequate quality control is implemented.

173.474	**Quality control for construction of packaging**
173.475	**Quality control requirements prior to each shipment of Class 7 (radioactive) materials.**

The loading procedure should address all operations necessary to correctly assemble the packaging components, load the contents, and close the packaging.

The section addressing preparation for shipment should address labeling and placarding requirements (49 CFR, Part 172, Subpart E and Subpart F) and any other applicable requirements. If the package must be secured to the conveyance in a particular fashion, this should also be specified in a subsection to be entitled, "Tiedown."

The section(s) addressing preshipment inspections should address verifications for compliance with the following requirements within 49 CFR:

173.441	**Radiation level limitations**
173.442	**Thermal limitations**
173.443	**Contamination control**
173.474	**Quality control for construction of packaging**
173.475	**Quality control requirements prior to each shipment of Class 7 (radioactive) materials.**

The section addressing shipment requirements should address requirements and procedures applicable when the package is en route to its destination. For example, the requirements of 49 CFR 173.447, "Storage incident to transportation," should be addressed in this section.

The unloading procedure should detail all steps necessary to safely unload the package from the conveyance and for unloading the contents from the packaging.

If the packaging may be reused, the operating instructions should include procedures for reconditioning the packaging to a state that will meet the design requirements established in the drawing and specification.

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1.7 QUALITY ASSURANCE

The quality assurance program implemented by the shipper's organization must implement actions to provide adequate confidence that the shipments will comply with the regulations. The DOE Order 414.1A (DOE 1999) includes general quality elements to be considered in development of the shippers quality program. Shippers are cautioned to invoke only the quality requirements applicable to Type A packaging and transportation.

The following regulatory requirements address quality control applicable to Type A packagings:

173.474	**Quality control for construction of packaging**
173.475	**Quality control requirements prior to each shipment of Class 7 (radioactive) materials.**

The shipper is responsible for ensuring that the packaging materials, components, and arrangement are in

accordance with the qualified design as documented herein. The shipper is also responsible for ensuring that the packaging is assembled, loaded (with compatible contents), closed, and prepared for shipment properly.

The DOE/EM-05 recommends that quality control be implemented as needed for the shipper to ensure compliance with the regulations. This is considered best achieved at three possible points in the packaging operation process:

1. Receiving inspections for procured packagings or components. The inspections should be of adequate scope and detail to ensure that the supplied hardware complies with the qualified design.
2. Preloading inspections to be performed prior to assembly and loading of the packaging. These inspections should verify that no packaging components have been damaged or altered and the arrangement is in accordance with the qualified design.
3. Preshipment inspections to be performed prior to shipment. This final inspection should verify that the assembled package, its marking and labeling, and its tiedown arrangement (if applicable) are correct. Further, preshipment inspections should address verifications for compliance with the following requirements:

173.441 Radiation level limitations
173.442 Thermal limitations
173.443 Contamination control.

The data presented for specific packagings in this document includes applicable quality control elements. This data should be used for guidance in implementing the inspections mentioned above.

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2.0 STEEL DRUMS

2.1 Myers Model G5501, UN1A2, 208-L, Galvanized Drum With High-Density Polyethylene Liner

2.2 Myers Model 5526, UN1A2, 208-L, Painted Drum

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2.1 MYERS MODEL G5501, UN1A2, 208-L, GALVANIZED DRUM WITH HIGH-DENSITY POLYETHYLENE LINER (DOCKET: 96-44-7A, 5/98)

Figure 2-1: Myers Model G5501 Drum

2.1.1 Package Description

Table 2.1-1. Authorized Configurations.

Table 2.1-2. Dimensions.

Table 2.1-3. Materials/Method of Construction.

2.1.2 Authorized Contents

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 DOT-7A Compliance with the actual contents.

2.1.2.1 Physical Form and Maximum Gross Weight

Solids Only. Three forms are authorized. Each shipper must determine the most appropriate form for the particular contents to be shipped, and comply with any special requirements.

- Material Form No. 1: Solids—any particle size.
- Material Form No. 2: Solids—large particle size only (e.g., sand, concrete, debris, soil, etc.).
- Material Form No. 3: Solids—objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)

Maximum Gross Weight. All forms 408 kg (900 lb).

2.1.2.2 Chemical Form

The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

2.1.2.3 Radiological

Four drums underwent a total of five drop tests as identified in **Table F-8**. Following is a summary of the damage that occurred to the test units during the 1.2-m (4-ft) drop test. The damage that occurred during the drop flat onto the side of the drum at the welded seam and at the bolt and filter locations caused the drum to

indent a distance of 29.21-cm (11.5-in.) across the bottom of the drum. The drum pushed inward 5.08-cm (2-in.) along the bottom, and flattened a distance measuring 25.40-cm (10-in.) by 10.16-cm (4-in.) along the bottom rolling hoop. The damage that occurred during the drop onto the top of the drum at the bolt and filter locations, center-of-gravity over the impact point, caused an indentation measuring 44.45-cm (17.50-in.) across. The drum pushed outward 1.27-cm (0.50-in.) along the top rolling hoop due to the bolt being pushed down into the drum. Two drop tests were conducted with two different test units onto the bottom rim at the welded seam, center-of-gravity over the impact point. The bottom of the first test unit indented a distance measuring 40.64-cm (16-in.) across and folded inward a distance of 7.62-cm (3-in.) The bottom edge of the rim split 4.445-cm (1.75-in.) in length and separating approximately 0.635 (0.25-in.). There was no release of the contents due to the containment provided by the rigid liner and multiple bags. A second drop test in this same orientation was conducted on another test unit to confirm the design of the drum. Damage occurred at the area of impact and measured a distance of 25.40 to 43.18 cm (10- to 17-in.) across the bottom. The bottom sidewall folded inward 5.08-cm (2-in.). The bottom of the drum pushed outward from the sidewall to the center bottom of the drum a distance of 19.05-cm (7.50-in.). The damage that occurred during the flat onto the bottom drop was minimal. The bottom of the drum pushed outward slightly and evenly along the entire base of the drum.

The shipper must ensure that the radiation level at any surface would not increase by more than 20% as a result of the decrease in distance to the center of the package load (TS-R-1 [ST-1, Revised]). The internal load and shifting of contents needs to be considered and taken into account during transport.

2.1.2.4 Simulated Payload

The simulated payload used during testing was sand/soil/gravel; large bulky objects such as lead bricks and sharp metal parts; and a mixture of flour and fluorescein. These objects were used to simulate Material Form Nos. 1, 2, and 3.

2.1.3 Restrictions/Specifications

1. Ensure that the drum is closed per the manufacturer’s instructions. Using a calibrated wrench, torque the bolt to 81.6 N-m (60 ft-lb). Using a 2 or 3 pound non-metallic hammer, tap the closure ring around its circumference to seat the ring. Check the torque reading on the closure bolt. Re-torque if necessary. Repeat the ring seating and re-torque activity until the torque measurement stabilizes at 81.6 N-m (60 ft-lb). If the ends of the ring touch before the required torque is reached, then ring is defective and should not be used.
2. Using a calibrated wrench, tighten the locking nut against the un-threaded closure ring lug to 54.4 N-m (40 ft-lb) (typical).
3. Ensure that the NucFil-013 filter is installed according to manufacturer’s instructions; torque to 20.4 N-m (15 ft-lb) (use a calibrated wrench).
4. The drum gasket material must have an operating range of -40◦ C to 70◦ C (-40◦ F to +158◦ F).
5. Ensure that the rigid liner vent hole is "open."
6. Contents are to be placed inside a 12-14-mil glove box bag, which is enclosed by an optional poultry bag, which is enclosed by a 3.5-mil liner bag. Each bag is twisted and horse-tailed closed. Ensure that all inner bags do not contain any holes, rips, or defects.

7. For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

2.1.4 49 CFR 178.350 Regulatory Requirements

Table 2.1-4. Regulatory Compliance Assessment.

2.1.5 Quality Control

Table 2.1-5. Packaging/Acceptance/Use Criteria.

2.1.6 Additional Information

Evaluation and testing of the Myers Model G5501 configuration took place at Hanford in May 1998 as Docket Number 96-44-7A. Comparison and evaluation of the subject packaging with the DOT-17C, 55-gal drums tested and evaluated under Docket 94-37-7A (DOE/RL 1996, Vol. 1) was performed by Waste Management Federal Services, Inc., Northwest Operations, for the water spray, stack, penetration bar drop, and vibration tests. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

2.1.6.1 Primary Users

Site/Contact/Phone	Address
Lawrence Livermore National Laboratory K. Hainebach COMM/925-422-4572	Lawrence Livermore National Laboratory Post Office Box 808 Livermore, CA 94551-0808

2.1.6.2 Suppliers

Drum Manufacturer:	Myers Container Corporation 8435 N.E. Killingsworth Portland, OR 97220 1-800-406-9377 503-255-0553
Rigid Liner Manufacturer:	Meese Orbitron Dunne 1745 Cragmont Street Madison, IN 47250 1-800-829-4535 812-273-1008

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2.2 MYERS MODEL 5526, UN1A2, 208-L, PAINTED DRUM (DOCKET: 96-44-7A, 5/98)

Figure 2-2: Myers Model 5526 Drum

2.2.1 Package Description

Table 2.2-1 Authorized Configurations

Table 2.2-2 Dimensions

Table 2.2-3. Materials/Method of Construction.

2.2.2 Authorized Contents

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 DOT-7A Compliance with the actual contents.

2.2.2.1 Physical Form and Maximum Gross Weight

Solids Only: Three forms are authorized. Each shipper must determine the most appropriate form for the particular contents to be shipped, and comply with any special requirements.

- Material Form No. 1: Solids—any particle size.
- Material Form No. 2: Solids—large particle size only (e.g., sand, concrete, debris, soil, etc.).
- Material Form No. 3: Solids—objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)

Maximum Gross Weight. All forms 408 kg (900 lb).

2.2.2.2 Chemical Form

The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

2.2.2.3 Radiological

Six drums were drop-tested as identified in **Table F-8**. Following is a summary of the damage that occurred to the test units during the 1.2-m (4-ft) drop test. The damage that occurred during the drop flat onto the side of the drum at the welded seam and at the bolt and filter locations caused the drum to indent a distance of 35.56-cm (14-in.) across the bottom of the drum. The drum pushed outward 7.62-cm (3-in.) along

the bottom, and flattened a distance measuring 25.40-cm (10-in.) by 7.62-cm (3-in.) along the side. A second drum, having a plain lid, was dropped in this same orientation. Similar damage as that previously discussed occurred to this test unit. Two drums were dropped onto the top at the bolt location, center-of-gravity over the impact point. The first drum incorporated the ¾-in. plug, and the other was a plain lid. Damage was similar to both drums. Damage occurred to each of the lids measuring approximately 45.72-cm (18-in.) across. The first drum pushed inward a distance of approximately 22.86-cm (9-in.) to the center of the lid, and the second drum pushed inward a distance of 12.70-cm (5.0-in.) from the top edge. The first drum crushed 33.02-cm (13-in.) across at the top to the first rolling hoop, and the rolling hoop flattened a distance of 3.81-cm (1.50-in.). The upper portion of the second drum flattened 44.45-cm (17.50-in.) across the area of impact. The first drum pushed inward approximately 1.27-cm (0.50-in.) at the first rolling hoop at the area of impact. One test unit was dropped onto the bottom rim at the welded seam, center-of-gravity over the impact point. At the area of impact, the bottom rim puckered slightly on each side of the W axis. The entire bottom of the drum pushed outward 45.72-cm (18-in.) across and pushed inward 15.24-cm (6-in.). The sixth test unit was dropped flat onto the bottom. The bottom of the drum indented a distance of 35.56-cm (14-in.) across the bottom of the drum. The drum pushed outward slightly, evenly across the entire bottom of the drum.

The shipper must ensure that the radiation level at any surface would not increase by more than 20% as a result of the decrease in distance to the center of the package load (TS-R-1 [ST-1, Revised]). The internal load and shifting of contents needs to be considered and taken into account during transport.

2.2.2.4 Simulated Payload

The simulated payload used during testing was sand/soil/gravel; large bulky objects such as lead bricks and sharp metal parts; and a mixture of flour and fluorescein. These objects were used to simulate Material Form Nos. 1, 2, and 3.

2.2.3 Restrictions/Specifications

1. Ensure that the drum is closed per the manufacturer’s instructions. Using a calibrated wrench, torque the bolt to 81.6 N-m (60 ft-lb). Using a 2 or 3 pound non-metallic hammer, tap the closure ring around its circumference to seat the ring. Check the torque reading on the closure bolt. Re-torque if necessary. Repeat the ring seating and re-torque activity until the torque measurement stabilizes at 81.6 N-m (60 ft-lb). If the ends of the ring touch before the required torque is reached, then ring is defective and should not be used.
2. Using a calibrated wrench, tighten the locking nut against the un-threaded closure ring lug to 54.4 N-m (40 ft-lb) (typical).
3. Ensure that the NucFil-013 filter or ¾-in. plug are installed according to manufacturer’s instructions; torque to 20.4 N-m (15 ft-lb) (use a calibrated wrench).
4. The drum gasket material must have an operating range of -40° C to 70°C (-40° F to +158° F).
5. Contents are to be placed inside a 3.5-mil liner bag. This bag is twisted and horse-tailed closed. Ensure that the bag does not contain any holes, rips, or defects.
6. For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

2.2.4 49 CFR 178.350 Regulatory Requirements

Table 2.2-4. Regulatory Compliance Assessment.

2.2.5 Quality Control

Table 2.2-5. Packaging/Acceptance/Use Criteria.

2.2.6 Additional Information

Evaluation and testing of the Myers Model 5526 configurations took place at Hanford in May 1998 as Docket Number 96-44-7A. Comparison and evaluation of the subject packaging with the DOT-17C, 55-gal drums tested and evaluated under **Docket 94-37-7A** (DOE/RL 1996, Vol. 1) was performed by Waste Management Federal Services, Inc., Northwest Operations, for the water spray, stack, penetration bar drop, and vibration tests. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in **Section 1.1.2**.

2.2.6.1 Primary Users

Site/Contact/Phone	Address
Lawrence Livermore National Laboratory K. Hainebach COMM/925-422-4572	Lawrence Livermore National Laboratory Post Office Box 808 Livermore, CA 94551-0808

2.2.6.2 Suppliers

Drum Manufacturer:	Myers Container Corporation 8435 N.E. Killingsworth Portland, OR 97220 1-800-406-9377 503-255-0553

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3.0 STEEL BOXES

3.1 M-100 CONTAINER, MODEL M-101/7A/12/90 (DOCKET: 96-43-7A, 9/98)

3.2 TRUPACT-II STANDARD WASTE BOX (SWB) (DOCKET: 98-45-7A, 6/99)

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3.1 M-100 CONTAINER, MODEL M-101/7A/12/90 (DOCKET: 96-43-7A, 9/98)

Figure 3-1: M-100 Container **(Model M-101/7A/12/90).**

NOTE: The approved Type A packaging design documentation discussed in this report may also be used to support use of the packaging as an Industrial Packaging or as a Strong-Tight Packaging.

3.1.1 Package Description

The approved, design, tested in September 1998, is the M-101/7A/12/90, Issue #4, Revision 6. The approved packaging configurations evaluated and tested are single-piece wall construction, consisting of 12 gauge HR ASTM A569 carbon steel. The M-100 Container is produced using a press-brake method. The filter is located at one end. The containment system includes a gasket that adheres to the cover, and twenty-six hex head cap screws, lock washers, and flat washers. The bolt holes are slotted, not drilled. A 3/8-in. chain link lift lug is located at each corner of the cover (four total). A bottom "pan" is continuously welded to the interior walls of the container. The distance that the bottom "pan" comes up along each wall is 8 cm (3 in.). Internal channels are welded vertically along the walls (channels are not welded to the bottom "pan"). The walls wrap around underneath the container and are continuously welded to the exterior of the container bottom. The distance that the walls wrap underneath the bottom of the container is 8 cm (3 in.). The risers (removable clip or fixed styles) are approximately 10.16 cm (4 in.) in height and 15.24 cm (6 in.) in width. The top portion of the riser that is welded onto the container subplate has a 2.54-cm (1-in.) edge. Each riser includes three internal gussets. The three 17.78 cm (7-in.) wide subplates are welded to the underside of the container. These welds are located every 15.24 cm (6 in.) on center.

Table 3.1-1. Dimensions

Table 3.1-2. Materials/Method of Construction.

Table 3.1-3. Packaging Weights.

3.1.2 Authorized Contents

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 DOT-7A compliance with the actual contents.

3.1.2.1 Physical Form and Maximum Gross Weight

Liquids. Not authorized.

Gases. Not authorized.

Solids. Three forms are authorized. Each shipper must determine the most appropriate form for the particular contents to be shipped, and comply with any special requirements.

- Material Form No. 1: Solids—any particle size.
- Material Form No. 2: Solids—large particle size only (e.g., sand, concrete, debris, soil, etc.).
- Material Form No. 3: Solids—objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)

Maximum Gross Weight. All forms 4082.33 kg (9000 lb).

3.1.2.2 Chemical Form

The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

3.1.2.3 Radiological

CAUTION: Testing was conducted using a uniform distributed load. No consideration was given to point sources being in the package. It is the responsibility of the shipper to use the damage information provided below to determine if a significant change in radiation level would result for a specific load. Note that point sources within the load require that the shipper use extreme caution.

NOTE: The shipper must ensure that the radiation level at any surface would not increase by more than 20% as a result of the decrease in distance to the center of the package load (TS-R-1 [ST-1, Revised]). The internal load and shifting of contents needs to be considered and taken into account during transport.

Testing Damage. The M-100 Container underwent drop testing as identified in Table F-8. Following is a summary of the damage that occurred to the test units during the 1.2-m (4-ft) drop test, that could impact the radiological evaluation of the performance of the package. Three drops onto the top portion of the container were conducted. During the drop onto the top corner at the lifting ring, the bottom of the container pushed inward and outward approximately 5.08 cm (2 in.) upon impact of the slap-down. Damage during the drop onto the lid along the short edge of the package consisted of the lid shifting approximately 0.635 cm (0.25 in.) at the impact point. The sidewall and bottom of the container bowed outward between the support channels approximately 5.08 cm (2 in.). During the drop onto the top long edge of the package, bulging at the top and sides of the container occurred.

Four drops onto the bottom portion of the container were conducted. One test unit incorporated the removable riser style. This test unit was dropped onto the bottom long edge of the package. Upon impact, the riser clips released and all risers disengaged. Slight crushing along the edge of impact occurred. A riser subplate lifted outward approximately 0.64 cm (0.25 in.) for a distance of 49.53 cm (19.5 in.). Three drops were conducted onto the bottom portion of the container, and incorporated the fixed riser style. During the drop onto the bottom long edge of the package, all three risers crushed/flattened along the impact edge. During the drop onto the bottom short edge of the package, the riser along the edge of impact pushed inward and flattened slightly. The riser on the opposite end squashed slightly. The sides and bottom of the container showed slight bulging. During the drop onto the bottom corner of the package, the riser at the area of impact

ripped out of the weld and tore approximately 0.125 cm (1/8 in.) wide and 3.18 cm (1.25 in.) in length. The tear occurred in the outer layer of the container body (material overlaps) where the edge of the fixed riser is welded onto the bottom of the container. The corner of impact showed crushing effects across an area measuring approximately 32.02 cm (13 in.). This area indented a distance of 6.35 to 7.62 cm (2.5 to 3 in.). The center riser and one end riser pulled away from the container. A slight tear occurred in the outer layer of the container body (material overlaps) where this end riser was welded onto the bottom of the container. The end riser crushed across a distance of approximately 22.86 cm (9 in.) at the area of impact. Crushing occurred approximately 12.70 to 15.24 cm (5 to 6 in.) onto the container body. The sides and bottom of the container had slight bulging.

During a flat drop onto the filtered end, a riser at the end of impact broke off.

3.1.2.4 Simulated Payload

The simulated payload used during testing was six 208-L (55-gal) drums filled to approximately 453.59 kg (1000 lb) each. A mixture of sand and soil filled the void between the drums and the container body. A mixture of flour and fluorescein was added as necessary for testing purposes (e.g., around the base of the container prior to adding test contents; over the top of the test contents prior to closure; or both). These objects were used to simulate Material Form Nos. 1, 2, and 3.

3.1.3 Restrictions/Specifications

1. The manufacturer(s) of the packaging 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. It is critical that weld quality requirements be clearly specified and stated. Suppliers must not establish the quality standards for the seller.
2. Follow the operating instructions provided in the *Fabricator's and User's Report* (Greaves 1999). Ensure that the gasket material is clean, smooth, and continuous, and that no rips or tears exist. The gasket material must have an operating range of -40° C to +70° C (-40° F to +158° F).
3. Prior to use, ensure the filter is tightened with a calibrated wrench to 14.91 N (11 ft-lbf, +2.0/-0.0). (Note that the manufacturer may supply a plug that looks similar to a filter.)
4. Prior to loading contents into the container, cover/protect the bolt holes of the container body so that materials do not drop into this space.
5. The container cover is secured with a system of conventional, high-strength bolts, washers, and lock washers. Two of the bolts are painted red and drilled to receive the stranded wire of the tamper-proof seal. These bolts are to be placed at diagonal corners of the container, in a hole adjacent to the lifting lug.
6. Place a lock washer, then flat washer onto a bolt. Thread the bolt into a tapped hole in the container body until finger tight. Repeat the process at each hole.
7. Starting at a corner and using a calibrated torque wrench, torque the bolts to 51.52 N (38 ft-lbf)± 10%. Alternate holes (every-other-one) until proper torque is achieved for all bolts.
8. For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

3.1.4 49 CFR 178.350 Regulatory Requirements

Table 3.1-4. Regulatory Compliance Assessment.

3.1.5 Quality Control

Table 3.1-5. Packaging/Acceptance/Use Criteria.

3.1.6 Additional Information

Evaluation and testing of the M-100 Container, Model M-101/7A/12/90, Issue #4, Revision 6, configurations took place at Hanford in September 1998 as Docket Number 96-43-7A. Comparison and evaluation of the subject packaging with similar steel boxes tested and evaluated as shown in **DOE/RL 1996, Vol. 1**, was performed by Waste Management Federal Services, Inc., Northwest Operations, for the water spray, and penetration bar drop tests. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in **Section 1.1.2.**

3.1.6.1 Primary Users

Site/Contact/Phone	Address
Office of Environmental Restoration and Waste Management (EM-43) Stephen Warren COMM/301-903-7673	U.S. Department of Energy 19901 Germantown Road Germantown, MD 20874
Sponsor's Technical Representative	Address
Brainard Associates, Inc. Jim Greaves COMM/440-498-9199	5381 Brainard Road Solon, OH 44139

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4.0 WOODEN BOXES

NOTE: Information for this packaging category will be added upon completion of testing and evaluation activities.

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5.0 FIBERBOARD CONTAINERS

NOTE: Information for this packaging category will be added upon completion of testing and evaluation activities.

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6.0 UF_6 CYLINDERS

NOTE: Information for this packaging category will be added upon completion of testing and evaluation activities.

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7.0 LIQUIDS AND GASES

NOTE: Information for this packaging category will be added upon completion of testing and evaluation activities.

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8.0 MISCELLANEOUS

8.1 "STAGECOACH" MODEL 320162, V1.1, FLEXIBLE CONTAINER

8.2 MODIFIED WRAP 1-TRIP, 208-L DRUM

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8.1 "STAGECOACH" MODEL 320162, V1.1, FLEXIBLE CONTAINER (DOCKET: 99-49-7A, 11/99)

Figure 8-1: "Stagecoach" Container **(Model 320162, V1.1).**

NOTE: The approved Type A packaging design documentation discussed in this report may also be used to support use of the packaging as an Industrial Packaging or as a Strong-Tight Packaging.

8.1.1 Package Description

The approved "Stagecoach" Model 320162, V1.1design tested and evaluated in November 1999 is considered proprietary information, and is patented by the manufacturer, U.F. Strainrite, Lewiston, Maine. The "Stagecoach" is a freestanding, flexible, woven plastic container that includes a 6-mil liner. Two plastic ties are provided to assist in securing the liner. In addition, the "Stagecoach" incorporates a duffel-type closure. The four side walls of the container each consist of two sheets of triple-wall natural kraft corrugated fiberboard. The cover consists of one sheet of triple-wall natural kraft corrugated fiberboard. The fiberboard is encapsulated between an inner and outer layer of ultraviolet-resistant, weather-resistant, woven, coated polypropylene fabric. Velcro* is used to secure the "pocket" for the fiberboard encapsulation for the side walls. The bottom of the “Stagecoach” consists of the polypropylene fabric and does not contain any fiberboard material. The cover of the “Stagecoach” overhangs three of the side walls approximately 15.24 cm (6 in.) and incorporates six grommets (2 left; 2 center; and 2 right). Three corresponding tabs are located on one side wall of the container, each containing one grommet. Ties are provided and are inserted through the grommets for closure and tamper-proof purposes. The remaining side of the cover is stitched to a side wall. The seams of the container are chain stitched. There are three rows of stitching. The “Stagecoach” does not contain any filters.

For ease in transporting the "Stagecoach" packaging, it may be banded to a hardwood pallet. The container was tested with and without a pallet banded in place to ensure that features added to the package would not reduce the safety of the package per 49 CFR 173.410(e). Three different pallet styles were tested. The pallet styles tested had no negative impact on the performance of the container. Banding used was ¾-in. carbon steel. Two or four bands may be used; however, due to the flexibility of the packaging, four bands are recommended.

Table 8.1-1. Dimensions.

Table 8.1-2. Materials/Method of Construction.

Table 8.1-3. Packaging Weights.

8.1.2 Authorized Contents

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 DOT-7A compliance with the actual contents. Refer to caution statement in Section 8.1.2.3.

8.1.2.1 Physical Form and Maximum Gross Weight

Liquids. Not authorized.

Gases. Not authorized.

Solids. Three forms are authorized. Each shipper must determine the most appropriate form for the particular contents to be shipped, and comply with any special requirements.

- Material Form No. 1: Solids—any particle size.
- Material Form No. 2: Solids—large particle size only (e.g., sand, concrete, debris, soil, etc.).
- Material Form No. 3: Solids—objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)

Maximum Gross Weight. All forms 1360.77 kg (3000 lb).

8.1.2.2 Chemical Form

The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

8.1.2.3 Radiological

CAUTION: This container is a flexible packaging. Testing was conducted using a uniform distributed load. No consideration was given to point sources being in the package. It is the responsibility of the shipper to use the damage information provided below to determine if a significant change in radiation level would result for a specific load. Note that point sources within the load require that the shipper use extreme caution.

NOTE: The shipper must ensure that the radiation level at any surface would not increase by more than 20% as a result of the decrease in distance to the center of the package load (TS-R-1 [ST-1, Revised]). The internal load and shifting of contents needs to be considered and taken into account during transport.

Testing Damage. The “Stagecoach” underwent stack testing as identified in Table F-26. Following is a summary of the damage that occurred to the test unit during the stack test, that could impact the radiological evaluation of the performance of the package. A compressive weight of 6876.46 kg (15,160 lb) was applied for a 24-hour period. A side wall bent and pushed outward approximately 21.88 cm (8.75 in.). The height was originally recorded as 110 cm (44 in.). After the test, the height was recorded in various areas and ranged from 55.63 through 76.25 cm (22.25 through 30.5 in.). The external dimensions at the side wall seams basically remained the same at 110 cm (44 in.). The cardboard inside the cover compressed from the original thickness of 1.25 cm (0.50 in) to 0.63 cm (0.25 in.). The side walls basically remained at the same thickness at 2.5 cm (1 in.). There was no visual release of contents.

8.1.2.4 Simulated Payload

The simulated payload used during testing was damp, clean sand/soil, and large bulky objects such as six taped lead bricks (weighing approximately 25-30 lb each), to a gross weight of approximately 1360.77 kg (3000 lb) for each test unit. A mixture of flour and fluorescein was added around the base of the liner prior to adding test contents, and over the top of the test contents prior to closure of the liner. These materials were used to simulate Material Form Nos. 1, 2, and 3.

NOTE: Due to the moisture in the sand/soil, a thin sheet of plastic was used between the sand/soil and flour/fluorescein mixture. The remainder of the simulated payload was evenly distributed within the liner.

8.1.3 Restrictions/Specifications

1. The “Stagecoach” is not evaluated nor recommended for air travel.

2. The Stagecoach, as closed in the assembly instructions, is not hermetically sealed. The design features a containment system with tamperproof seal. The containment system consists of (1) An inner 6-mil liner bag that contains the contents and is closed by two plastic ties; (2) An inner duffel closure design that includes a sewn-on tie; and (3) The body of the container which is made from corrugated fiberboard that is encapsulated in a woven polypropylene fabric. Two layers of polypropylene fabric make up the external sidewall and cover surface of the container, and one layer of polypropylene fabric makes up the internal sidewall and cover surface of the container. The base of the Stagecoach consists of two layers of polypropylene fabric. There is no corrugated fiberboard in the base. The cover of the container is stitched on one side. The cover overhangs three of the side walls by approximately 15.24 cm (6 in.) and contains grommets for securing to the package. Two wire ties and one plastic tamper-proof tie are provided which are inserted through the grommets in the cover and corresponding grommets in tabs that are stitched to the front body of the packaging.

   All seams of the Stagecoach are chain stitched. There are three rows of stitching. Although the Stagecoach cover is stitched along one side, and secured in place by ties, the cover should not be relied on to provide containment. It is reasonable to believe, based on common sense engineering evaluations, that if atmospheric pressure drops rapidly and/or substantially, the inner 6-mil polyethylene liner would experience a rupture or fissure. However, this type of pressure change would not result from normal atmospheric changes; it is the type of pressure change that could occur in air transportation. Air transport of the Stagecoach is not authorized. Additionally, the solid matter would be retained because of the inner duffel closure design. The multiple layers of fabric, including fiberboard, would also assist in providing containment for solid materials. It is the shipper’s responsibility to ensure that the contents will not allow the escape of radioactive materials due to an equalization of pressure.

3. The package may be banded to a suitable pallet with strapping appropriate for the package weight. If a pallet is used, no protrusions from the pallet shall exist as pallet protrusions (or weaknesses) could result in puncturing the packaging during use.

4. The shipper shall ensure that the amount of radiation at any surface would not increase by more than 20% (IAEA 1996).

5. For heavy, bulky materials, equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned and/or secondarily wrapped within the package such that they will not damage the package.

8.1.4 49 CFR 178.350 Regulatory Requirements

Table 8.1-4. Regulatory Compliance Assessment.

8.1.5 Quality Control

Table 8.1-5. Packaging/Acceptance/Use Criteria.

8.1.6 Additional Information

Evaluation and testing of the "Stagecoach" Model 320162, V1.1 configuration took place at Hanford in November 1999 as Docket Number 99-49-7A. Testing and evaluation of the subject packaging was performed by Waste Management Technical Services, for the water spray, penetration bar drop, stack, and drop tests. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in **Section 1.1.2.**

8.1.6.1 Primary Users

Site/Contact/Phone	Address
Hanford Site – Waste Management Project David W. Andrews (MSIN: T3-28) COMM/509-373-0815	Fluor Hanford P.O. Box 1000 Richland, WA 99352

8.1.6.2 Supplier

Packaging Manufacturer:	Robert R. Therrien, Sales Manager U.F. Strainrite P.O. Box 1667 48 Commercial Street Lewiston, ME 04241-1667 COMM/207-777-3100 or 1-800-487-3136

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8.2 MODIFIED WRAP 1-TRIP, 208-L DRUM (DOCKET: 99-48-7A, 04/01)

Figure 8-2: Modified WRAP 1-Trip, 208-L Drum.
Figure 8-3: Modified WRAP 1-Trip, 208-L Drum, Sealing Detail.

NOTE: . The approved Type A packaging design documentation discussed in this report may also be used to support use of the packaging as an Industrial Packaging or as a Strong-Tight Packaging.

8.2.1 Package Description

The original and previously tested drum design was identified as the Westinghouse Hanford Company (WHC), WRAP-1 Waste Drum, and was tested by Los Alamos National Laboratory and evaluated by Westinghouse Hanford Company in 1994 under Docket 94-35-7A. Historical information on the original design may be found in DOE/RL-96-57, Vol. 1, Section 8.12. A new drum design became necessary due to the inability to obtain the original drum design, and changes in the adhesive used to adhere the inner ring to the drum body.

The two new assemblies (Assembly -010 and Assembly -020) that were tested and evaluated under Docket 99-48-7A, Modified WRAP 1-Trip, 208-L Drum, were built to meet "Technical Description for Procurement," WMTS-TDP-012, Rev. 3, and Hanford Drawing H-2-824300, Rev 5. The drum consists of a UN1A2, 208-L (55-gal), filtered, 1.4 mm ± 0.13 mm carbon steel, internally and externally painted drum. Modifications consist of the addition of an inner ring (adhered to the inside of the drum), inner foam seal, a filtered inner lid (swaged and secured into place with special equipment), and an inner Neoprene gasket adhered to the underside of the external lid. An optional D-seal may be adhered to the top outer perimeter of the internal lid. The purpose of the D-seal is to improve confinement for worn mechanical ports that may exist in the special equipment that is used to swage the inner lid closed. A high-density polyethylene (HDPE) bottom impact plate is added prior to filling the drum to protect the drum bottom from possible protruding contents. Assembly-020 is identical to Assembly-010 except that Assembly -020 incorporates a 10-mil, nylon-reinforced, polyethylene liner bag for placement of contents. If used, this liner bag is folded over one time, and is not sealed.

The configurations tested included the Assembly -010 drum design that utilized the two different adhesives for the inner ring and the optional D-seal. The Assembly -020 design was not tested as the addition of the 10-mil liner bag would enhance the performance of the drum design, and would not detract from the containment system. Testing consisted of vibration, penetration bar, and multiple free-drop tests. An evaluation was performed regarding the water spray and stack tests.

Table 8.2-1. Dimensions.

Table 8.2-2. Materials/Method of Construction.

Table 8.2-3. Packaging Weights.

8.2.2 Authorized Contents

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 DOT-7A, Type A compliance with the actual contents. Refer to statement in Section 8.2.2.3.

8.2.2.1 Physical Form and Maximum Gross Weight

Liquids. Not authorized.

Gases. Not authorized.

Solids. Three forms are authorized. Each shipper must determine the most appropriate form for the particular contents to be shipped, and comply with any special requirements.

- Material Form No. 1: Solids-any particle size.
- Material Form No. 2: Solids-large particle size only (e.g., sand, concrete, debris, soil, etc.).
- Material Form No. 3: Solids-objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)

Maximum Gross Weight. All forms - 454 kg (1,000 lb).

8.2.2.2 Chemical Form

The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

8.2.2.3 Radiological

NOTE: The shipper must ensure that the radiation level at any surface would not increase by more than 20% as a result of the decrease in distance to the center of the package load [see TS-R-1 (ST-1, Revised)]. The internal load and shifting of contents needs to be considered and taken into account during transport.

Testing was conducted using a uniform distributed load. No consideration was given to point sources being in the package. It is the responsibility of the shipper to use the damage information provided below to determine if a significant change in radiation level would result for a specific load. Note that point sources within the load require that the shipper use caution.

Testing Damage. The Modified WRAP 1-Trip, 208-L Drum designs underwent vibration testing, the 1-m (3.3-ft) penetration bar drop test, and the 1.2 m (4 ft) free drop test in several different orientations. The Assembly -020 configuration was not tested due to the determination that the 10-mil liner bag would enhance the package design. A total of three drums underwent vibration testing. The vibration test resulted in no damage or release of contents. However, the external NucFil filter loosened slightly on two of the test units, and loosened by about one-quarter turn on one test unit. As a result, a suitable thread-locking compound shall be added around the threads of the outer filter prior to torquing and shipping the drums. Detailed vibration test information is provided in Table G-7.

The penetration bar drop onto the center of the external drum lid resulted in minimal damage. The free-drop orientations conducted were center of gravity over the top of the drum to impact at the bolt location and welded seam; center of gravity over the bottom of the drum to impact at the welded seam; and flat onto the side of the drum to impact at the welded seam. A total of eight test units underwent drop testing. More detailed results of the drop testing are documented in Table F-19. In summary, the most severe damage occurring to the test units was during the center of gravity drops onto either the top or bottom of the drums as documented. In each of these types of drop orientations, the change in the overall height of the drum was approximately 5 to 6 cm (2 to 2.5 in.). There was no visual release of contents from any of the test units.

8.2.2.4 Simulated Payload

The simulated payload used during testing was damp, clean sand/soil, and large bulky objects such as seven taped lead bricks [weighing approximately 23 kg (50 lb) each], to a gross weight of approximately 454 kg (1,000 lb) for each test unit. A mixture of approximately 907 grams (2 lb) of flour and 85 grams (3 oz) fluorescein was added around the base of the drum prior to adding test contents, and over the top of the test contents prior to closure of the inner lid. These materials were used to simulate Material Form Nos. 1, 2, and 3.

NOTE: Due to the moisture in the sand/soil, a thin sheet of plastic (i.e., less than 1-mil) was used between the sand/soil and flour/fluorescein mixtures. The remainder of the simulated payload was evenly distributed within the drum.

8.2.3 Restrictions/Specifications

1. Special equipment (bagless transfer system) is required for loading and closure of this packaging. The as-tested drums were purchased from Greif Brothers Inc., according to WMTS-TDP-012, Rev. 3, Technical Description for Procurement. Assembly of the as-tested packaging is according the Hanford Drawing H-2-824300, Rev. 5. Dimensional tolerances identified within the procurement specification and drawing shall be strictly adhered to and followed.

2. The inner lid shall be fitted with a NucFil-013, ¾-in.-14 NPT, carbon-activated filter. A 2.54 cm (1-in.) diameter hole is punched slightly off center of the inner drum lid so as not to interfere with the filters. The internal filter is threaded through the hole and a locking nut is tightened onto the backside of the filter. The filter is torqued to 16 N-m (12 ft-lb ± 1 ft-lb).

3. The inner ring shall be adhered and sealed around its circumference to the drum body with either 3M Scotch-Weld 3549B/A Urethane Adhesive or Ellsworth Resinlab EP-1225 Epoxy Urethane Adhesive. Allow the adhesive to cure for 24 hours. Fill any gaps and/or voids between the inner ring and drum body. Remove any excess adhesive from the top and bottom surface of the ring.

4. Dimension and placement of the inner lid seal is critical for proper drum closure per DOT-7A, Type A packaging testing. The inner gasket shall lie flat against the inner lid and inner seal. There shall be no rips or tears; ends shall be butted up against each other and have no gaps.

5. The inner seal shall meet the following specifications:
   - Foam rubber, satin finish
   - Adhesive-backed or apply Scotch-Grip 847 adhesive
   - Density: 3.5 - 5.0 lb/cu ft
   - 25 percent compression resistance: 2.0 to 5.0 psi.

6. The fit-up of the Neoprene inner gasket material that is adhered to the underside of the external drumhead is critical. The overlap and/or any gap of this gasket shall be no more than 1/16-in.

7. A NucFil-013, ¾-in. NPT, stainless steel, carbon-activated filter shall be installed by the shipper into the provided flange on the outer drum lid. The flange is located near the outer perimeter of the outer lid

to avoid interference with the filter located in the inner lid. The outer filter is torqued to 16 N-m (12 ft-lb ± 1 ft-lb). A suitable thread-locking compound shall be applied around the filter threads prior to transport of the package.

8. The locking ring and bolt shall be tightened to 68 N-m (50 ft-lb ± 1 ft-lb) torque with tapping of the ring followed by tightening. A jam nut shall also be used to prevent unintentional loosening during transport. The location of the jam nut shall be between the lugs, and the jam nut shall be tightened against the unthreaded lug. The ends of the closure ring shall not touch and may have a maximum gap of no more than ¼-in.

9. The drumhead gasket material, Neoprene inner gasket, and inner foam rubber seal shall have an operating range of -40 °C to +70 °C (-40 °F to +158 °F).

10. For heavy, bulky materials, equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned and/or secondarily wrapped within the package such that they will not damage the package. This loading must be evaluated to assure that the packaging, if tested, would not fail.

11. The shipper shall ensure that the amount of radiation at any surface would not increase by more than 20% [see TS-R-1 (ST-1, Revised)].

12. Transport by aircraft is not authorized.

8.2.4 49 CFR 178.350 Regulatory Requirements

Table 8.2-4. Regulatory Compliance Assessment.

8.2.5 Quality Control

Table 8.2-5. Packaging/Acceptance/Use Criteria.

8.2.6 Additional Information

Evaluation and testing of the Modified WRAP 1-Trip, 208-L Drum assemblies took place at Hanford during January and February 2001 as Docket Number 99-48-7A. Testing and evaluation of the subject packaging was performed by Duratek Federal Services Inc., Northwest Operations for the vibration, penetration bar drop, and 1.2 m (4 ft) drop tests. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.2.6.1 Primary Users

Site/Contact/Phone	Address
Hanford Site - Waste Management Project Kendrick (Ken) J. Leist (MSIN: T4-52) 509-376-0325 E-Mail: Kendrick_J_Ken_Leist@rl.gov	Fluor Hanford P.O. Box 1000 Richland, WA 99352

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9.0 REFERENCES

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TS-R-1 (ST-1, Revised) Safety Standards Series, *Regulations for the Safe Transport of Radioactive Material*, 1996 Edition (Revised), International Atomic Energy Agency, Vienna, Austria.

NRC, 1990, *Information Notice 90-82*, IN-90-82, U.S. Nuclear Regulatory Commission, Washington, D.C.

WEC 1999, *Specification for the TRUPACT-II Standard Waste Box*, E-I-343, Rev. 3, Westinghouse Electric Company, Waste Isolation Division, Carlsbad, New Mexico.

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

CODE OF FEDERAL REGULATIONS AND FEDERAL REGISTER

10 CFR 71, "Packaging and Transportation of Radioactive Material," Title 10, *Code of Federal Regulations*, Part 71, as amended, U.S. Nuclear Regulatory Commission, Washington, D.C.

49 CFR 100-499, "Other Regulations Relating to Transportation," Title 49, Subtitle B, *Code of Federal Regulations*, Parts 100 through 499, as amended, U.S. Department of Transportation, Washington, D.C.

49 CFR 171, "Hazardous Materials Regulations, General Information, Regulations, and Definitions," Title 49, *Code of Federal Regulations*, Part 171, as amended, U.S. Department of Transportation, Washington, D.C.

49 CFR 172, "Hazardous Materials Regulations, Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements," *Code of Federal Regulations*, Part 172, as amended, U.S. Department of Transportation, Washington, D.C.

49 CFR 173, "Hazardous Materials Regulations, Shippers-General Requirements for Shipments and Packagings," Title 49, *Code of Federal Regulations*, Part 173, as amended, U.S. Department of Transportation, Washington, D.C.

49 CFR 178, "Hazardous Materials Regulations, Specifications for Packagings" Title 49, *Code of Federal Regulations*, Part 178, as amended, U.S. Department of Transportation, Washington, D.C.

U.S. DEPARTMENT OF ENERGY ORDERS

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APPENDIX A

COMPLIANCE WITH GENERAL REQUIREMENTS FOR PACKAGES AND PACKAGING (49 CFR 173.24)

HM-169A (effective April 1, 1996)

Table A-1. Steel Drums--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). HM-169A (effective April 1, 1996).

Table A-2. Steel Boxes--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). HM-169A (effective April 1, 1996).

Table A-3. Wooden Boxes--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). HM-169A (effective April 1, 1996).

Table A-4. Fiberboard Containers--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). HM-169A (effective April 1, 1996).

Table A-5. UF_6 Cylinders--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). HM-169A (effective April 1, 1996).

Table A-6. Liquid and Gas Packagings--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). HM-169A (effective April 1, 1996).

Table A-7. Miscellaneous Packagings--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). HM-169A (effective April 1, 1996).

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APPENDIX B

COMPLIANCE WITH ADDITIONAL GENERAL REQUIREMENTS FOR NON-BULK PACKAGING AND PACKAGES (49 CFR 173.24a)

HM-169A (effective April 1, 1996)

Table B-1. Steel Drums--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). HM-169A (effective April 1, 1996).

Table B-2. Steel Boxes--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). HM-169A (effective April 1, 1996).

Table B-3. Wooden Boxes--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). HM-169A (effective April 1, 1996).

Table B-4. Fiberboard Containers--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). HM-169A (effective April 1, 1996).

Table B-5. UF_6 Cylinders--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). HM-169A (effective April 1, 1996).

Table B-6. Liquid and Gas Packagings--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). HM-169A (effective April 1, 1996).

Table B-7. Miscellaneous Packagings--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). HM-169A (effective April 1, 1996).

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APPENDIX C

COMPLIANCE WITH ADDITIONAL GENERAL REQUIREMENTS FOR BULK PACKAGINGS (49 CFR 173.24b)

HM-169A (effective April 1, 1996)

Table C-1. Steel Drums--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). HM-169A (effective April 1, 1996).

Table C-2. Steel Boxes--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). HM-169A (effective April 1, 1996).

Table C-3. Wooden Boxes--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). HM-169A (effective April 1, 1996).

Table C-4. Fiberboard Containers--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). HM-169A (effective April 1, 1996).

Table C-5. UF_6 Cylinders--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). HM-169A (effective April 1, 1996).

Table C-6. Liquid and Gas Packagings--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). HM-169A (effective April 1, 1996).

Table C-7. Miscellaneous Packagings--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). HM-169A (effective April 1, 1996).

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APPENDIX D

COMPLIANCE WITH GENERAL DESIGN REQUIREMENTS (49 CFR 173.410)

HM-169A (effective April 1, 1996)

Table D-1. Steel Drums--Compliance with General Design Requirements (49 CFR 173.410). HM-169A (effective April 1, 1996).

Table D-2. Steel Boxes--Compliance with General Design Requirements (49 CFR 173.410). HM-169A (effective April 1, 1996).

Table D-3. Wooden Boxes--Compliance with General Design Requirements (49 CFR 173.410). HM-169A (effective April 1, 1996).

Table D-4. Fiberboard Containers--Compliance with General Design Requirements (49 CFR 173.410). HM-169A (effective April 1, 1996).

Table D-5. UF_6 Cylinders--Compliance with General Design Requirements (49 CFR 173.410). HM-169A (effective April 1, 1996).

Table D-6. Liquid and Gas Packagings--Compliance with General Design Requirements (49 CFR 173.410). HM-169A (effective April 1, 1996).

Table D-7. Miscellaneous--Compliance with General Design Requirements (49 CFR 173.410). HM-169A (effective April 1, 1996).

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APPENDIX E
COMPLIANCE WITH ADDITIONAL DESIGN REQUIREMENTS FOR TYPE A PACKAGES (49 CFR 173.412)

HM-169A (effective April 1, 1996)

Table E-1. Steel Drums--Compliance with Additional Design Requirements for Type A Packages (49 CFR 173.412). HM-169A (effective April 1, 1996).

E1.0 SUMMARY OF PRESSURE TESTS ON EVALUATED STEEL DRUMS

Paragraph 173.412(f) in effect requires a pressure differential of 77.2 kPa (11.2 psig) across the surfaces of the containment system acting from the inside to the outside. In all the steel drum packagings, the containment system is defined as the drum itself. Pressure test documentation for various drums is provided in DOE/RL-96-57, Volume 1. Refer to the Volume 1 document when Table E-2 indicates that no testing has been conducted--only an evaluation.

Table E-2: Steel Drums--"Reduced Pressure" Tests Summary.

Table E-3: Steel Boxes--Compliance with Additional Design Requirements for Type A Packages (49 CFR 173.412). HM-169A (effective April 1, 1996).

E2.0 SUMMARY OF PRESSURE TESTS ON EVALUATED STEEL BOXES

Paragraph 173.412(f) in effect requires a pressure differential of 77.2 kPa (11.2 psig) across the surfaces of the containment system acting from the inside to the outside. In all the steel box packagings, the containment system is defined as the box itself. Pressure test documentation for various boxes is provided in DOE/RL-96-57, Volume 1. Refer to the Volume 1 document when Table E-3 indicates that no testing has been conducted--only an evaluation.

Table E-4: Steel Boxes--"Reduced Pressure" Tests Summary.

Table E-5: Wooden Boxes--Compliance with Additional Design Requirements for Type A Packages (49 CFR 173.412). HM-169A (effective April 1, 1996).

E3.0 SUMMARY OF PRESSURE TESTS ON EVALUATED WOODEN BOXES

NOTE: A summary of information will be compiled for this packaging category upon completion of testing and evaluation for this packaging category.

Table E-6: Wooden Boxes--"Reduced Pressure" Tests Summary.

Table E-7: Fiberboard Containers--Compliance with Additional Design Requirements for Type A Packages (49 CFR 173.412). HM-169A (effective April 1, 1996).

Table E-8: UF_6 Cylinders--Compliance with Additional Design Requirements for Type A Packages (49 CFR 173.412). HM-169A (effective April 1, 1996).

Table E-9: Calculated Safety Factor for UF_6 Cylinders.

Table E-10: Table E-10. Liquid and Gas Packages--Compliance with Additional Design Requirements for Type A Packages (49 CFR 173.412). HM-169A (effective April 1, 1996).

Table E-11: Liquid and Gas Packagings--"Reduced Pressure" Tests Summary.

Table E-12: Packages Meeting 49 CFR 173.412(k) Criterion.

Table E-13: Miscellaneous Packagings--Compliance with Additional Design Requirements for Type A Packages (49 CFR 173.412). HM-169A (effective April 1, 1996).

Table E-14: Table E-14. Miscellaneous Packagings Containment System Analysis.

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APPENDIX F

SUMMARY OF TYPE A PACKAGING TESTS (49 CFR 173.465 and 173.466)

HM-169A (effective April 1, 1996)

F1.0 INTRODUCTION

The purpose of this section is to provide more details concerning the Type A packaging tests that were conducted or against which the packages were analyzed for compliance. The tests involved are as follows:

1. Water spray
2. Free drop
3. Stacking
4. Penetration.

These tests, test methods, and determination of pass/fail criteria are discussed at length in Section 1.0.

F1.1 49 CFR 173.465(a)

(a) The packaging, with contents, must be capable of withstanding the water spray, free drop, stacking, and compression tests prescribed in this section. One prototype may be used for all tests if the requirements of paragraph (b) of this section are met.

Requirement F-1. Water Spray Test.

49 CFR 173.465	Discussion
(b) *Water Spray Test*	Major Points
The water spray test must precede each test or test sequence prescribed in this section. The water spray test must 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	(1) Must precede each test (2) 2 in./hr (3) 1-hr duration

the next test must 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.	Comments This is usually a conditioning of a package, rather than a test as such. One would not expect a loss of contents or significant increase in dose rate resulting from just the water spray test. However, consideration must be given to the possibility of water leakage into the package with subsequent transport of radioactive contents out as leakage. Designer, tester, and evaluator to do and shipper responsibility to ensure.

F1.2 PACKAGING CATEGORY--STEEL DRUMS

In evaluating steel drums against this requirement, one would consider the following:

- The effect the water spray would have on the ability of the steel drums to meet the other Specification 7A
- The potential for inleakage of water with the subsequent potential for transport of the radioactive contents out of the packagings performance requirements
- Because these same packagings are air-leak tight, prevention of the inleakage of water under such passive conditions as a water spray (rain) is expected.

NOTE: A summary of information will be compiled for this packaging category upon completion of testing and evaluation for this packaging category.

Table F-1. Water Spray Test Results for Steel Drums.

F1.3 PACKAGING CATEGORY--STEEL BOXES

In evaluating steel boxes against this requirement, one would consider the following:

- The effect the water spray would have on the ability of the steel boxes to meet the other Specification 7A performance requirements
- The potential for inleakage of water with the subsequent potential for transport of the radioactive contents out of the packagings
- Because these same packagings are air-leak tight, prevention of the inleakage of water under such passive conditions as a water spray (rain) is expected.

NOTE: A summary of information will be compiled for this packaging category upon completion of testing and evaluation for this packaging category.

Table F-2. Water Spray Test Results for Steel Boxes.

F1.4 PACKAGING CATEGORY--WOODEN BOXES

In evaluating wooden boxes against this requirement, one would consider the following:

- The effect the water spray would have on the ability of the wooden boxes to meet the other Specification 7A performance requirements
- The potential for inleakage of water with the subsequent potential for transport of radioactive contents out of the packagings.

NOTE: A summary of information will be compiled for this packaging category upon completion of testing and evaluation for this packaging category.

Table F-3. Water Spray Test Results for Wooden Boxes.

F1.5 WATER INLEAKAGE--WOODEN BOXES

NOTE: A summary of information will be compiled for this packaging category upon completion of testing and evaluation for this packaging category.

Table F-4. Water Spray Test Results for Fiberboard Containers.

F1.6 WATER INLEAKAGE--FIBERBOARD CONTAINERS

NOTE: A summary of information will be compiled for this packaging category upon completion of testing and evaluation for this packaging category.

Table F-5. Water Spray Test Results for UF_6 Cylinders.

Table F-6. Water Spray Test Results for Liquid and Gas Packagings.

Table F-7. Water Spray Test Results for Miscellaneous Packagings.

Requirement F-2. Free Drop Test.

49 CFR 173.465	**Discussion**
(c) *Free Drop Test* The specimen must drop onto the target so as to suffer maximum damage to the safety features being tested and:	Major Points (1) Manner to cause maximum damage.
(1) The height of the drop measured from the lowest point of the specimen to the upper surface of the target may not be less than the distance specified in Table 12, for the applicable package mass. The target must be as specified in 173.465(c)(5). Table 12 is as follows:	Designer, tester, and evaluator to do and shipper responsibility to ensure.

Table 12--Free-Drop Distance for Testing Packages to Normal Conditions of Transport.

Packaging Mass		Free Drop Distance		Comments
Kilograms	Pounds	Meters	Feet	(1) The orientation causing maximum damage may not be readily apparent. Typically, the following

<5,000	<11,000	1.2	4
>5,000 to 10,000	>11,000 to 22,000	0.9	3
>10,000 to 15,000	>22,000 to 33,000	0.6	2
>15,000	>33,000	0.3	1

guidelines should be considered:

Drums - Side drop with bolt closure ring (BCR) at impact point. Angle drop, approximately 45° on BCR and on bottom at intersection of chime and side seam.

Boxes - Top (lid) corner near features, such as lifting rings and filters, if any exist.

Approximate center of gravity over impact point.

(2) A quick-release device is required to ensure no change in package orientation.

(2) For the package containing fissile material, the free drop test specified in subparagraph (c)(1) of this section must be preceded by a free drop from a height of 0.3 meter (1 foot) on each corner, or in the case of cylindrical packages, onto each of the quarters of each rim.	For fissile material packagings, further testing and evaluation are required.
(3) For fiberboard or wood rectangular packages with a mass of 50 kilograms (110 pounds) or less, a separate specimen must be subjected to a free drop onto each corner from a height of 0.3 meter (1 foot).	Designer, tester, evaluator to do and shipper responsibility to ensure.
(4) For cylindrical fiberboard packages with a mass of 100 kilograms (220 pounds) or less, a separate specimen must be subjected to a free drop onto each of the quarters of each rim from a height of 0.3 meter (1 foot).	Designer, tester, evaluator to do and shipper responsibility to ensure.
(5) The target for the free drop test must be 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.	As a rule of thumb, an essentially nonyielding surface is one at least five times the mass of the impacting object. Tester and evaluator to do and shipper responsibility to ensure.

Table F-8. Free Drop Test Results for Steel Drums.

Table F-9. Free Drop Test Results for Steel Boxes.

Table F-10. Free Drop Test Results for Wooden Boxes.

Table F-11. Corner Free Drop Test Results for Wooden Boxes.

Table F-12. Free Drop Test Results for Fiberboard Boxes.

Table F-13. Corner Free Drop Test Results for Fiberboard Boxes.

Table F-14. Free Drop Test Results for Fiberboard Drums.

Table F-15. Corner Free Drop Test Results for Fiberboard Drums.

Table F-16. Free Drop Test Results for UF_6 Cylinders.

Table F-17. Additional Drop Test Results for Liquid and Gas Packagings.

Table F-18. Free Drop Test Results for Liquid and Gas Packagings.

Table F-19. Free Drop Test Results for Miscellaneous Packagings.

Requirement F-3. Stacking Test.

49 CFR 173.465	Discussion
(d) *Stacking Test* The specimen must be subjected for a period of at least 24 hours to a compressive load equivalent to the greater of the following: (i) Five times the mass of the actual package; or (ii) The equivalent of 13 kilopascals (1.9 pounds per square inch) multiplied by the vertically projected area of the package. (2) The compressive load must be applied uniformly to two opposite sides of the specimen, one of which must be the base on which the package would normally rest.	Major Points (1) 5 times actual weight (2) 13 kPa (1.9 lb/ft^2) times the area of package Comments (1) Be alert. For packages with a large top surface area, the 13 kPa (1.9 lb/ft^2) can quickly become very large. (2) Any decreases in distances to package surfaces should be documented for use in evaluating the "no significant dose rate increase" requirement. Tester and evaluator to do and shipper responsibility to ensure.

Table F-20. Stacking Test Results for Steel Drums.

Table F-21. Stacking Test Results for Steel Boxes.

Table F-22. Stacking Test Results for Wooden Boxes.

Table F-23. Stacking Test Results for Fiberboard Containers.

Table F-24. Stacking Test Results for UF_6 Cylinders.

Table F-25. Stacking Test Results for Liquid and Gas Packagings.

Table F-26. Stacking Test Results for Miscellaneous Packagings.

Requirement F-4. Penetration Test.

49 CFR 173.465	Discussion
(e) *Penetration Test* For the penetration test, the specimen must be placed	Major Points (1) 13-lb bar (2) 1 m (3.3 ft)

on a rigid, flat, horizontal surface that will not move significantly while the test is being performed.	(3) Most vulnerable point
(1) A bar 3.2 centimeters (1.25 inches) in diameter with a hemispherical end, and a mass of 6 kilograms (13.2 pounds) must be dropped and directed to fall with its longitudinal axis vertical, onto the center of the weakest part of the specimen, so that, if it penetrates far enough, it will hit the containment system. The bar may not be significantly deformed by the test; and	Comments Penetration of the outer packaging(s) is not necessarily a cause for failure. The question is, "Did the test result in a loss of contents?" For outer packaging components not meeting this requirement, one could specify an inner component(s) that will meet the requirement or design protective devices to ensure that the bar cannot reach the primary containment system.
(2) The height of the drop of the bar measured from its lower end to the intended point of impact on the upper surface of the specimen must be 1 meter (3.3 feet) or greater.	Tester and evaluator to do and shipper responsibility to ensure.

Table F-27. Penetration Test Results for Steel Drums.

Table F-28. Penetration Test Results for Steel Boxes.

Table F-29. Penetration Test Results for Wooden Boxes.

Table F-30. Penetration Test Results for Fiberboard Containers.

Table F-31. Penetration Test Results for UF_6 Cylinders.

Table F-32. Penetration Test Results for Liquid and Gas Packagings.

Table F-33. Penetration Test Results for Miscellaneous Packagings.

Requirement F-5. Additional Tests for Liquid & Gas Packagings.

49 CFR 173.466	Discussion
(a) In addition to the tests prescribed in 173.465, Type A packagings designed for liquids and gases must be capable of withstanding the following tests:	Comments Tester and evaluator to do and shipper responsibility to ensure.
(1) *Free Drop Test*. The packaging specimen must drop onto the target so as to suffer the maximum damage to its containment. The height of the drop measured from the lowest part of the packaging specimen to the upper surface of the target must be 9 meters (30 feet) or greater. The target must be as specified in 173.465(c)(5).	(1) 9 meters (30 feet) free drop
(2) *Penetration Test*. The specimen must be subjected to the test specified in 173.465(e)	(2) 1.7 meters (5.5 feet) penetration test.

except that the height of the drop must be 1.7 meters (5.5 feet).

NOTE:
For additional free-drop test information for liquid and gas packagings, refer to Table F-17.
All penetration test information for liquid and gas packagings may be found on Table F-32.

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APPENDIX G

COMPLIANCE WITH VIBRATION STANDARDS (49 CFR 178.608)

G1.0 INTRODUCTION

The purpose of this section is to provide more details concerning the packaging tests that were conducted for compliance with the vibration standard for testing packages (49 CFR 178.608).

This vibration test standard is being applied to Type A packages to demonstrate compliance with 49 CFR 173.410 (f), which states:

> ". . . each package used for the shipment of Class 7 (radioactive) materials must be designed so that-- . . . (f) The package will be capable of withstanding the effects of any acceleration, vibration, or vibration resonance that may arise under normal conditions of transport without any deterioration of the effectiveness of the closing devices on the various receptacles or of the integrity of the package as a whole and without loosening or unintentionally releasing the nuts, bolts, or other securing devices even after repeated use (see 173.24, 173.24a, and 173.24b)."

This test, test method, and determination of pass/fail criteria are discussed in Section 1.0.

Requirement G-1. Vibration Test.	
49 CFR 178.608	**Discussion**
(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, selected at random, must be filled and closed as for shipment. (2) The three samples must be placed on a vibrating	Major Points (1) Three sample packagings. (2) Vibrating platform has vertical or rotary double-amplitude of one inch. (3) Packagings free to move vertically, bounce, and rotate.

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) 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 Materials Safety.	(4) One-hour duration. (5) Pass a piece of material 1.6-mm (0.063-in.) thick between package and the platform.
(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.	Manufacturer and shipper responsible to ensure that package is capable of passing test.

Table G-1. Steel Drums--Compliance With Vibration Standard (49 CFR 178.608).

Table G-2. Steel Boxes--Compliance With Vibration Standard (49 CFR 178.608).

Table G-3. Wooden Boxes--Compliance With Vibration Standard (49 CFR 178.608).

Table G-4. Fiberboard Containers--Compliance With Vibration Standard (49 CFR 178.608).

Table G-5. UF_6 Cylinders--Compliance With Vibration Standard (49 CFR 178.608).

Table G-6. Liquid and Gas Packagings--Compliance With Vibration Standard (49 CFR 178.608).

Table G-7. Miscellaneous Packagings--Compliance with Vibration Standard (49 CFR 178.608).

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APPENDIX H

U.S. DEPARTMENT OF TRANSPORTATION LETTER OF CONCURRENCE

In April 1992, the U.S. Department of Transportation (DOT) reviewed and approved the *Test and Evaluation Document for DOT Specification 7A Type A Packagings*. The DOT Letter of Concurrence is provided in DOE/RL 1996, Volume 1**, Appendix I.**

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3.2 TRUPACT-II STANDARD WASTE BOX (SWB) (DOCKET: 98-45-7A, 6/99)

Figure 3-2: TRUPACT-II Standard Waste Box, Bolted Closure.

NOTE: The approved Type A packaging design documentation discussed in this report may also be used to support use of the packaging as an Industrial Packaging or as a Strong-Tight Packaging.

3.2.1 Package Description

The Standard Waste Box (SWB) was originally tested and evaluated by Mound in 1988 and 1989. Westinghouse Hanford Company (WHC) evaluated and approved a design change that incorporated a lid lift nut under Docket 89-07-7A in 1989. Historical information on these designs may be found in DOE/RL 1996, Vol. 1. The SWB design underwent evaluation in 1999 by Waste Management Federal Services, Inc., Northwest Operations (WMNW) under Docket 98-45-7A. Changes are minor and consist of better identification of the materials of construction as used and applied in commercial practice. Evaluation of the approved SWB design under Docket 98-45-7A includes the following:

- Westinghouse Waste Isolation division Drawing No. 165-F-001-W, Revisions F through K.
- Westinghouse Electric Company, Waste Isolation Division, Specification E-I-343, Revision 3, *Specification for the TRUPACT-II Standard Waste Box* (WEC 1999).

The lid and body are made of 10 gauge carbon steel. The lid incorporates a lid lift nut that may be used for lifting the lid only. The gasket assembly is made of closed cell rubber, and is cut with a knife die. Forty-two, ½" – 13 UNC x 1¾" socket flat head cap screws secure the lid to the body. The cap screws are secured by applying a non-locking liquid anaerobic thread sealant prior to placing into position. The cap screws are threaded into rivets that are installed in the body tube. The rivets may be manufactured or can be supplied off-the-shelf. The rivets may be procured from RIVNUT Engineered Products. The SWB has two flat sides that each incorporate three lift clips (six total) on the upper-most portion of the box body. The ends of the container are rounded and each incorporate two body bumpers (four total). The body bumpers are located on the upper and lower portion of the body. The box body contains four recessed NPT, ¾" pipe couplings. Two couplings are located on each of the flat sides of the box. A maximum of two commercial quality ¾" pipe plugs (NPTF or PTF) are installed in the pipe couplings; and a minimum of two NucFil-013, ¾" NPT filters are installed in the pipe couplings. Thread tape is used prior to installing the plugs or filters. The SWB is painted according to the user's specifications.

Table 3.2-1. Dimensions

Table 3.2-2. Materials/Method of Construction.

Table 3.2-3. Packaging Weights.

3.2.2 Authorized Contents

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 DOT-7A compliance with the actual contents.

3.2.2.1 Physical Form and Maximum Gross Weight

Liquids. Not authorized.

Gases. Not authorized.

Solids. Five forms are authorized. Each shipper must determine the most appropriate form for the particular contents to be shipped, and comply with any special requirements.

- Material Form No. 1: Solids—any particle size.
- Material Form No. 2: Solids—large particle size only (e.g., sand, concrete, debris, soil, etc.).
- Material Form No. 3: Solids—objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)
- Material Form No. 4: Solids as described in Form No. 3 above, including large, bulky, dense objects with sharp and obtrusive members or components, but having Form No. 1 and/or No. 2 as dispersible contaminates associated with the material (e.g., steel plates, motors, valves, steel pipes, concrete blocks).
- Material Form No. 5: Solids—four 208 L (55 gal) drums [in any arrangement not exceeding 453.592 kg (1,000 lb) per drum] and overpacked within the SWB.

Maximum Gross Weight. All forms 1814.369 kg (4000 lb).

3.2.2.2 Chemical Form

The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

3.2.2.3 Radiological

CAUTION: Testing was conducted using a uniform distributed load. No consideration was given to point sources being in the package. It is the responsibility of the shipper to use the damage information provided below to determine if a significant change in radiation level would result for a specific load. Note that point sources within the load require that the shipper use extreme caution.

NOTE: The shipper must ensure that the radiation level at any surface would not increase by more than 20% as a result of the decrease in distance to the center of the package load (TS-R-1 [ST-1, Revised]). The internal load and shifting of contents needs to be considered and taken into account during transport.

Testing Damage. Drop testing conducted by Mound in 1988 and 1989 is as identified in Table F-9. Following is a summary of the damage that occurred to the test units during the 1.2-m (4-ft) drop test, that could impact the radiological evaluation of the performance of the package. A dent [approximately 10.16 cm (4 in.)] resulted from the 1.2-m (4-ft) drop test onto the bottom edge.

3.2.2.4 Simulated Payload

The simulated payload used during testing that was conducted by Mound in 1988 and 1989 was represented as follows:

- Flour, fluorescein, and sand to a weight of 1832.513 kg (4040 lb) to represent Material Form Nos. 1 and 2.
- Flour, fluorescein, and debris to a weight of 1856.1 kg (4092 lb) to represent Material Form Nos. 1, 3, and 4.
- Flour, fluorescein, and four steel drums to a weight of 1859.729 kg (4100 lb) to represent Material Form Nos. 1 and 5.

3.2.3 Restrictions/Specifications

1. The SWB shall be operated in accordance with the Westinghouse Electric Company, Waste Isolation Division, *Specification for the TRUPACT-II Standard Waste Box*, E-I-343, Revision 3 (WEC 1999), and Westinghouse Waste Isolation Division Drawing Number 165-F-001-W, Revisions F through K.
2. Inspect rivets for damaged threads and loose fit. If any rivets require adjustment or replacement, follow the guidance provided in WEC 1999.
3. Install a minimum of two NucFil-013 filters in any of the four filter mounting locations. Filters shall be installed by first applying thread sealant tape or compound to the filter body pipe threads. Next, insert the filters into the filter mounting locations and tighten to a final torque of 13.56 ±6.78 N-m (10 ±5 ft-lb).

   NOTE: Users may have difficulty installing the filter as it is a straight thread and the coupling is a tapered thread. This may be corrected by using a ¾-in. NPT tap in the coupling prior to installing the filter.

   NOTE: The rubber gasket supplied with the filter can be removed at the user's option prior to installation of the filter. The SWB relies on the mechanical interface of the pipe threads with thread sealant to generate a leak-tight joint.
4. Install a maximum of two pipe plugs in any remaining open mounting locations. Plugs shall be installed by first applying thread sealant tape or compound to the plug pipe threads. Next, insert the plugs into the mounting locations and tighten to a final torque of 13.56 ±6.78 N-m (10 ±5 ft-lb).
5. Ensure that the gasket assembly is not ripped or torn. Wipe the gasket sealing surface of the body and lid to remove any loose debris. Install the gasket according to WID 1999. The gasket material must have an operating range of -40° C to +70° C (-40° F to +158° F).
6. A lifting attachment point is located in the center of the lid and will accept a ¼-in.–20 UNC lifting eye. The lid lifting point is for the lid only!
7. Coat all lid screw threads with a non-locking liquid anaerobic thread sealant prior to placing into position. Install a screw in each corner of the lid, approximately ¼-in. or 3 to 4 turns. Install the four corner screws. Install the middle screws on the straight sides. Install the middle screws on the curved

ends. Install the remaining screws in any sequence. Using a calibrated torque wrench, pre-torque all screws in a crisscrossing pattern to 40.68 (-0, +13.56) N-m [30 (-0, +10) ft-lb]. Torque all screws in a crisscrossing pattern to a final torque of 67.8 (-0, +13.56) N-m [50 (-0, +10) ft-lb].

NOTE: If needed, a lineup bar may be used to pull the lid into position with the body. Be careful not to damage the rivet threads. If the threads are damaged, repair as stated in WEC 1999.

8. For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

9. The shipper shall ensure that the amount of radiation at any surface would not increase by more than 20% [IAEA 1996, Paragraph 646(b)].

3.2.4 49 CFR 178.2(c) Notification

At the time of testing and evaluation, the specific organization taking on the responsibility of manufacturer is unknown. Note that neither the organization that fabricates the packaging nor the organization that tests the packaging is by the DOT definition necessarily the manufacturer. In 49 CFR 178.2(e) the manufacturer is defined by the DOT as follows: "Manufacturer means the person whose name and address or symbol appears as part of the specification markings required by this part or, for a packaging marked with the symbol of an approval agency, the person on whose behalf the approval agency certifies the packaging." The specification marking is defined as, "Specification markings mean the packaging identification markings required by this part (49 CFR 178) including, where applicable, the name and address or symbol of the packaging manufacturer or approval agency." In this particular case, it is assumed in this document that the shipper will assume the responsibility of manufacturer.

The Type A packaging evaluated is the result in a sharing of responsibilities. The packaging was designed to meet the Type A packaging requirements when loaded and used as described in this document. The design was developed by the Waste Isolation Pilot Plant (WIPP), Carlsbad, NM. Test units were prepared by a fabricator (unidentified) and tested in the DOE's DOT-7A Type A Packaging Test and Evaluation Program by Mound Laboratory to show that when loaded as described they would meet the physical test requirements. Design changes were evaluated in the DOE's DOT-7A Type A Test and Evaluation Program by WHC under Docket 89-07-7A and WMNW under Docket 98-45-7A to show that the identified package designs meet the identified requirements. As part of the evaluation process, those requirements not demonstrated as being met are identified as the responsibility of the shipper.

This document, in conjunction with the design drawings and packaging specification, identify the requirements for Type A packaging that are met and those requirements that remain to be completed (i.e., identified as shipper is to ensure…). It can therefore serve as a starting point for the notification required by this section. Any organization having packages fabricated should, before using or supplying the packagings to others, prepare a notification that updates the information. The notification should be supplied with the packagings.

3.2.5 49 CFR 178.350 Regulatory Requirements

Table 3.2-4. Regulatory Compliance Assessment.

3.2.6 Quality Control

Table 3.2-5. Packaging/Acceptance/Use Criteria.

3.2.7 Additional Information

Evaluation of the SWB design was performed by WMNW and took place at Hanford in June 1999 under

Docket Number 98-45-7A. Historical information on previous designs tested and evaluated by Mound and WHC may be found in DOE/RL 1996, Vol. 1. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

3.2.7.1 Primary Users

Site/Contact/Phone	Address
Mr. Mike Caviness (505) 234-7463 e-mail: CavineM@wipp.carlsbad.nm.us	TRU Waste Programs Westinghouse Electric Company Waste Isolation Division (GSA-211) Post Office Box 2078 Carlsbad, New Mexico 88221

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Table 1-1. New Packaging Configurations

Docket	Configurations	Description
99-48-7A	**Assembly –010**	**Modified WRAP 1-Trip, 208-L Drum**
	Assembly -020	

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Table 2.1-1. Authorized Configurations.

Myers Container Corporation, Model G5501, Galvanized Drum	UN1A2, 208-L (55-gal) galvanized drum (16 gauge head thickness; 18 gauge body and bottom thickness). Lid includes a NucFil-013* filter and an EPDM gasket. A 12-14-mil vinyl glove box bag-out bag (twist and tape close) encloses contents. An optional poultry bag (twist and tape close) may then enclose the glove box bag. A 3.5-mil poly liner bag (twist and tape close) encloses all the noted bagged contents. A 90-mil HDPE rigid liner (with ¾-in. vent hole open) encloses all bagged contents.

*NucFil is a trademark of Nuclear Filter Technology, Incorporated.
EPDM = Ethylene/Propylene/Diene/Monomer.
HDPE = high-density polyethylene.

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Table 2.1-2. Dimensions.

UN1A2, 208-L Galvanized Drum Configuration	**External Height With Lid On**		**Usable Internal Height**		**Inside Diameter**	
	cm	**in.**	**cm.**	**in.**	**cm.**	**in.**
Myers Model G5501	87.00	34.25	84.46	33.25	57.15	22.50
Meese Orbitron Rigid Liner	**Dimensional Range (Drawing No. AYD 770581, Rev. C)**					
External Height	80.77 to 82.55 cm (31.8 to 32.5 in.)					
Outer Diameter	55.63 to 56.90 cm (21.9 to 22.4 in.)					
Opening – Min. Dia.	48.26 cm (19.0 in.)					

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Table 2.1-3. Materials/Method of Construction.

Item	Description
Drum	Myers Model G5501, UN1A2, 208-L (55-gal), galvanized steel; 18 gauge body and bottom.
Drum lid	16 gauge steel. Cover includes 12-gauge bolt ring with 5/8-in. bolt, a NucFil-013* filter inserted into a ¾-in. Rieke flange.
Drum gasket	EPDM (ASTM 1056, SAE J18, Type R Class E, Grade RE43 B Z1 Z2.
Rigid Liner	90-mil Meese Orbitron HDPE rigid liner with the ¾-in. vent hole open. (Meese Orbitron Dunne Company Drawing Number AYD 770581, Rev. C)
Bags	A 12-14-mil glove box bag encloses contents. An optional poultry bag may enclose the glove box bag. A 3.5-mil liner bag encloses all the noted bagged contents.

*NucFil is a trademark of Nuclear Filter Technology, Incorporated.
ASTM = American Society of Testing and Materials.
EPDM = Ethylene/Propylene/Diene/Monomer.
HDPE = high-density polyethylene.

Table 2.1-4. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, General requirements for packages and packaging (HM-169A)	Meets applicable requirements. See Appendix A. Table A-1.
49 CFR 173.24a, Additional general requirements for non-bulk packaging and packages (HM-169A)	Meets applicable requirements. See Appendix B, Table B-1.
49 CFR 173.24b, Additional general requirements for bulk packages (HM-169A)	Meets applicable requirements. See Appendix C, Table C-1.
49 CFR 173.410, General design requirements (HM-169A)	Meets applicable requirements. See Appendix D, Table D-1.
49 CFR 173.412, Additional design requirements for Type A packages (HM-169A)	Meets applicable requirements. See Appendix E, Table E-1.
49 CFR 173.465, Type a packaging tests (HM-169A)	Meets applicable requirements.
Water spray	Pass by evaluation. See Appendix F, Table F-1.
Free drop 1.2 m (4 ft)	Pass. See Appendix F, Table F-8. Multiple 4-ft drop tests were conducted on a number of test units with successful results. The impact orientations included: Top – CG over corner on bolt and filter location. Side – flat onto welded seam, bolt, and filter locations. Bottom – CG over corner on rim and welded seam location.
Corner drop	Bottom – flat onto bottom
Stack	Not required.
Penetration	Pass by evaluation. See Appendix F, Table F-20. Pass by evaluation. See Appendix F, Table F-27.
49 CFR 178.608, Vibration standard [Applied to demonstrate compliance with 49 CFR 173.410(f)]	Pass by evaluation. See Appendix G, Table G-1.

Table 2.1-5. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/ Inspection criteria*
Lid/body interface sealing surface	Vendor qualifications and experience	Functional: • Ease of lid/closure ring application • Bolt closure ring—bolt size • Gasket, adhesive as specified • Geometry, as specified
Gasket Weld areas		Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces • Dimensions, as specified • Continuous welds
Body and chime	Metal thickness	Lot tests by shipper, as appropriate
Air leak tests	Bolt size	Vendor Data and/or Certification: • Marking • Test data • Type A document provided as appropriate • Air leak tests
	Protective coating application	Visual: • Surface/coating as specified • Lack of imperfections in application • Lack of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 2.2-1. Authorized Configurations.

Myers Container Corporation, Model 5526, Painted Drum	UN1A2, 208-L (55-gal) painted drum (18 gauge head, body, and bottom thickness). Three different lid styles may be used (plain, ¾-in. plug, or NucFil-013* filter) that incorporate a square-cut natural sponge rubber gasket. A 3.5-mil poly liner bag (twist and tape close) encloses the contents.

*NucFil is a trademark of Nuclear Filter Technology, Incorporated.

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Table 2.2-2. Dimensions.

UN1A2, 208-L Painted Drum Configuration	External Height With Lid On		Usable Internal Height		Inside Diameter	
	cm	in.	cm.	in.	cm.	in.
Myers Model 5526	87.88	33.75	83.19	32.75	57.15	22.50

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Table 2.2-3. Materials/Method of Construction.

Item	Description
Drum	Myers Model 5526, UN1A2, 208-L (55-gal), steel, exterior painted (yellow) enamel; 18 gauge body and bottom.
Drum lid	18 gauge steel. Cover includes 12-gauge bolt ring with 5/8-in. bolt, and may be plain, include a ¾-in. plug, or a NucFil-013* filter inserted into a ¾-in. Rieke flange.
Drum gasket	Square-cut, natural rubber sponge, open cell 1A3 B1 (ASTM D1056-1994), tan, (BASCO part number 3/8x3/8x68).
Bags	A 3.5-mil liner bag encloses contents.

*NucFil is a trademark of Nuclear Filter Technology, Incorporated.
ASTM = American Society of Testing and Materials.
BASCO = Barrel Accessories and Supply Company.

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Table 2.2-4. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, General requirements for packages and packaging (HM-169A)	Meets applicable requirements. See Appendix A, Table A-1.
49 CFR 173.24a, Additional general requirements for non-bulk packaging and packages (HM-169A)	Meets applicable requirements. See Appendix B, Table B-1.
49 CFR 173.24b, Additional general requirements for bulk packages (HM-169A)	Meets applicable requirements. See Appendix C, Table C-1.
49 CFR 173.410, General design requirements (HM-169A)	Meets applicable requirements. See Appendix D, Table D-1.
49 CFR 173.412, Additional design requirements for Type A packages (HM-169A)	Meets applicable requirements. See Appendix E, Table E-1.
49 CFR 173.465, Type a packaging tests (HM-169A) Water spray Free drop 1.2 m (4 ft) Corner drop Stack Penetration	Meets applicable requirements. Pass by evaluation. See Appendix F, Table F-1. Pass. See Appendix F, Table F-8. Multiple 4-ft drop tests were conducted on a number of test units with successful results. The impact orientations included: Top – CG over corner on bolt and plug location. Side – flat onto welded seam, bolt, and filter locations. Bottom – CG over corner on rim and welded seam location. Bottom – flat onto bottom Not required. Pass by evaluation. See Appendix F, Table F-20. Pass by evaluation. See Appendix F, Table F-27.
49 CFR 178.608, Vibration standard [Applied to demonstrate compliance with 49 CFR 173.410(f)]	Pass by evaluation. See Appendix G, Table G-1.

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Table 2.2-5. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/ Inspection criteria*
Lid/body interface sealing surface	Vendor qualifications and experience	Functional: • Ease of lid/closure ring application • Bolt closure ring—bolt size • Gasket, adhesive as specified • Gasket, no twists • Geometry, as specified
Gasket		Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces • Dimensions, as specified
Weld areas		Continuous welds
Body and chime	Metal thickness	Lot tests by shipper, as appropriate
Air leak tests	Bolt size	Vendor Data and/or Certification: • Marking • Test data • Type A document provided as appropriate • Air leak tests
	Protective coating application	Visual: • Surface/coating as specified • Lack of imperfections in application • Lack of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 3.1-1. Dimensions.

Description		Length cm (in.)	Width cm (in.)	Height cm (in.)
Outside dimensions (closed) with 4-in. risers		200.66 (79.0)	137.16 (54.0)	106.68 (42.0)
Interior volume = 2.55m^3 (89.9 ft^3)				
Clear opening dimensions:	Cover	193.04 (76.0)	129.54 (51.0)	5.08 (2.0)
	Body	193.04 (76.0)	129.54 (51.0)	90.49 (35.63)
Internal dimension with cover on		193.04 (76.0)	129.54 (51.0)	95.58 (37.63)

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Table 3.1-2. Materials/Method of Construction.

Item/component	Description
Container body, cover, and risers	12 gauge HR ASTM A569 carbon steel
Gasket	1/2-in. x 1 1/2-in. Neoprene[a] ASTM D-1056 SCE-42
Fasteners	Twenty-six, 3/8-in. - 16 x 7/8 hex head cap screws, ANSI B18.2.1, SAE Grade 8; 3/8-in. lock washers, ANSI B18.21.1 SAE Grade 8; and 3/8-in. SAE flat washers
Vent filter	NucFil[b] -013, 3/4-in. NPT
Vent filter fitting	2-in. Rieke steel plug with 3/4-in. opening; Part No. S-220C
Lift lug	Chain link, four places; Crosby Spectrum 4, 3/8-in. trade size, or equivalent.

ANSI = American National Standards Institute
ASTM = American Society for Testing and Materials
EPDM = Ethylene Propylene Diene Monomer
[a]Neoprene is a trademark of E.I. duPont de Nemours & Company
[b]NucFil is a trademark of Nuclear Filter Technology, Incorporated

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Table 3.1-3. Packaging Weights.

Item	Weight kg (lb)
Gross weight	4082.33 (9000)
Empty packaging (approximate)	453.59 (1000)
Payload of packaging (approximate)	3628.74 (8000)

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Table 3.1-4. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, General requirements for packages and packaging (HM-169A)	Meets applicable requirements. See Appendix A, Table A-2.
49 CFR 173.24a, Additional general requirements for non-bulk packaging and packages (HM-169A)	Meets applicable requirements. See Appendix B, Table B-2.
49 CFR 173.24b, Additional general requirements for bulk packages (HM-169A)	Meets applicable requirements. See Appendix C, Table C-2.
49 CFR 173.410, General design requirements (HM-169A)	Meets applicable requirements. See Appendix D, Table D-2.
49 CFR 173.412, Additional design requirements for Type A packages (HM-169A)	Meets applicable requirements. See Appendix E, Table E-3.
49 CFR 173.465, Type a packaging tests (HM-169A) Water spray Free drop 1.2 m (4 ft)	Meets applicable requirements. Pass by evaluation. See Appendix F, Table F-2. Pass. See Appendix F, Table F-9. Multiple 4-ft drop tests were conducted on a number of test units with successful results. The impact orientations included: Top – CG over the top corner at the lifting ring location. Top – CG over the short edge of the package. Top – CG over the long edge of the package. End – flat at the filter location. Bottom – CG over the short edge of the package.

Corner drop Stack Penetration	Bottom – CG over the bottom corner. Bottom – CG over the long edge of the package. Not required. Pass. See Appendix F, Table F-21. Pass by evaluation. See Appendix F, Table F-28.
49 CFR 178.608, Vibration standard [Applied to demonstrate compliance with 49 CFR 173.410(f)]	Pass. See Appendix G, Table G-2.

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Table 3.1-5. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/ Inspection criteria*
Lid/body interface sealing surface	Vendor qualifications and experience	Functional: • Ease of lid application • Flange--flat surface; no foreign matter • Size, material, and geometry as specified
Gasket		Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces • Dimensions, as specified
Weld areas		Continuous welds
Lid and body Lifting lugs Bolts		• Metal type, thickness, and quality as specified • Bolt type, number, locations, and materials as specified Vendor Data and/or Certification: • Marking • Test data • Type A document provided as appropriate • Air leak tests

	Protective coating application	Visual: • Surface/coating as specified • Lack of imperfections in application • Lack of rust, dents, nicks
Filter		Type, location, and installation as specified

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 3.2-1. Dimensions.

TRUPACT-II **Standard Waste Box**	**Height** **cm (in.)**	**Width** **cm (in.)**	**Length** **cm (in.)**
External (includes handles)	93.98 (37.0)	138.43 (54.5)	180.34 (71.0)
Internal	93.218 (36.7)	132.08 (52.0)	174.498 (68.7)

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Table 3.2-2. Materials/Method of Construction.

Item/component	Description
Container lid and body	10 gauge, ASTM A 569 or ASTM A 570, Grade 30 minimum, hot rolled sheet, carbon steel
Lid frame bar	Flat bar, ½" x 1 ¾", ASTM A 36
Lid lift nut	Steel bar, round ø 1 ¼", ASTM A 108, Grade 1018, cold drawn
Body tube frame	Rectangular tube, 1 ½" x 2" x 11 gauge, ASTM A 513, Type 1 or 2, Grade 1008 through 1020
Body bumper	4 total; square tube, 1" x 1" x 0.063”, ASTM A 513, Type 1 or 2, Grade 1008 through 1020
Body lift clips	6 total; flat bar, 3/8" x 1", ASTM A 36 carbon steel
Pipe couplings	4 total; NPT, ¾", steel, welded or seamless, ASTM A 865, recessed taper-tapped, extra strong
Pipe plugs	2 maximum; ¾" alloy steel, socket, NPTF or PTF, commercial quality
Filters	2 minimum; NucFil[a] -013, ¾", NPT
Gasket assembly	Closed cell rubber, ½" x 1 ½", ASTM D 1056, Type 2, Class A, Grade 2, Suffix A1 and F1 (four pieces with adhesive back)
Cap screws	42 total; alloy steel, ½" – 13 UNC x 1 ¾" ASTM F 835, socket flat head countersunk
Rivet	42 total; steel bar, round ø AR, ASTM A 576, Grade 1008, 1010, 1018, or 1110 (or RIVNUT[b] Engineered Products, Part Number S50-3069)

NOTE: Westinghouse Waste Isolation Division, Drawing No. 165-F-001-W, Rev. K, and Specification E-I-343, Rev. 3

ASTM = American Society for Testing and Materials

[a]NucFil is a trademark of Nuclear Filter Technology, Incorporated

[b]RIVNUT is a trademark of The B. F. Goodrich Company.

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Table 3.2-3. Packaging Weights.

Item	Weight kg (lb)
Gross weight	1814.369 (4000)
Empty packaging (approximate)	290.2991 (640)
Payload of packaging (approximate)	1519.534 (3350)

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Table 3.2-4. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, General requirements for packages and packaging (HM-169A)	Meets applicable requirements. See Appendix A, Table A-2.
49 CFR 173.24a, Additional general requirements for non-bulk packaging and packages (HM-169A)	Meets applicable requirements. See Appendix B, Table B-2.
49 CFR 173.24b, Additional general requirements for bulk packages (HM-169A)	Meets applicable requirements. See Appendix C, Table C-2.
49 CFR 173.410, General design requirements (HM-169A)	Meets applicable requirements. See Appendix D, Table D-2.
49 CFR 173.412, Additional design requirements for Type A packages (HM-169A)	Meets applicable requirements. See Appendix E, Table E-3.
49 CFR 173.465, Type A packaging tests (HM-169A Water spray Free drop 1.2 m (4 ft) Corner drop Stack Penetration	Meets applicable requirements. Pass. See Appendix F, Table F-2. Pass. See Appendix F, Table F-9. Multiple 4-ft drop tests were conducted on a number of test units with successful results. The impact orientations included: Top – CG over the top corner. Bottom – CG over the bottom corner. Flat on an end. Not required. Pass. See Appendix F, Table F-21. Pass. See Appendix F, Table F-28.

49 CFR 178.608, Vibration standard [Applied to demonstrate compliance with 49 CFR 173.410(f)]	Pass by evaluation. See Appendix G, Table G-2.

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Table 3.2-5. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/ Inspection criteria*
Lid/body interface sealing surface	Vendor qualifications and experience	Functional: • Ease of lid application • Flange--flat surface; no foreign matter • Geometry as specified • Size, material, and geometry as specified
Gasket		Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces • Dimensions, as specified
Weld areas		Continuous welds, no sharp edges
Lid and body Rivets Bolts		• Metal type, thickness, and quality as specified • Rivet and bolt type, number, locations, and materials as specified Vendor Data and/or Certification: • Marking • Test data • Type A document provided

		• as appropriate • Air leak tests
	Protective coating application	Visual: • Surface/coating as specified • Lack of imperfections in application • Lack of rust, dents, nicks
Filters and plugs		Type, location, and installation as specified

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 8.1-1. Dimensions.

U.F. Strainrite—Stagecoach Model 320162, V1.1	Length		Width		Height	
	cm	(in.)	cm	(in.)	cm	(in.)
Internal Dimensions	105	(42)	105	(42)	105	(42)
External Dimensions	110	(44)	110	(44)	110	(44)
Pallet Dimensions: Style A Style B & C	 111 120	 (44.5) (48)	 111 120	 (44.5) (48)	 12.5 12.5	 (5) (5)

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Table 8.1-2. Materials/Method of Construction.

Table 8.1-2. Materials/Method of Construction.	
U.F. Strainrite—Stagecoach—Model 320162, V1.1	
Item	**Description**
Side walls (4)	Each side wall consists of two sheets of triple-wall natural kraft corrugated fiberboard. The fiberboard is encapsulated between an inner and outer layer of ultraviolet-resistant, weather-resistant, woven, coated polypropylene fabric (black). Velcro* is used to secure the "pocket" for the fiberboard encapsulation for the side walls. The aggregate average thickness of each side wall is 2.54 cm (1.0 in.). The container side walls incorporate an inner duffel that includes a sewn-on tie.
Cover (1)	The cover consists of one sheet of triple-wall natural kraft corrugated fiberboard. The fiberboard is encapsulated between an inner and outer layer of ultraviolet-resistant, weather-resistant, woven, coated polypropylene fabric (black). The aggregate average thickness of the cover is 1.27 cm (0.50 in.). The cover overhangs three of the side walls approximately 15.24 cm (6 in) and contains grommets for securing to the package. One side of the cover is stitched to a side wall.
Base (1)	The base of the container consists of two layers of ultraviolet-resistant, weather-resistant, woven, coated polypropylene fabric (black).
Liner (1)	Polyethylene, 6-mil, yellow.
Pallets Tested	Style A: 7-ply sheet top and bottom (approx. ¾ in.), 4 in. x 4 in. centers (three each), glued and 2-in. staples. Measures 44.5 in. x 44.5 in. x 5 in. Style B: 7-ply sheet top (approx. ¾ in.), 4 in. x 4 in. centers (3 each), 3.5-in.-wide 7-ply sheet slats (3 each) base, and 2-in. staples. Measures 48 in. x 48 in. x 5 in.

	Style C: six each, 1 in. x 6 in. slats top and bottom, four each 2 in. x 4 in. centers, nailed. Measures 48 in. x 48 in. x 5 in.
Banding	Two or four, 3/4-in. carbon steel bands secure the package to the pallet. Due to the flexibility of the packaging, four bands are recommended.
*Velcro is a registered trademark of Velcro Industries B.V., Amsterdam, Netherlands.	

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Table 8.1-3. Weights.

Component	Weight kg (lb)
Stagecoach (empty)	26.3 (58)
Gross weight of filled package	1360.77 (3000)
Pallet (in addition to gross weight) Style A Style B Style C	 38.1 (84) 34.5 (76) 27.2 (60)

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Table 8.1-4. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, General requirements for packages and packaging (HM-169A)	Meets applicable requirements. See Appendix A, Table A-7.
49 CFR 173.24a, Additional general requirements for non-bulk packaging and packages (HM-169A)	Meets applicable requirements. See Appendix B, Table B-7.
49 CFR 173.24b, Additional general requirements for bulk packages (HM-169A)	Meets applicable requirements. See Appendix C, Table C-7.
49 CFR 173.410, General design requirements (HM-169A)	Meets applicable requirements. See Appendix D, Table D-7.
49 CFR 173.412, Additional design requirements for Type A packages (HM-169A)	Meets applicable requirements. See Appendix E, Table E-13.
49 CFR 173.465, Type a packaging tests (HM-169A)	Meets applicable requirements.
Water spray	Pass. See Appendix F, Table F-7.
Free drop 1.2 m (4 ft)	Pass. See Appendix F, Table F-19. Multiple 4-ft drop tests were conducted on a number of test units with successful results. Various pallet styles were included. One drop was conducted without a pallet. The impact orientations included: Top – flat.

	Top – CG over the top corner. Bottom – CG over the bottom edge of the package. Bottom – CG over the bottom corner.
Corner drop	Not required.
Stack	Pass. See Appendix F, Table F-26.
Penetration	Pass. See Appendix F, Table F-33.
49 CFR 178.608, Vibration standard [Applied to demonstrate compliance with 49 CFR 173.410(f)]	Pass by evaluation. See Appendix G, Table G-7.

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Table 8.1-5. Packaging/Acceptance/Use Criteria

Critical	Major	Acceptance/Pre-use/Inspection Criteria*
Container lid, side walls, and bottom interface	Manufacturer qualifications and experience	Acceptable Conditions: • No holes in internal and external fabric layers • No dents or deformations in inner cardboard • Stitching may be broken (intermittent), however no gaps along stitched seam rows • Dimensions as specified • Velcro secured “pockets” • Closure and tamper ties provided
Duffel closure	Manufacturer qualifications and experience	Continuous stitching to side walls and tie attached
Liner bag	Manufacturer qualifications and experience	• No holes • Closure ties provided • Dimensions and thickness as specified
Pallet and metal banding	Provided by the user	• Not required • If used, suitable pallet design for gross weight of packaging; 2 or 4 bands--4 preferred

*These criteria apply to first-time use. This packaging design is not intended for reuse.

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Table 8.2-1. Dimensions*.

Greif Brothers UN1A2, 208-L Drum*	Minimum mm (in.)	Maximum mm (in.)
Top rolling hoop centerline from drum top with the lid off	66.7 (2.625)	101.6 (4.00)
	Diameter mm (in.)	**Height mm (in.)**
External height, lid on, and closed as for use	N/A	≤ 887.5 (34.9375)
Internal diameter	572.0 ±1.588 (22.50 ±0.0625)	N/A
External diameter with lid and closure ring (excluding lugs)	≤ 609.6 (24.00)	N/A
*Built to meet WMTS-TDP-012, Rev. 3, Technical Description for Procurement, "Technical Description for Procurement of Internally Lined 208 Liter (55-Gal) Open-Head Drum (Catalog ID 597487)."		

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Table 8.2-2. Material/Method of Construction.

Assembly*		Item	Description
-010	**-020**		
X	X	Drum head/body/ bottom	Greif Brothers, UN1A2, 208-L, low carbon steel, single sheet; 1.4 mm ± 0.13 mm (0.0551 in. ± 0.0051 in.) lid/body/bottom thickness; three rolling hoops. The body seam is welded in accordance with 49 CFR 178.504 and is a round seam. The dimensions of the drum are critical. The top head fitted with ¾-in. Rieke[1] zinc-plated flange and plug. The plug gasket shall be flexible cellular ethylene/propylene/diene material (EPDM) or buyer-approved equivalent. The gasket material shall have a minimum durometer hardness of 65 points. This gasket shall retain its sealing abilities across a temperature range of -40 to 70 °C (-40 to 158 °F). The external coating is green alkyd enamel on the top, body, and bottom. The internal lining shall be applied to the top, body, and bottom, and be Morton Sterilkote[2] 15M Modified Phenolic or equivalent. Drum markings on the side of the as-tested drum were as follows: 1A2/X427/S/00 1A2/Y1.2/150/00 USA/GBC6W USA/GBC6W Drum markings on the bottom of the as-tested drum were as follows: UN1A2/X427/S/00/1.4 UN1A2/Y1.2/150/00/1.4
X	X	Filter (External Lid and Internal Lid)	One NucFil[3]-013 filter is installed in the external drumhead. One NucFil-013 filter and locking nut are installed in the internal drumhead.

X	X	External Lid Gasket	Glued to drum head; material shall be flexible cellular EPDM and shall meet American Society for Testing and Materials (ASTM) D 1056, Type 2, Class A, Grade 3, with suffix B2 or buyer-approved equivalent. This gasket shall retain its sealing abilities across a temperature range of -40 to 70 °C (-40 to 158 °F).
X	X	Inner gasket	1/8-in. thick sheet, Neoprene/sbr rubber, 35-65 durometer shore A. Gasket is trimmed to allow both filters to function properly. Gasket is adhered to the underside of the outer lid using Scotch-Grip[4] 847 or compatible adhesive. Dimension and placement is critical for proper drum closure.
X	X	Closure ring, nut, and bolt	12-gauge bolt ring with a drop forged lug. The closure ring is a roundback design, and shall have corrosion protection by powder coating, painting, or electroplating per ASTM B 633, Fe/Zn 12, Type I. Both bolt and locking nut are zinc-plated steel with a hex head. The 5/8-in. bolt is supplied with two 5 mm ±1.5 mm (0.197 in. ±0.059 in.) holes. One hole is placed in the bolt head; the other is to be placed in bolt threads 32 mm ±1.5 mm (1.260 in. ±0.059 in.) from end of bolt. Bolt to be approximately 100 mm (4 in.) long. Hole located in threaded part of bolt must be de-burred. Both holes must be protected from corrosion.
X	X	Impact plate	1/8-in. thick, high-density polyethylene (HDPE) or polyethylene (P/E).
X	X	Inner drum lid	16-gauge low carbon steel and as identified on Hanford Drawing H-2-824300, Rev. 5.
X	X	Inner ring	16-gauge low carbon steel and as identified on Hanford Drawing H-2-824300, Rev. 5. The inner ring shall be adhered and sealed around its circumference at its interface with the drum body with 3M[5] Scotch-Weld[6] 3549B/A Urethane Adhesive, or Ellsworth Resinlab™ EP-1225 Epoxy Urethane Adhesive.
X	X	Inner seal	15/16-in. wide x 5/16-in. thick foam rubber, satin finish, adhesive backed or apply Scotch-Grip 847 or compatible adhesive. Density: 3.5 - 5.0 lb/cu ft; 25% compression resistance: 2.0 - 5.0 psi; or approved equivalent. Dimension and placement is critical to proper drum closure.
X	X	D-Seal	Optional. Frostking V25G, EPDM.
	X	Bag	Nylon cord, reinforced, polyethylene, 10-mil or higher, or equal. (Procured from Lancs, LI-600-PEY, 10-mil, nylon cord, reinforced, polyethylene, Yellow Tint, 112 cm x 188 cm [44 in. x 74 in.]).
*Built to meet WMTS-TDP-012, Rev. 3, Technical Description for Procurement, "Technical Description for Procurement of Internally Lined 208 Liter (55-Gal) Open-Head Drum (Catalog ID 597487)," and Hanford Drawing H-2-824300, Rev. 5.			

Footnotes

[1]Rieke is a copyright of the Rieke Corporation.

[2]Morton Sterilkote is a trademark of Biotec Industries.

[3]NucFil is a trademark of Nuclear Filter Technology, Inc.

[4]Scotch-Grip is a trademark of the Minnesota Mining and Manufacturing Company.

3M is a trademark of the Minnesota Mining and Manufacturing Company.

[6]Scotch-Weld is a trademark of the Minnesota Mining and Manufacturing Company.

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Table 8.2-3. Packaging Weights.

Modified 1-Trip Drum - 208-L	Weight kg (lb)
Net weight (without simulated payload)	32 (70)
Gross weight (with simulated payload)	454 (1,000)

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Table 8.2-4. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, General requirements for packages and packaging (HM-169A)	Meets applicable requirements. See Appendix A, Table A-7.
49 CFR 173.24a, Additional general requirements for non-bulk packaging and packages (HM-169A)	Meets applicable requirements. See Appendix B, Table B-7.
49 CFR 173.24b, Additional general requirements for bulk packages (HM-169A)	Meets applicable requirements. See Appendix C, Table C-7.
49 CFR 173.410, General design requirements (HM-169A)	Meets applicable requirements. See Appendix D, Table D-7.
49 CFR 173.412, Additional design requirements for Type A packages (HM-169A)	Meets applicable requirements. See Appendix E, Table E-13.
49 CFR 173.465, Type a packaging tests (HM-169A)	Meets applicable requirements.
Water spray	Pass by evaluation. See Appendix F, Table F-7.
Free drop 1.2 m (4 ft)	Pass. See Appendix F, Table F-19. Multiple 1.2 m (4-ft) drop tests were conducted on a number of test units with successful results. The impact orientations included: Top - CG over the top to impact at the bolted closure and welded seam.

	Bottom - CG over the bottom to impact the rim and the welded seam. Side- Flat onto the side to impact the welded seam.
Corner drop	Not required.
Stack	Pass by evaluation. See Appendix F, Table F-26.
Penetration	Pass. See Appendix F, Table F-33
49 CFR 178.608, Vibration standard [Applied to demonstrate compliance with 49 CFR 173.410(f)]	Pass. See Appendix G, Table G-7.

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Table 8.2-5. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/Pre-use/Inspection Criteria*
Drum head, body, and bottom design	Vendor qualification and experience Metal thickness Protective coating application Cure date for gasket materials	Dimensions and design shall meet WMTS-TDP-012, Rev. 3, Technical Description for Procurement, and Hanford Drawing H-2-824300, Rev. 5. Drumhead gasket as specified. External coating and internal lining for drum as specified. Closure ring, nut, and bolt as specified. Placement of first rolling hoop as specified. Lack of dents, no deformation of sealing surfaces. No rips or tears in gasket materials. Size, material, and geometry as specified. Welded seam and bottom rim continuous, no sharp edges. Lack of rust and/or imperfections in coatings.
Filters (outer and inner lids)		Type, location, and installation as specified.
Inner gasket and inner seal		Materials of construction and placement as specified. No deformations of sealing surfaces; no rips or tears.
Inner lid and inner ring		Lack of dents, no deformation of sealing surfaces.

		Size, material, geometry, and placement as specified.
Impact plate		Material and placement as specified.
Air leak tests		Vendor data and/or certification. Marking. Test data. Type A document provided, as appropriate.

*These criteria apply to first-time use. This packaging design is not intended for reuse.

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TEST AND EVALUATION DOCUMENT FOR THE U.S. DEPARTMENT OF TRANSPORTATION SPECIFICATION 7A TYPE A PACKAGINGS

(Formerly WHC-EP-0558, Rev. 3)

1.0 INTRODUCTION

The U.S. Department of Energy (DOE) has been conducting, through several of its operating contractors, an evaluation and testing program to qualify Type A radioactive material packagings per U.S. Department of Transportation (DOT) Specification 7A (DOT-7A) of the Code of Federal Regulations (CFR), Title 49, Part 178 (49 CFR 178). The program is currently administered by the DOE, Office of Transportation, Emergency Management, and Analytical Services, DOE/EM-76, at DOE-Headquarters (DOE-HQ) in Germantown, Maryland.

This document summarizes the evaluation and testing performed for all of the packagings successfully qualified in this program. This document supersedes *DOE Evaluation Document for DOT-7A Type A Packaging* (Edling 1987), originally issued in 1987 by Monsanto Research Corporation - Mound Laboratory (MLM), Miamisburg, Ohio, for the Department of Energy, Security Evaluation Program (DP-4). Mound Laboratory issued four revisions to the document between November 1988 and December 1989. In September 1989, the program was transferred to Westinghouse Hanford Company (Westinghouse Hanford) in Richland, Washington. One additional revision was issued in March 1990 by Westinghouse Hanford.

This revision reflects the earlier material and incorporates a number of changes. Evaluation and testing activities on three DOT-7A Program Dockets resulted in the qualification of three new packaging configurations, which are incorporated herein and summarized below.

Table 1-1. New Packaging Configurations.

This document was prepared initially in July 1991 as a draft and submitted to DOE-HQ for review. The DOE-HQ forwarded a copy of the draft to the DOT for review. The DOT provided concurrence to the draft in April 1992 via a letter (included herein as Appendix I) which was forwarded to Westinghouse Hanford with DOE's direction to distribute this document. A number of miscellaneous changes have been made for completeness and to reflect the programmatic changes that have occurred since 1987.

1.1 PURPOSE AND SCOPE

The purpose of this document is to provide technical documentation of the evaluation and testing activities successfully completed to qualify a number of packagings to the requirements of DOT-7A (49 CFR 178.350). The packagings described herein are considered acceptable for transport of Type A quantities of radioactive material subject to the applicable restrictions and specifications.

This document is not intended to supply all of the information necessary for the fabrication of the identified DOT-7A packagings. The drawings in the document are for illustrative purposes and are intended to assist the reader in selecting a packaging meeting the requirements for the material to be shipped. If one desires to fabricate one of the packagings in the document, the primary user or custodian of that packaging should be contacted for the information.

The specific packaging data contained in this document will serve to meet the requirements of 49 CFR 173.415(a) for ". . . documentation of tests . . ." when the packagings are used as prescribed. In addition to the documentation of tests, the shipper must maintain on file, other appropriate data applicable to the shipment, such as the following:

- Evaluation of the properties of the actual contents to be shipped for compatibility with the packaging
- The Quality Control Program and its implementation.

Therefore, it is apparent that this document does not "stand alone" for all the documentation needed when offering a package for transportation. The shipper is responsible in many areas for ensuring that the loaded package is acceptable.

Changes in technology and in the mission of the various DOE facilities and contractors will generate the need for new packaging designs on a continuing basis. If a new design is needed (i.e., not currently covered in this document), contact one of the DOT-7A Program administrative or technical contacts listed in Sections 1.1.1 and 1.1.2, respectively, for assistance on qualifying a new packaging.

1.1.1 Administrative Contacts

The DOT-7A Program is currently administered by the DOE, Office of Transportation, Emergency Management, and Analytical Services, DOE/EM-76, at DOE-HQ in Germantown, Maryland. The responsible persons are as follows:

Current Administrative Contacts

Any organization wishing to have a packaging qualified in this program should contact the person listed above.

1.1.2 Technical Contacts

Westinghouse Hanford, Transportation and Packaging, is currently conducting the evaluation and testing activities. The persons responsible for these activities are as follows:

Current Technical Contacts

Please contact one of the persons listed above with any technical questions or any questions regarding dockets that have been established in the program.

The program has a great deal of experience with designs and materials that adequately perform to the requirements.

The normal approach to qualification of a new packaging design is to develop the design and operational documentation, review this documentation, and expose several test units to the Type A packaging tests (49 CFR 173.465 and 173.466). If the packaging performs adequately, it will be approved for use and included in this document at the next revision.

1.2 RESPONSIBILITIES

There are a number of specific functions that must be performed to ensure that a DOT-7A package is properly prepared for safe transport and in full compliance with the applicable regulations. The affiliation or the specific arrangements between the designer, manufacturer, and user should be adequately described and understood.

The following paragraphs discuss specific responsibilities.

1.2.1 The U.S. Department of Energy

The Packaging Certification Staff of DOE/EM-76 is responsible for the administration of the DOT-7A Program. This includes approval authority for all of the various program documents, requests for evaluation and testing of new packagings, and approval of their qualification. General programmatic direction is also under the control of DOE/EM-76.

1.2.2 Shipper

Shippers of Type A quantities of radioactive material are generally responsible for all aspects of the shipment. It is DOE policy to fully comply with the regulations for such shipments as established in 49 CFR 173. Normally the shipper will be able to locate an acceptable packaging, which places primary emphasis on ensuring compatibility with contents and correctness in operations.

1.2.3 Manufacturer

The manufacturer of a DOT-7A Type A packaging, which is covered in this document or otherwise authorized for use within the DOE system, is responsible for using materials, fabrication methods, manufacturing, and quality controls to ensure that the packaging is equivalent to the specified design. No design changes, substitutions, or changes in fabrication methods or controls are authorized without the approval of DOE/EM-76.

1.2.4 Testing Laboratory

The testing laboratory is responsible for evaluation and testing of new DOT-7A packaging designs based on the direction of DOE/EM-76. This process involves review of the applicants' design data, inspection of the test unit packages, performance of the Type A packaging tests, and documentation of the results. Westinghouse Hanford is currently performing this function for DOE/EM-76; Westinghouse Hanford is also maintaining and distributing the various DOT-7A Program documents.

1.3 APPLICABLE U.S. DEPARTMENT OF TRANSPORTATION REGULATIONS

The DOT regulations for shipping hazardous materials are located in 49 CFR, Parts 100-499. Copies of these regulations can be obtained from the Government Printing Office or other sources. The packagings described herein have been qualified to meet DOT-7A (49 CFR 178.350) for Type A packagings. Specification 7A is a general specification and invokes the applicable requirements of 49 CFR 173, Subparts A, B, and I.

Some of the important regulations affecting shipments of Type A quantities of radioactive material are summarized in the following paragraphs. The primary sections of the regulations applicable to Type A packaging requirements are as follows:

173.21	Forbidden materials and packages

173.22	Shipper's responsibility
173.24	General requirements for packagings and packages
173.24(a)	Additional general requirements for non-bulk packagings and packages
173.24(b)	Additional general requirments 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 standard.

1.3.1 Contents Characterization

Specification 7A packagings are qualified for transporting Type A quantities of radioactive material. Characterization of contents for compatibility with the selected packaging is an important aspect of any shipment and is primarily the responsibility of the shipper. The regulations address this area with a number of items, which are summarized in the following paragraphs.

1.3.1.1 Radiological. The following items in 49 CFR 173, Subpart I address the radiological characteristics of the material to be shipped:

173.417	Authorized packagings--fissile materials
173.431	Activity limits for Type A and Type B packages
173.433	Requirements for determination of A_1 and A_2 values for radionuclides
173.441	Radiation level limitations
173.451	Fissile materials--general requirements
173.453	Fissile materials--exceptions
173.455	Classification of fissile materials packages
173.459	Mixing of fissile material packages.

The shipper must characterize the payload as needed to determine compliance with these requirements.

1.3.1.2 Physical Form. The physical form of the material has a direct and an indirect effect on the applicability of a number of requirements. For example, the form affects the density of the material, which will affect the gross weight, which affects the requirements invoked for package handling features. In the DOT-7A Program, solid materials are classed into one of three Material Forms (Forms) as follows:

- Form Number 1: Solids--any particle size
  - A packaging qualified for these contents is expected to contain radioactive contents of any representative particulate size.

- Form Number 2: Solids--large particle size only (i.e., sand, concrete, debris, soil)
  - Contents of a corresponding particulate size such as soil or construction debris. (Glass or plastic labware having fine particulate available for dispersion would not fit this category and would require a packaging qualified for fine particulate, Form Number 1.)

- Form Number 3: Solids--objects with no significant dispersible or removable contamination (for definition, see 49 CFR 173.443, "Contamination control").
  - Metals with activation products
  - Forms of metals/alloys/compounds of uranium, thorium
  - Solid materials with the radioactive material firmly fixed in place, possibly by the application of a fixing media (i.e., paint)
  - Solidified material.

NOTE: These are examples only and each form must be analyzed for compliance with the "no removable or dispersible contamination" criterion found in 49 CFR 173.443.

Packagings intended to transport liquids and gases must be designed to withstand more severe test conditions than those designed for solids.

1.3.1.3 Thermal. Thermal limitations and requirements applicable to packagings are addressed in the following sections:

173.412(d)	Containment and shielding--temperature range
173.442	Thermal limitations
173.448(b)	Heat output.

The thermal heat generation of the contents, for whatever reason, must not degrade the packaging. Normally, Type A quantities of radionuclides do not generate enough decay heat to be of concern. If there is any doubt, the decay heat should be calculated and the package design analyzed to ensure no problems.

1.3.1.4 Chemical. The chemical characteristics of the contents are addressed by the following requirements:

173.21	Forbidden materials and packages
173.24(b)(3)	Mixture, reaction
173.24(e)(2)	Reaction
173.24(e)(3)	Plastic compatibility/permeability
173.24(f)	Closures, gaskets
173.412(g)	Compatibility, behavior under irradiation
173.412(h)	Gas generation, radiolysis.

The contents must not react with the packaging so as to degrade it and must not develop chemical conditions which could lead to an explosion. The basic chemical makeup of the nonradioactive constituents of the contents to be shipped must be understood in order to adequately design a packaging.

1.3.2 Packaging Design

The regulatory requirements primarily applicable to the design of a Type A packaging are listed as follows:

173.24(b)	Design and construction
173.24(e)(3)	Plastic packagings and receptacles
173.411(a)-(f)	General design requirements

173.412	Additional design requirements for Type A packages
173.462(c)	Containment system . . . specified
173.462(d)	External features . . . clearly identified
178.3	Marking of packagings.

The packagings identified in this document have been designed and qualified to meet these requirements for transporting contents as shown in the subsequent sections. The following paragraphs are intended to summarize the design-related requirements.

1.3.2.1 General Arrangement. The packaging design will generally fall into one of three basic configurations: (1) single packaging, (2) composite packaging, or (3) combination packaging (see definitions 49 CFR 171.8). Single packagings are generally recommended for solids meeting the definition of Form Number 2 or Form Number 3, or gases. For packaging of solids classed as Form Number 1 and liquids, composite or combination packagings are recommended.

1.3.2.2 Containment. The requirements that pertain directly to containment of contents are as follows:

173.24(b)	Design and construction
173.24(e)(2)	Reaction
173.24(e)(3)	Plastic packagings and receptacles
173.24(f)	Closures and gaskets
173.462(c)	Containment system . . . specified
173.469(a)(4)	Leak tightness.

Basically, there can be "no significant release of the hazardous materials to the environment," and the packaging must remain effective when subjected to normal conditions of transport, with account being taken for any reactions between the contents and the packaging materials. In practice, "no significant release," implies no measurable leakage based on visual evaluation.

Containment is formed by those materials or components that are or may be in direct contact with the contents during shipment. The design process will involve choices of basic material, use of filters or other pressure relief devices, gaskets or other seal materials, closure mechanisms, and other features. Typical containment materials are high-density polyethylene (HDPE), polypropylene, glass, and steel.

1.3.2.3 Shielding. The following requirements directly address shielding design of Type A packagings:

173.412(d)	Temperature (-40 to 70 °C [-40 to 158 °F]), brittle fracture
173.412(k)	Shielding/containment interface
173.441	Radiation level limitations.

Shielding may be required for Type A quantities of radionuclides. Lead or steel are commonly used materials for shielding. The regulations require that the shielding and containment system remain intact and effective when subjected to normal conditions of transport.

1.3.2.4 Lifting and Handling. The following requirements directly address the design of lifting and handling features of Type A packagings:

173.411(a)	Handling, securing
173.411(b)	Manual handling (gross weight 10 to 50 kg [22 to 110 lb])
173.411(c)	Mechanical handling (gross weight above 50 kg [110 lb])
173.411(d)	Lifting attachments.

The exterior design of the packaging shall meet the above requirements.

1.3.2.5 Tiedown. The following requirements directly address the design of tiedown features of Type A packagings:

173.411(a)	Handling, securing
173.412(l)	Tiedown, failure.

Package tiedown features and equipment shall be designed to comply with these requirements.

1.3.3 Package Qualification and Testing

Type A packagings must be designed to withstand the tests delineated in 49 CFR 173, Sections 173.465 and/or 173.466 as applicable. Section 173.461 addresses the methods by which compliance with these requirements may be addressed. The DOT-7A Program typically demonstrates acceptable performance by exposing several prototype test units to the test conditions. The tests that are performed are described briefly below.

1.3.3.1 Reduced Pressure Test [49 CFR 173.412(i)]. The reduced pressure test is intended to simulate the reduction of ambient (external) pressure to the package to 25 kPa (3.5 psia). This may be achieved by pressurizing the internal cavity of the packaging to 78 kPa (11.2 psig) or by placing a closed packaging into a chamber that can be evacuated to 25 kPa (3.5 psia). In both cases, leak detection by visual, soap bubble, pressure change, or other method is used.

1.3.3.2 Water Spray Test [49 CFR 173.465(b)]. The water spray test simulates exposure to rainfall of approximately 5 cm (2 in.)/hour for at least one hour. This test must precede each of the other tests or test sequences described in 49 CFR 173.465. 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 package. The time interval is two hours if the spray is applied from four different directions simultaneously. Other tests will follow immediately if the spray is applied from each of the four directions consecutively.

1.3.3.3 Compression Test [49 CFR 173.465(d)]. The compression test lasts for a period of at least 24 hours. The compressive load is equivalent to either five times the weight of the actual package or 1,300 kg/m^2 (265 lb/ft^2) multiplied by the vertically projected area of the package, whichever is greater. The load is applied uniformly to two opposite sides of the package, one of which must be the base on which the package would normally stand.

1.3.3.4 Penetration Test [49 CFR 173.465(e) and 173.466(a)(2)]. The package is placed on a rigid, flat, horizontal surface. A bar (penetration bar) 3.2 cm (1.25 in.) in diameter with a hemispherical end, weighing 6 kg (13.2 lb), with its longitudinal axis vertical, is dropped onto the center of the weakest part of the package, so that, if it penetrates far enough, it will hit the containment system. The bar must not be deformed by the test.

The distance of the fall of the bar is measured from its lower end to the upper surface of the package. The determination of this distance depends on the basic physical form of the contents for which the packaging is designed. The penetration drop height for packagings designed to contain only solids is 1 m (3.3 ft). This distance is 1.7 m (5.5 ft) for packagings designed to contain liquids and/or gases.

1.3.3.5 Free Drop Test [49 CFR 173.465(c) and 173.466(a)(1)]. The free drop test consists of a fall onto a flat, horizontal, rigid surface. The orientation of the test package is such that the fall will cause maximum damage to the package and its safety features. The distance of the fall will be measured from the lowest part of the packaging to the upper surface of the target. The distance of the fall is determined by the gross weight

of the packaging, packaging material type, and material form to be shipped.

1.3.3.6 Vibration Standard [49 CFR 178.608]. Three randomly selected sample packagings are filled and closed as for shipment. The sample packagings are placed on a vibrating platform that has a vertical or rotary double-amplitude (peak-to-peak displacement) of 2.54 cm (1 in.). The packages should be constrained horizontally to prevent them from falling off the platform, but must be free to move vertically, bounce, and rotate.

The test must be performed for at least one hour at a frequency that causes the package to be raised from the vibrating platform so that a piece of material of approximately 1.6-mm (0.063-in.) thickness can be passed between the bottom of any package and the platform.

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.

1.3.3.7 Demonstration of Compliance With Tests. Following the test sequences, which expose the prototypes to the applicable tests, the performance of the packaging is evaluated. If determined acceptable, the packaging is approved for use by DOE/EM-76 and included in this document.

1.3.4 The HM-181 Regulation Changes

The now implemented HM-181 regulations affect requirements for packaging and transportation of hazardous materials in the United States, similar to the United Nations (UN) recommendations for packaging of dangerous goods.

The implementation of HM-181 took effect as of October 1, 1994. Under the HM-181 regulation changes, most nonbulk hazardous material packagings must be tested against performance criteria that simulate stresses encountered during shipment. The results of these tests must be documented and the packagings marked or certified with a UN certification. Packagings not marked with the certification will be refused entry into international destinations and may be refused by domestic air carriers. The transition period in which all domestic shipments must attain compliance is five years or sooner, depending on the material to be shipped.

The packaging test requirements vary depending on the density, vapor pressure, and packing group for a particular material. Packing Group I packagings are subjected to the most stringent performance tests. Packing Groups II and III invoke progressively less stringent performance requirements.

The HM-181 regulation changes have no direct effect on this document or the use of Specification 7A. However, there is an indirect effect since HM-181 resulted in the deletion of many of the specification packagings covered in 49 CFR 178. For example, the DOT Specification 17-C drum (49 CFR 178.115) was deleted from the regulations. This document refers in many places to this and similar specifications. Accordingly, when referring to these specifications in procedures, specifications, and purchasing documents, reference the specification followed by the words, "in effect in December 1990 (i.e., prior to DOT rulemaking HM-181)." Another indirect effect may be encountered when shipping liquids via an air carrier. The HM-181 requirements regarding qualification of the packaging to the reduced external pressure conditions may be invoked, requiring review and/or additional testing of the packagings described herein.

Note that the appendices are divided into pre-HM-181 and post-HM-181 sections. The as-tested packaging information has been placed accordingly into the appendices.

1.4 USE OF TYPE B PACKAGINGS

The U.S. Nuclear Regulatory Commission (NRC)-approved Type B packagings may be used to transport Type A quantities of radioactive materials provided applicable requirements are met. The NRC provided

some clarification regarding such use of NRC-approved Type B packagings in Information Notice 90-82 dated December 31, 1990 (NRC 1990). This information is summarized in the following paragraphs.

The NRC and DOT share primary responsibility for approving package designs for transportation of radioactive materials within the United States. The NRC regulations for the transportation of radioactive materials are codified in 10 CFR Part 71, "Packaging and Transportation of Radioactive Material." The DOT's hazardous materials regulations, which include radioactive material, are codified in 49 CFR Parts 100-199. Requirements for shippers of radioactive materials are given in 49 CFR 173.400 through 173.478. In addition, a provision in the NRC regulations, 10 CFR 71.5, requires that NRC licensees comply with DOT's hazardous materials regulations.

In general, pursuant to 10 CFR Part 71, NRC approves package designs for shipment of fissile and greater-than-Type A quantities of radioactive material. The design for packages up to Type A quantities is subject to the requirements of DOT in 49 CFR Part 173.

In authorizing the use of NRC-approved packages for transportation of Type A quantities of radioactive material, DOT regulations specify, in 49 CFR 173.415, that certain conditions be met. One condition (49 CFR 173.471) is that the shipment of the package be made in compliance with the terms of the NRC certificate of compliance (certificate). For example, a radiographic source changer authorized for a Type B quantity of a specific radionuclide in special form is also authorized for a Type A quantity of the same specific radionuclide in special form, provided that all the terms and conditions of the certificate are met. Note that NRC approvals include the type and form of material, the maximum quantity of material per package, and the operating instructions and maintenance procedures for the package.

Alternately, an NRC-approved package may be shipped under the provisions of 49 CFR 173.415(a) as a DOT-7A package. In this instance, the shipper (if requested) must provide DOT with 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 DOT-7A. The shipper is required to maintain this documentation on file for at least one year after the latest shipment. Thus, a radiographic source changer approved by NRC for shipment of a specific radionuclide in special form could be used to ship a Type A quantity of a different nuclide, provided that the package is re-evaluated under the provisions of 49 CFR 173.415(a).

When an NRC-approved package is used as a DOT-7A package, the NRC package identification marking should be covered and new markings ("USA DOT-7A TYPE A" and "radioactive material") affixed to the package, pursuant to 49 CFR 173.415(a).

Users of the NRC-approved packages should be aware of the requirements for using NRC-approved packages for low-level radioactive materials exempted under 10 CFR 71.10. In particular, users of NRC-approved packages should:

- Determine what provision of 49 CFR 173.415 applies
- Comply with all requirements in 49 CFR 173.415(a) and 49 CFR 178.350 when the shipment is made pursuant to 49 CFR 173.415(a). Note that the use of an NRC-approved package pursuant to 49 CFR 173.415(a) requires that the package be re-evaluated as a DOT-7A Type A package, and that the shipper maintain the evaluation on file for one year after the last shipment
- Comply with all terms and conditions in the NRC certificate when the shipment is made pursuant to 49 CFR 173.415(c).

1.5 PROCUREMENT

Normally DOE shippers will procure complete packagings or components of packagings from commercial

suppliers to satisfy shipment needs. The DOE/EM-76 recommends that any packaging procurement be conducted in two basic steps:

1. Obtain from the packaging supplier the documentation that will demonstrate compliance with the requirements (i.e., drawings, specifications, etc.) and perform a technical review.
2. Upon acceptance of the documentation (i.e., all comments satisfactorily resolved), release the supplier to manufacture the packagings or components.

Procurement of the packagings identified herein or their components will involve preparation of a technical specification followed by execution of the normal process used for procuring equipment or components. The following paragraphs summarize this process.

1.5.1 Specification Development

The shipper should prepare a technical specification for the packaging or component to be supplied that includes, as a minimum, any technical requirements specified in this document. The specification should also identify any other deliverables desired and the requirements applicable to each. When the specification is complete, the shipper normally will prepare a purchase requisition, which will accompany the specification, to initiate the formal procurement process.

1.5.2 Request for Proposals

The first formal step in the procurement process is preparation of a purchase requisition and the subsequent issuance of a request for proposal (RFP). The procurement package will include the completed specification, schedule requirements, and other pertinent technical information such as technical evaluation criteria, technical proposal instructions to bidders, etc. Upon completion and management approval of the purchase requisition and the specification, the shipper should contact the purchasing organization at the site or facility to coordinate the RFP process. The buyer who is the cognizant purchasing representative will become the focal point in the process of negotiating with potential suppliers.

1.5.3 Order Placement

Normally several or more suppliers will respond to the RFP. This will initiate a selection process for determining the candidate who will supply acceptable deliverables for the lowest cost. The selection process will normally involve the shipper's technical review of each of the proposals and procurement department review including cost and price analysis. Upon completion of the reviews, a supplier (the seller) will be selected and the order placed.

1.5.4 Documentation Review and Approval

The next major action for the shipper will be to review any seller-provided documentation such as drawings, specifications, analyses, manufacturing processing instructions, and quality control processes. Upon acceptance of this data, the supplier will be released to manufacture the components or packagings per the purchase order.

1.5.5 Packaging Manufacturing and Delivery

The seller will manufacture the fleet packagings as specified in the purchase order when released by the buyer. When complete, the packagings will be delivered to the shipper's facility for receiving inspection and use.

1.6 PACKAGING OPERATIONS

Packaging operations involve assembling the packaging, loading the contents, closing the package, and preparing for shipment. The operating instructions for a packaging are the primary vehicle for the shipper to maintain control on the assembly, loading, and closure processes for a packaging and its preparation for shipment and other items. Accordingly, shippers are requested to ensure that the operating instructions for the packaging system to be used implement the operational requirements discussed in the following paragraphs.

The operating instructions should consist of the following primary elements:

- Packaging description
- Authorized contents
- Preloading inspections
- Loading procedure
- Preparation for shipment
- Preshipment inspections
- Shipment requirements
- Unloading procedure
- Reuse/reconditioning (if applicable).

The packaging description and authorized contents sections should be similar to the material for a packaging included herein.

The shipper should determine, per the following requirements, the preloading inspections to be performed and the acceptance criteria considered necessary to ensure that the packaging complies and that adequate quality control is implemented.

173.474	Quality control for construction of packaging
173.475	Quality control requirements prior to each shipment of radioactive materials.

The loading procedure should address all operations necessary to correctly assemble the packaging components, load the contents, and close the packaging.

The section addressing preparation for shipment should address labeling and placarding requirements (49 CFR 173.444 and 173.446) and any other applicable requirements. If the package must be secured to the conveyance in a particular fashion, this should also be specified in a subsection to be entitled, "Tiedown."

The section(s) addressing preshipment inspections should address verifications for compliance with the following requirements:

173.441	Radiation level limitations
173.442	Thermal limitations
173.443	Contamination control.

The section addressing shipment requirements should address requirements and procedures applicable when the package is en route to its destination. For example, the requirements of 49 CFR 173.447, "Storage incident to transportation," should be addressed in this section.

The unloading procedure should detail all steps necessary to safely unload the package from the conveyance and for unloading the contents from the packaging.

If the packaging may be reused, the operating instructions should include procedures for reconditioning the packaging to a state that will meet the design requirements established in the drawing and specification.

1.7 QUALITY ASSURANCE

The quality assurance program implemented by the shipper's organization must implement actions to provide adequate confidence that the shipments will comply with the regulations. The DOE Order 5700.6C includes general quality elements to be considered in development of the shippers quality program. Shippers are cautioned to invoke only the quality requirements applicable to Type A packaging and transportation.

The following regulatory requirements address quality control applicable to Type A packagings:

173.474	Quality control for construction of packaging
173.475	Quality control requirements prior to each shipment of radioactive materials.

The shipper is responsible for ensuring that the packaging materials, components, and arrangement are in accordance with the qualified design as documented herein. The shipper is also responsible for ensuring that the packaging is assembled, loaded (with compatible contents), closed, and prepared for shipment properly.

The DOE/EM-76 recommends that quality control be implemented as needed for the shipper to ensure compliance with the regulations. This is considered best achieved at three possible points in the packaging operation process:

1. Receiving inspections for procured packagings or components. The inspections should be of adequate scope and detail to ensure that the supplied hardware complies with the qualified design.
2. Preloading inspections to be performed prior to assembly and loading of the packaging. These inspections should verify that no packaging components have been damaged or altered and the arrangement is in accordance with the qualified design.
3. Preshipment inspections to be performed prior to shipment. This final inspection should verify that the assembled package, its marking and labeling, and its tiedown arrangement (if applicable) are correct. Further, preshipment inspections should address verifications for compliance with the following requirements:

173.441	Radiation level limitations
173.442	Thermal limitations
173.443	Contamination control.

The data presented for specific packagings in this document includes applicable quality control elements. This data should be used for guidance in implementing the inspections mentioned above.

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2.0 STEEL DRUMS

2.1 DOT-6C 5- AND 10-GALLON STEEL DRUMS (DOCKETS: MLM)

Figure 2-1. DOT-6C 5- and 10-Gallon Steel Drums, 49 CFR 178.99. (contents restricted, see Section 2.1.3).

2.1.1 Package Description

Table 2.1-1. Dimensions.

Table 2.1-2. Materials/Method of Construction.

2.1.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

2.1.2.1 Physical Form

2.1.2.1.1 Solids only. Three forms are authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements (e.g., room temperature vulcanizing [RTV], etc.).

- Material Form No. 1: Solids--any particle size.
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.)
- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination controls.)

2.1.2.1.2 Maximum Gross Weight. Form No. 1, No. 2, and No. 3:

- 5-gal = 80 lb
- 10-gal = 160 lb.

2.1.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

2.1.2.3 Radiological. Dents approximately 1.1 in. and 1.5 in. appeared in the 5-gal and 10-gal drums, respectively, following the 4-ft drop test on the bottom edge. The shipper must ensure that the radiation level at the surface of the package would not increase by more than 20% if such deformations occurred.

2.1.3 Restrictions/Specifications

For Form No. 1 Contents--RTV sealant (or equivalent) must be applied to the surface of the gasket in contact with the drum body.

For Form No. 2 and No. 3 Contents--No packaging component requirements other than specified in Section 2.1.1.

Bolt closure tightened, with tapping, until the lugs begin to bend inward or come together--typically less than 40 ft-lb. A jam nut shall also be used to prevent unintentional loosening during transport.

The gasket material must have an operating range of -40 °F to +158 °F.

For heavy bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

2.1.4 49 CFR 178.350 REGULATORY REQUIREMENTS

Table 2.1-3. Regulatory Compliance Assessment.

2.1.5 Quality Control

Table 2.1-4. Packaging/Acceptance/Use Criteria.

2.1.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

2.1.6.1 Primary Users

Site/Contact/Phone	Address
Rocky Flats	**Rocky Flats Plant**
K. Lenarcic	P.O. Box 464
COMM/FTS 303-966-2377	Golden, CO 80402-0464

2.2 DOT-17C 5-GALLON STEEL DRUM (DOCKETS: MLM)

Figure 2-2. DOT-17C 5-Gallon Steel Drum, 49 CFR 178.115.

2.2.1 Package Description

Table 2.2-1. Dimensions.

Table 2.2-2. Materials/Method of Construction.

2.2.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

2.2.2.1 Physical Form

2.2.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements (e.g., RTV, etc.).

- Material Form No. 1: Solids--any particle size.
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.)
- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)

2.2.2.1.2 Maximum Gross Weight. Form No. 1, No. 2 and No. 3:

- 100 lb.

2.2.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

2.2.2.3 Radiological. The 4-ft drop test caused deformation of the package resulting in a decrease in the distance from the exterior to the center of the package at the bottom edge of 0.5 in. (approximate). The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such a deformation would occur.

2.2.3 Restrictions/Specifications

For Form No. 1 Contents--RTV sealant (or equivalent) must be applied to the surface of the gasket in contact with the drum body.

For Form No. 2 and No. 3 Contents--No packaging component requirements other than as specified in Section 2.2.1.

Bolt closure tightened, with tapping, until the lugs begin to bend inward or come together--typically less than 40 ft-lb. A jam nut shall also be used to prevent unintentional loosening during transport.

The gasket material must have an operating range of -40 °F to +158 °F.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

2.2.4 49 CFR 178.350 Regulatory Requirements

Table 2.2-3. Regulatory Compliance Assessment.

2.2.5 Quality Control

Table 2.2-4. Packaging/Acceptance/Use Criteria.

2.2.6 ADDITIONAL INFORMATION

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

2.2.6.1 Primary Users

Site/Contact/Phone	Address
Los Alamos National Laboratory	**Los Alamos National Laboratory**
N. King	P.O. Box 1663
COMM/FTS 505-667-4125	Los Alamos, NM 87545
Battelle Columbus Laboratories	**Battelle Columbus Laboratories**
T. R. Emsweiler	505 King Avenue
614-879-5165	Columbus, OH 43201

2.3 DOT-17C 30-GALLON STEEL DRUM (DOCKETS: MLM)

Figure 2-3. DOT-17C 30-Gallon Steel Drum, 49 CFR 178.115.

2.3.1 Package Description

Table 2.3-1. Dimensions.

Table 2.3-2. Materials/Method of Construction.

2.3.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

2.3.2.1 Physical Form

2.3.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements (e.g., RTV, etc.).

- Material Form No. 1: Solids--any particle size.
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.)
- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)

2.3.2.1.2 Maximum Gross Weight

- Form No. 1 = 400 lb
- Form No. 2 = 500 lb
- Form No. 3 = 500 lb.

2.3.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

2.3.2.3 Radiological. The 4-ft drop test caused deformation of the package resulting in a decrease in the distance from the exterior to the center of the package at the bottom edge of 2.75 in. (approximate). The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such a deformation would occur.

2.3.3 Restrictions/Specifications

For Form No. 1 Contents--RTV sealant (or equivalent) must be applied to the surface of the gasket in contact with the drum body.

For Form No. 2 and No. 3 Contents--No packaging component requirements other than specified in Section 2.3.1.

The lid closure ring bolt shall be tightened to 40 $\pm$ 4 ft-lb with tapping of ring during tightening. A jam nut shall also be used to prevent unintentional loosening during transport.

The gasket material must have an operating range of -40 °F to +158 °F.

For heavy bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

2.3.4 49 CFR 178.350 Regulatory Requirements

Table 2.3-3. Regulatory Compliance Assessment.

2.3.5 Quality Control

Table 2.3-4. Packaging/Acceptance/Use Criteria.

2.3.6 Additional Information

Evaluation and testing of the subject packaging took place at MLM. A complete test report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

2.3.6.1 Primary Users

Site/Contact/Phone	Address
Battelle Columbus Laboratories	**Battelle Columbus Laboratories**
T. R. Emsweiler	505 King Avenue
614-879-5165	Columbus, OH 43201

2.4 DOT-17C 35-GALLON STEEL DRUM (DOCKETS: MLM)

Figure 2-4. DOT-17C 35-Gallon Steel Drum, 49 CFR 178.115.

2.4.1 Package Description

Table 2.4-1. Dimensions.

Table 2.4-2. Materials/Method of Construction.

2.4.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

2.4.2.1 Physical Form

2.4.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements (e.g., RTV, etc.).

- Material Form No. 1: Solids--any particle size.
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.).
- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see CFR 173.443, Contamination control.)

2.4.2.1.2 Maximum Gross Weight. Form No. 1, No. 2 and No. 3:

- 400 lb.

2.4.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

2.4.2.3 Radiological. The 4-ft drop test caused deformation of the package resulting in a decrease in the distance from the exterior to the center of the package at the top edge of 1.125 in. (approximate). The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such a deformation would occur.

2.4.3 Restrictions/Specifications

For Form No. 1 and No. 2 Contents--RTV sealant (or equivalent) must be applied to the surface of the gasket in contact with the drum body.

For Form No. 3 Contents--No packaging component requirements other than as specified in Section 2.4.1.

The locking ring bolt shall be tightened to 40 $\pm$ 4 ft-lb with tapping of the ring during tightening per the following procedure:

1. Tighten the bolt to 40 ft-lb torque.
2. Hit the closure ring vigorously with a metal hammer, eight to nine times, equally spaced around the ring.
3. Repeat this cycle three additional times.
4. Torque bolt one last time to 40 ft-lb.

A jam nut shall also be used to prevent unintentional loosening during transport.

The cover seal gasket material must have operating range of -40 °F to +158 °F.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

2.4.4 49 CFR 178.350 Regulatory Requirements

Table 2.4-3. Regulatory Compliance Assessment.

2.4.5 Quality Control

Table 2.4-4. Packaging/Acceptance/Use Criteria.

2.4.6 Additional Information

Evaluation and testing of the subject packaging took place at MLM in 1989. A complete test report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

2.4.6.1 Primary User(s):

Site/Contact/Phone	Address
Rocky Flats	**Rocky Flats Plant**
K. Lenarcic	P.O. Box 464
COMM/FTS 303-966-2377	Golden, CO 80402-0464

2.5 DOT-17C 55-GALLON STEEL DRUM, OPTIONAL PRESSURE RELIEF DEVICE AND/OR HIGH-DENSITY POLYETHYLENE LINER (DOCKETS: MLM; 89-13-7A, 01/90; 90-18-7A, 01/91; 94-37-7A, 08/94)

Figure 2-5. DOT-17C 55-Gallon Steel Drum.

Figure 2-6. High-Density Polyethylene Liners for Use with DOT-17C 55-Gallon Steel Drums.

2.5.1 Package Description

Table 2.5-1. Authorized Configurations. (2 pages)

Table 2.5-2. Dimensions.

Table 2.5-3. Materials/Method of Construction. (2 pages)

2.5.2 Authorized Contents

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 DOT-7A compliance with the actual contents.

2.5.2.1 Physical Form

2.5.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

- Material Form No. 1: Solids--any particle size.

Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.).

- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)

2.5.2.1.2 Maximum Gross Weight

- Form No. 1 = 408 kg (900 lb)
- Form No. 2 = 454 kg (1,000 lb)
- Form No. 3 = 454 kg (1,000 lb).

2.5.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

2.5.2.3 Radiological. The 1.2-m (4-ft) drop test caused deformation of the package resulting in a decrease in the distance from the exterior to the center of the package at the bottom chime of 6.35 cm (2.5) in. (approximate). The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such a deformation would occur.

2.5.3 Restrictions/Specifications

The lid-locking ring bolt shall be tightened to 54 $\pm$ 5 Nm (40 $\pm$ 4 ft-lb) torque with tapping of ring during tightening. A jam nut shall also be used to prevent unintentional loosening during transport.

To prevent unintentional loosening, the NucFil filter (if used) shall be:

1. Installed and torqued to 13.6 Nm (10 ft-lb) and tack-welded; or
2. Secured by use of Loctite**(1)** No. 262 (red) and torqued to 13.6 Nm (10 ft-lb); or
3. Torqued to 20.3 Nm (15 ft-lb).

The drum gasket material must have an operating range of -40 °C to 70 °C (-40 °F to +158 °F).

Note: Users are to ensure the appropriate configurations, as provided in **Table 2.5-1** are followed.

If an open Type IV liner is used, a 3.5-mil polyethylene bag may be placed inside the liner to enclose the contents. Any contents that are heavy, sharp objects should be enclosed by a plastic bag (e.g., glovebox bag) that has been enclosed by a secondary plastic bag.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

2.5.4 49 CFR 178.350 Regulatory Requirements

Table 2.5-4. Regulatory Compliance Assessment.

2.5.5 Quality Control

Table 2.5-5. Packaging/Acceptance/Use Criteria.

2.5.6 Additional Information

Evaluation and testing of configurations HF-1, HF-2, LL-1, MD-1, RF-1, RF-2, and RF-3 took place at MLM and were documented in Edling 1987. Westinghouse Hanford performed testing and evaluation to

qualify the vented liner versions of HF-2, LL-1, MD-1 and RF-3 and configuration RF-4 in January 1990 as part of Docket 89-13-7A. Configurations RF-5, RF-6, RF-7 and RF-8 were qualified based on evaluation and extension of test results in January 1991 as part of Docket 90-18-7A. Configuration on LL-2 was vibration and 1.2-m (4-ft) drop tested by Westinghouse Hanford in August 1994 as a part of Docket 94-37-7A. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

2.5.6.1 Primary Users

Site/Contact/Phone	Address
Rocky Flats K. Lenarcic COMM/303-966-2377	**Rocky Flats Plant** P.O. Box 464 Golden, CO 80402-0464
Hanford T. Romano COMM/509-373-0371	Westinghouse Hanford Company P.O. Box 1970 Richland, WA 99352
Lawrence-Livermore National Laboratory K. Hainebach COMM/510-422-4572	**Lawrence-Livermore National Laboratory** P.O. Box 808 Livermore, CA 94550
MLM L. Lamsa COMM/513-865-4182	**EG&G/Mound** Mound Road Miamisburg, OH 45343

2.5.6.2 Suppliers

Liners: HF, MD -	**Meese Incorporated** 1745 Cragmont St. Madison, IN 47250 812-273-1008	RF -	**K&M Plastic** 1601 Pratt Blvd. Elkgrove, IL 60007 708-439-3311 **Plasti-Drum** 1225 Davies Lockport, IL 60441 815-838-7210 **Russell Stanley Co.** 8 Ritter Ave. Woodbridge, NJ 07095 201-634-6000

*Page correction for Vol. 1 document. This will be Rev. 0-E

2.6 DOT-17H 30-GALLON STEEL DRUM, OPTIONAL PRESSURE RELIEF DEVICE (DOCKETS: MLM 90-17-7A, 07/90--90-20-7A, 07/90)

Figure 2-7. DOT-17H 30-Gallon Steel Drum, 49 CFR 178.118.

Figure 2-8. High-Density Polyethylene Liners for Use with DOT-17H 30-Gallon Steel Drums.

2.6.1 Package Description

Table 2.6-1. Authorized Configurations.

Table 2.6-2. Dimensions.

Table 2.6-3. Materials/Method of Construction.

2.6.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

2.6.2.1 Physical Form

2.6.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements (e.g., RTV, etc.).

- Material Form No. 1: Solids--any particle size.
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.).
- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)

2.6.2.1.2 Maximum Gross Weight. Material Forms No. 1, No. 2, and No. 3:

- 400 lb.

2.6.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

2.6.2.3 Radiological. The 4-ft drop test caused deformation of the package resulting in a decrease in the distance from the exterior to the center of the package at the bottom chime of 2.75 in. (approximate). The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such a deformation would occur.

2.6.3 Restrictions/Specifications

Material Form No. 1 contents--RTV must be applied to the seal gasket to body interface when the packaging is used to ship Form No. 1 contents.

The lid locking ring bolt shall be tightened to 40 $\pm$ 4 ft-lb torque with tapping of the ring during tightening. A jam nut shall also be used to prevent unintentional loosening during transport.

The NucFil filter (if used) shall be installed using Loctite No. 262 (Red) and torqued to 5 ft-lb or tack-welded to prevent unintentional loosening.

The drum gasket material must have an operating range of -40 °F to +158 °F.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

2.6.4 49 CFR 178.350 Regulatory Requirements

Table 2.6-4. Regulatory Compliance Assessment.

2.6.5 Quality Control

Table 2.6-5. Packaging/Acceptance/Use Criteria.

2.6.6 Additional Information

Evaluation and testing of configuration OR-1 took place at MLM and was documented in Edling 1987. Westinghouse Hanford qualified configurations AW-1 and FM-1 which utilize filtered drums and inner filtered bags. The testing and evaluation for these packagings was performed in July 1990 as part of Dockets 90-17-7A and 90-20-7A. Complete reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

2.6.6.1 Primary Users

Site/Contact/Phone	Address
Fernald C. E. Block COMM/FTS 513-738-6469	**Westinghouse Materials Company of Ohio** P.O. Box 398704 Cincinnati, OH 45239
Argonne National Laboratory-East (ANL-E) R. Ditch COMM/FTS 708-972-5865	**Argonne National Laboratories** 9700 South Cass Ave. Argonne, IL 60439
Oak Ridge National Laboratory H. E. Crowder COMM/FTS 615-574-2689	**Martin Marietta Energy Systems** Y-12 Plant Oak Ridge, TN 37830

2.7 DOT 17H 55-GALLON STEEL DRUM (DOCKETS: MLM)

Figure 2-9. DOT-17H 55-Gallon Steel Drum.

2.7.1 Package Description

Table 2.7-1. Dimensions.

Table 2.7-2. Materials/Method of Construction.

2.7.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

2.7.2.1 Physical Form

2.7.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate form

for his particular contents and comply with any special requirements (e.g., RTV, etc.).

- Material Form No. 1: Solids--any particle size.
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.).
- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)

2.7.2.1.2 Maximum Gross Weight.

- Form No. 1 = 900 lb
- Form No. 2 = 1,000 lb
- Form No. 3 = 1,000 lb.

2.7.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

2.7.2.3 Radiological. The 4-ft drop test caused deformation of the package resulting in a decrease in the distance from the exterior to the center of the package at the top edge of 3.75 in. (approximate). The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such a deformation would occur.

2.7.3 Restrictions/Specifications

For Form No. 1 Contents--RTV sealant (or equivalent) must be applied to the surface of the gasket in contact with the drum body.

For Form No. 2 and No. 3 Contents--No packaging component requirements other than specified in Section 2.7.1.

The lid closure ring bolt shall be tightened to 40 $\pm$ 4 ft-lb with tapping of ring during tightening. A jam nut shall also be used to prevent unintentional loosening during transport.

The gasket material must have an operating range of -40 °F to +158 °F.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

2.7.4 CFR 173.350 Regulatory Requirements

Table 2.7-3. Regulatory Compliance Assessment.

2.7.5 Quality Control

Table 2.7-4. Packaging/Acceptance/Use Criteria.

2.7.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

2.7.6.1 Primary Users

Site/Contact/Phone	Address
MLM Don Wikstrom COMM/FTS 513-865-3919	**Mound Laboratories** Mound Road Miamisburg, OH 45342
Battelle T. R. Emsweiler 614-879-5165	**Battelle Columbus Laboratories** 505 King Avenue Columbus, OH 43201
ORNL H. E. Crowder COMM/FTS 615-574-2689	**Martin-Marietta Energy Systems, Inc.** P.O. Box Y Oak Ridge Y-12 Plant Oak Ridge, TN 37830

2.8 MILITARY SPECIFICATION (MS) DRUMS--VARIOUS SIZES (DOCKETS: MLM)

Figure 2-10. Steel Drums, Military Specification Containers of Varying Sizes.

2.8.1 Package Description

Table 2.8-1. Dimensions and Weights.

2.8.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

2.8.2.1 Physical Form

2.8.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements (e.g., RTV, etc.).

- Material Form No. 1: Solids--any particle size.
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.).
- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)

2.8.2.1.2 Maximum Gross Weight. See Table 2.8-1, Dimensions and Weights.

2.8.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

2.8.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in decreases in the distance from the exterior to the center of the package (see table below). The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the

undamaged configuration) if such deformations would occur.

2.8.3 Restrictions/Specifications

Table 2.8-2. Restrictions/Specifications.

The bolt closure shall be tightened with tapping of the ring until the lugs begin to bend inward or come together, typically less than 40 ± 4 ft-lb of torque. A jam nut shall also be used to prevent unintentional loosening during transport.

The drum gasket material must have an operating range of -40 °F to +158 °F.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

2.8.4 CFR 173.350 Regulatory Requirements

Table 2.8-3. Regulatory Compliance Assessment.

2.8.5 Quality Control

Table 2.8-4. Packaging/Acceptance/Use Criteria.

2.8.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

2.8.6.1 Primary Users

Site/Contact/Phone	Address
MLM	**EG&G/Mound**
Don Wikstrom	Mound Road
COMM/FTS 513-865-3919	Miamisburg, OH 45342

2.9 SQUARE 71-GALLON STEEL DRUM, PACKAGING SPECIALTIES (DOCKETS: MLM)

Style 1A, 6 1/2-in. Crimped Cover; Style 1B, 6 1/2-in. Crimped Cover; Style 2, 18 1/4-in. Removable Head; Style 3, Fully Removable Head.

Figure 2-11. 71-Gallon Square Steel Drum, 6 1/2-Inch Crimped Cover (Style 1A).

Figure 2-12. 71-Gallon Square Steel Drum, 6 1/2-Inch Crimped Cover (Style 1B).

Figure 2-13. 71-Gallon Square Steel Drum, 18 1/4-Inch Removable Head (Style 2).

Figure 2-14. 71-Gallon Square Steel Drum, Fully Removable Head (Style 3).

2.9.1 Package Description

Table 2.9-1. Dimensions.

Table 2.9-2. Materials/Methods of Construction. (2 pages)

2.9.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

2.9.2.1 Physical Form

2.9.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

- Material Form No. 1: Solids--any particle size.
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.).
- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination Control.)

2.9.2.1.2 Maximum Gross Weight. Form No. 1, No. 2, and No. 3:

- 1,350 lb.

2.9.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

2.9.2.3 Radiological. Maximum dent of 4 in. (Style 1), 3.75 in. (Style 2), or 4.5 in. (Style 3) resulted from the 4-ft drop test on the bottom edge of the packaging. Each shipper must ensure that the radiation level at the surface of the packaging will not increase by more than 20% if such deformations would occur.

2.9.3 Restrictions/Specifications

The bung closure shall be tightened to 15 ft-lb on all styles.

The bolt closure shall be tightened to 30 ft-lb for Style 2 and 15 ft-lb for Style 3.

Tighten the bolt per the following procedure:

1. Tighten the bolt to the designated ft-lb torque.
2. Hit the closure ring vigorously with a metal hammer, 8 to 9 times, equally spaced around the closure ring.
3. Repeat this cycle three additional times.
4. Torque bolt one last time to the designated ft-lb.

A jam nut shall also be used to prevent unintentional loosening during transport.

The seal gasket material must have an operating range of -40 °F to +158 °F.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps), equipment or materials with sharp corners or protrusions, or material/equipment geometries that could result in highly localized forces, the shipper must

ensure that the contents are securely fastened/positioned within the package.

2.9.4 CFR 173.350 Regulatory Requirements

Table 2.9-3. Regulatory Compliance Assessment.

2.9.5 Quality Control

Table 2.9-4. Packaging/Acceptance/Use Criteria.

2.9.6 Additional Information

Evaluation and testing of the subject packaging took place at MLM in 1989. A complete test report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

2.9.6.1 Primary Users

Site/Contact/Phone	Address
West Valley Nuclear Services (WVNS)	**Department of Energy**
Steve Ketola	West Valley Project
COMM/FTS 716-942-4314	West Valley, New York

1.Loctite is a trademark of Loctite Corporation.

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3.0 STEEL BOXES

3.1 CAPITAL INDUSTRIES--FAMILY OF STEEL BOXES (DOCKETS: MLM)

Figure 3-1. Capital Industries, Incorporated, Family of Filtered and Nonfiltered Steel Boxes.

3.1.1 Package Description

Table 3.1-1. Dimensions and Weights.

Table 3.1-2. Materials/Method of Construction.

3.1.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

3.1.2.1 Physical Form

3.1.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

- Material Form No. 1: Solids--any particle size
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.)
- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)

3.1.2.1.2 Maximum Gross Weight. See Table 3.1-1, Dimensions and Weights.

3.1.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

3.1.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

3.1.3 Restrictions/Specifications

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/ containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

3.1.4 49 CFR 178.350 Regulatory Requirements

Table 3.1-3. Regulatory Compliance Assessment.

3.1.5 Quality Control

Table 3.1-4. Packaging/Acceptance/Use Criteria.

3.1.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

3.1.6.1 Primary User(s)

Site/Contact/Phone	Address
MLM	**EG&G/Mound**
Don Wikstrom	Mound Road
COMM/FTS 513-865-3919	Miamisburg, OH 45342

3.1.6.2 Suppliers

Capital Industries, Inc.
5801 3rd Avenue, S.
P.O. Box 80983
Seattle, WA 98108
206-762-8585

3.2 CONTAINER PRODUCTS CORPORATION--FAMILY OF STEEL BOXES (DOCKETS: MLM)

Figure 3-2. Container Products Corporation, Family of Filtered and Nonfiltered Steel Boxes.

3.2.1 Package Description

Table 3.2-1. Dimensions and Weights.

Table 3.2-2. Materials/Method of Construction.

3.2.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

3.2.2.1 Physical Form

3.2.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

- Material Form No. 1: Solids--any particle size
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.)
- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)

3.2.2.1.2 Maximum Gross Weight. See Table 3.2-1, Dimensions and Weights.

3.2.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

3.2.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

3.2.3 Restrictions/Specifications

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/ containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

3.2.4 49 CFR 178.350 Regulatory Requirements

Table 3.2-3. Regulatory Compliance Assessment.

3.2.5 Quality Control

Table 3.2-4. Packaging/Acceptance/Use Criteria.

3.2.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

3.2.6.1 Primary User(s)

Site/Contact/Phone	Address
DOE T. G. Adams 716-942-3235	**U.S. Department of Energy** Idaho Operations Office West Valley Project Office P.O. Box 191 West Valley, NY 14171

3.2.6.2 Suppliers

Container Products Corp.
P.O. Box 3767
Wilmington, NC 28406
COMM 919-392-6100

3.3 ROGAR FAMILY OF STEEL BOXES (DOCKETS: MLM)

Figure 3-3. RoGar Chemical and Nuclear Services, Family of Steel Boxes.

3.3.1 Package Description

Table 3.3-1. Dimensions and Weights.

Table 3.3-2. Materials/Method of Construction.

3.3.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

3.3.2.1 Physical Form

3.3.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

- Material Form No. 1: Solids--any particle size
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.)
- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)

3.3.2.1.2 Maximum Gross Weight. See Table 3.3-1, Dimensions and Weights.

3.3.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

3.3.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

3.3.3 Restrictions/Specifications

Lifting rings are for placement of the lid only. Procedures and training must ensure that these are rendered inoperable prior to shipment (i.e., welded in place, cut off, etc.).

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/ containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

3.3.4 49 CFR 178.350 Regulatory Requirements

Table 3.3-3. Regulatory Compliance Assessment.

3.3.5 Quality Control

Table 3.3-4. Packaging/Acceptance/Use Criteria.

3.3.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

3.3.6.1 Primary User(s)

Site/Contact/Phone	Address
MLM	**EG&G/Mound**
Don Wikstrom	Mound Road
COMM/FTS 513-865-3919	Miamisburg, OH 45342

3.3.6.2 Suppliers

RoGar Chemical & Nuclear Services, Inc.
582 Mayten Drive
Livermore, CA 94550
415-443-6101

3.4 ROCKY FLATS SAND BOX--STEEL BOX (DOCKETS: MLM)

Figure 3-4. Rocky Flats SAND Box Steel Box.

3.4.1 Package Description

Table 3.4-1. Dimensions and Weights.

Table 3.4-2. Materials/Method of Construction.

3.4.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

3.4.2.1 Physical Form

3.4.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

- Material Form No. 1: Solids--any particle size
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.)
- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)

3.4.2.1.2 Maximum Gross Weight. See Table 3.4-1, Dimensions and Weights.

3.4.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

3.4.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

3.4.3 Restrictions/Specifications

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/ containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

3.4.4 49 CFR 178.350 Regulatory Requirements

Table 3.4-3. Regulatory Compliance Assessment.

3.4.5 Quality Control

Table 3.4-4. Packaging/Acceptance/Use Criteria.

3.4.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

3.4.6.1 Primary User(s)

Site/Contact/Phone	Address
Rocky Flats	**Rocky Flats Plant**
K. Lenarcic	P.O. Box 464
COMM/FTS 303-966-2377	Golden, Colorado 80402-0464

3.5 ANL M-4 STEEL BIN (DOCKETS: MLM)

Figure 3-5. ANL M-4 Bin Steel Box.

3.5.1 Package Description

Table 3.5-1. Dimensions.

Table 3.5-2. Materials/Method of Construction.

3.5.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

3.5.2.1 Physical Form

3.5.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

- Material Form No. 1: Solids--any particle size
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.)
- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)

3.5.2.1.2 Maximum Gross Weight. 3,000 lb. (Based on limitation of overpack used. It is expected that the bin would pass with a much higher gross weight.)

3.5.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

3.5.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

3.5.3 Restrictions/Specifications

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/ containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

3.5.4 49 CFR 178.350 Regulatory Requirements

Table 3.5-3. Regulatory Compliance Assessment.

3.5.5 Quality Control

Table 3.5-4. Packaging/Acceptance/Use Criteria.

3.5.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

3.5.6.1 Primary User(s)

Site/Contact/Phone	Address
ANL	**Argonne National Laboratory**
C. L. Cheever	9700 South Cass Avenue
COMM/FTS 708-252-3311	Argonne, IL 60439

3.6 ANL-WEST STEEL BOX (DOCKETS: MLM)

Figure 3-6. ANL-West 7A-960 Steel Box.

3.6.1 Package Description

Table 3.6-1. Dimensions.

Table 3.6-2. Materials/Method of Construction.

3.6.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

3.6.2.1 Physical Form

3.6.2.1.1 Solids Only. Only one form is authorized:

- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)

3.6.2.1.2 Maximum Gross Weight. 960 lb. (Empty packaging weight--885 lb, net contents--75 lb.)

3.6.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

3.6.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

3.6.3 Restrictions/Specifications

The following two possible approaches are acceptable with respect to addressing inleakage and ensuring that there is no transport of radioactive materials out of the packaging.

- Securely enclose the radioactive contents within the box (i.e., wrapped and sealed in plastic, etc.) so that any inleaking water cannot come in contact with the radioactive material.

- Ensure that there is no loose or removable contamination that could be entrained in any liquid and that the radioactive material is not soluble in the liquid. Thus, even if the liquids come in contact with the radioactive material, there could be no transport from the package.

NOTE: There are obviously other possible approaches; however, if an alternative approach is chosen, the basis for the choice must be supported and documented. Using one of these alternatives or an equivalent

method allows these boxes to meet this requirement.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/ containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

3.6.4 49 CFR 173.850 Regulatory Requirements

Table 3.6-3. Regulatory Compliance Assessment.

3.6.5 Quality Control

Table 3.6-4. Packaging/Acceptance/Use Criteria.

3.6.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

3.6.6.1 Primary User(s)

Site/Contact/Phone	Address
ANL	**Argonne National Laboratory--West**
Max Geisler	P.O. Box 2528
COMM/FTS 208-526-7727	Idaho Falls, ID 83403-2528

3.7 TRUPACT-II STANDARD WASTE BOX (DOCKETS: MLM; 89-07-7A, 09/89)

NOTE: Information for the Standard Waste Box designs discussed in this section are applicable for revisions up to and including Revision E (Westinghouse Electric Drawing No. 165-F-001-W). For current design, test, and evaluation information, see DOE/RL-96-57, Vol. 2, Section 3.2.

Figure 3-7. TRUPACT-II Standard Waste Box, Style 1, Bolted Closure.

3.7.1 Package Description

Table 3.7-1. Dimensions and Weights.

Table 3.7-2. Materials/Method of Construction.

3.7.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

3.7.2.1 Physical Form

3.7.2.1.1 Solids Only. Five forms are authorized. Each shipper must determine the most appropriate form for

his particular contents.

- Material Form No. 1: Solids--any particle size
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.)
- Material Form No. 3: Solids--objects with no significant or removable contamination. (For definition see 49 CFR 173.443, Contamination control.)
- Material Form No. 4: Solids as described in Form No. 3 above, including large, bulky, dense objects with sharp and obtrusive members or components, but having Form No. 1 and/or No. 2 as dispersible contaminates associated with the material (e.g., steel plates, motors, valves, steel pipes, concrete blocks, etc.).
- Material Form No. 5: Four 55-gal drums (in any arrangement not exceeding 1,000 lb per drum) and overpacked within the standard waste box (SWB).

3.7.2.1.2 Maximum Gross Weight.

- 4,000 lb.

3.7.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

3.7.2.3 Radiological. A dent (approximately 4 in.) resulted from the 4-ft drop test on the bottom edge. The shipper must ensure that the radiation level at the surface of the package will not increase by more than 20% if such a deformation would occur.

3.7.3 Restrictions/Specifications

The SWB shall be operated in accordance with the Westinghouse/Waste Isolation Division instruction entitled, *Acceptance/Use Instruction Sheet for the TRUPACT-II Standard Waste Box - Bolted Lid Style* (WID 1989).

The lid closure bolts must be torqued to a minimum of 50 ft-lb.

The cover seal gasket material must have an operating range of -40 °F to 158 °F.

For heavy, bulky materials (e.g., concrete chunks, motors, and pumps), equipment or materials with sharp corners or protrusions, or material/ equipment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

3.7.4 49 CFR 173.350 Regulatory Requirements

Table 3.7-3. Regulatory Compliance Assessment.

3.7.5 Quality Control

Table 3.7-4. Packaging/Acceptance/Use Criteria.

3.7.6 Additional Information

Evaluation and testing of the subject packaging took place at MLM in 1989. A complete test report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

3.7.6.1 Primary User(s)

Site/Contact/Phone	Address
Waste Isolation Pilot Plant	**Westinghouse/Waste Isolation Division**
M. L. Caviness	P.O. Box 2078
(505) 234-7463	Carlsbad, NM 88221

3.8 ORNL LOW-LEVEL WASTE CONTAINER (DOCKETS: 89-04-7A, 10/90)

Figure 3-8. ORNL Low-Level Waste Container.

3.8.1 Package Description

Table 3.8-1. Dimensions and Weights.

Table 3.8-2. Materials/Method of Construction.

3.8.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

3.8.2.1 Physical Form

3.8.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

- Material Form No. 1: Solids--any particle size
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.)
- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)

3.8.2.1.2 Weights

	Vented	Nonvented
Payload weight	7,000 lb	9,000 lb
Maximum gross weight	8,150 lb	10,230 lb

3.8.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

3.8.2.3 Radiological. The shipper shall ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level prior to the test) as a result of the decrease in distance to the center of the package resulting from the 4-ft drop test. The decrease in distance to the center of the package as a result of testing was 4 3/4 in. for the vented container and 1 1/2 in. for the nonvented container.

3.8.3 Restrictions/Specifications

Operation of the subject packagings shall be in accordance with one of the following procedures (as applicable):

- *Operations, Maintenance and Inspection Procedure for DOT-7A Type A K1401-7V Low Level Waste Container (Vented)* (Holbrook 1991a)
- *Operations, Maintenance and Inspection Procedure for DOT-7A Type A K1401-9NV Low Level Waste Container," (Non-vented)* (Holbrook 1991b)

The lid closure gasket material shall have an operating range of -40 °F to 158 °F.

Torquing requirements shall be 30 ± 3 ft-lb for the 3/8-in. bolts and 40 $\pm$ 4 ft-lb for the 1/2-in. bolts.

The NucFil filter (if used) shall be installed and torqued to 10 ft-lb and tack-welded to prevent unintentional loosening.

For heavy, bulky materials (e.g., concrete chunks, motors, and pumps), equipment or materials with sharp corners or protrusions, or material/ equipment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

3.8.4 49 CFR 178.350 Regulatory Requirements

Table 3.8-3. Regulatory Compliance Assessment.

3.8.5 Quality Control

Table 3.8-4. Packaging/Acceptance/Use Criteria.

3.8.6 Additional Information

The packagings were evaluated and tested by Westinghouse Hanford as part of Docket 89-04-7A. Testing was completed on Model K1401-7V (vented) in June 1990 and in October 1990 for Model K1401-9NV (nonvented). A complete test report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

3.8.6.1 Primary User(s)

Site/Contact/Phone	Address
ORNL	**Oak Ridge National Laboratory**
R. H. Holbrook	Martin Marietta Energy Systems, Inc.
COMM/FTS 615-576-9182	P.O. Box 2003
	Oak Ridge, Tennessee 37831-7365

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Privacy & Security Notice

4.0 WOODEN BOXES

4.1 ANL-WEST FAMILY OF WOODEN BOXES (DOCKETS: MLM)

Figure 4-1. ANL-West 7A-217 Wooden Box (contents restricted, see Section 4.1.3).

Figure 4-2. ANL-West 7A-375 Wooden Box (contents restricted, see Section 4.1.3).

Figure 4-3. ANL-West 7A-670 Wooden Box (contents restricted, see Section 4.1.3).

Figure 4-4. ANL-West 7A-880 Wooden Box (contents restricted, see Section 4.1.3).

Figure 4-5. ANL-West 7A-995 Wooden Box. (contents restricted, see Section 4.1.3).

Figure 4-6. ANL-West 7A-1315 Wooden Box (contents restricted, see Section 4.1.3).

4.1.1 Package Description

Table 4.1-1. Dimensions and Weights.

4.1.1.1 Materials/Method of Construction. All appropriate information is given in Figures 4-1 through 4-6.

4.1.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

4.1.2.1 Physical Form

4.1.2.1.1 Solids Only. One material form is authorized:

- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.433, Contamination control.)

4.1.2.1.2 Maximum Gross Weight. See Table 4.1-1, Dimensions and Weights.

4.1.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

4.1.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged

configuration) if such deformations would occur.

4.1.3 Restrictions/Specifications

The following three possible approaches are acceptable with respect to addressing inleakage and ensuring that there is no transport of radioactive materials out of the packaging.

- Securely enclose the radioactive contents within the box (e.g., wrap and seal in plastic, etc.) so that any inleaking water cannot come in contact with the radioactive material.
- Seal the box using GEOCEL[(1)] or its equivalent. If the box is reused, it must be re-coated with at least one coat to cover the seal areas before each shipment.
- The third approach is to ensure that there is no loose or removable contamination that could be entrained in any liquid and that the radioactive material is not soluble in the liquid. Thus, even if the liquids come in contact with the radioactive material, there could be no transport from the package.

NOTE: There are obviously other possible approaches; however, if an alternative approach is chosen, the basis for the choice must be supported and documented. Using one of these alternatives or an equivalent method allows these wooden boxes to meet this requirement.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

4.1.4 49 CFR 178.350 Regulatory Requirements

Table 4.1-2. Regulatory Compliance Assessment.

4.1.5 Quality Control

Table 4.1-3. Packaging/Acceptance/Use Criteria.

4.1.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

4.1.6.1 Primary Users

Site/Contact/Phone	Address
Argonne National Laboratory-West (ANL-W)	**Argonne National Laboratory**
M. C. Geisler	P.O. Box 2528
COMM/FTS 208-526-0111	Idaho Falls, ID 83401
COMM/FTS 208-533-7666	

4.1.6.2 Supplier. Manufactured by Argonne National Laboratory-West.

4.2 LLNL FLUSH PANEL WOODEN BOX (DOCKETS: MLM)

Figure 4-7. LLNL Flush Panel Wooden Box (contents restricted, see Section 4.2.3).

4.2.1 Package Description

Table 4.2-1. Dimensions.

Table 4.2-2. Materials/Method of Construction.

4.2.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

4.2.2.1 Physical Form

4.2.2.1.1 Solids Only. Two material forms are authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.)
- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.433, Contamination control.)

4.2.2.1.2 Maximum Gross Weight

- 2,500 lb.

4.2.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

4.2.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

4.2.3 Restrictions/Specifications

The following three possible approaches are acceptable with respect to addressing inleakage and ensuring that there is no transport of radioactive materials out of the packaging.

- Securely enclose the radioactive contents within the box (e.g., wrap and seal in plastic, etc.) so that any inleaking water cannot come in contact with the radioactive material.
- Seal the box using GEOCEL or its equivalent. If the box is reused, it must be re-coated with at least one coat to cover the seal areas before each shipment.
- Ensure that there is no loose or removable contamination that could be entrained in any liquid and that the radioactive material is not soluble in the liquid. Thus, even if the liquids come in contact with the radioactive material, there could be no transport from the package.

NOTE: There are obviously other possible approaches; however, if an alternative approach is chosen, the basis for the choice must be supported and documented. Using one of these alternatives or an equivalent method allows these wooden boxes to meet this requirement.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

4.2.4 49 CFR 178.350 Regulatory Requirements

Table 4.2-3. Regulatory Compliance Assessment.

4.2.5 Quality Control

Table 4.2-4. Packaging/Acceptance/Use Criteria.

4.2.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

4.2.6.1 Primary Users

Site/Contact/Phone	Address
LLNL	**University of California**
Irene Meisel	Lawrence Livermore National Laboratory
COMM/FTS 510-422-5448	P.O. Box 808
	Livermore, CA 94550

4.3 MOUND WOODEN BOX - CONFIGURATION A (DOCKETS: MLM)

Figure 4-8. Configuration A Light Duty Wooden Box (contents restricted, see Section 4.3.3).

4.3.1 Package Description

Table 4.3-1. Dimensions and Weights.

Table 4.3-2. Materials/Method of Construction.

4.3.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

4.3.2.1 Physical Form

4.3.2.1.1 Solids Only. Two material forms are authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

- Material Form No. 2: Solids--large particle size (e.g., sand, concrete, debris, soil, etc.)

Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.433, Contamination control.)

4.3.2.1.2 Maximum Gross Weight. See Table 4.3-1, Dimensions and Weights.

4.3.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

4.3.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

4.3.3 Restrictions/Specifications

The following three possible approaches are acceptable with respect to addressing inleakage and ensuring that there is no transport of radioactive materials out of the packaging.

- Securely enclose the radioactive contents within the box (e.g., wrap and seal in plastic, etc.) so that any inleaking water cannot come in contact with the radioactive material.
- Seal the box using GEOCEL or its equivalent. If the box is reused, it must be re-coated with at least one coat to cover the seal areas before each shipment.
- Ensure that there is no loose or removable contamination that could be entrained in any liquid and that the radioactive material is not soluble in the liquid. Thus, even if the liquids come in contact with the radioactive material, there could be no transport from the package.

NOTE: There are obviously other possible approaches; however, if an alternative approach is chosen, the basis for the choice must be supported and documented. Using one of these alternatives or an equivalent method allows these wooden boxes to meet this requirement.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

4.3.4 49 CFR 178.350 Regulatory Requirements

Table 4.3-3. Regulatory Compliance Assessment.

4.3.5 Quality Control

Table 4.3-4. Packaging/Acceptance/Use Criteria.

4.3.6 Additional Information

Evaluation and testing of this packaging performed at MLM were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

4.3.6.1 Primary Users

Site/Contact/Phone	Address

MLM	**Mound-MRC**
Don Wikstrom	P.O. Box 32
COMM/FTS 513-865-3919	Mound Road
	Miamisburg, OH 45342

4.3.6.2 Supplier. Manufactured onsite.

4.4 MOUND WOODEN BOX - CONFIGURATION B (DOCKETS: MLM)

Figure 4-9. Configuration B Medium Duty Wooden Box (contents restricted, see Section 4.4.3).

4.4.1 Package Description

Table 4.4-1. Dimensions and Weights.

Table 4.4-2. Materials/Method of Construction.

4.4.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

4.4.2.1 Physical Form

4.4.2.1.1 Solids Only. Two material forms are authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.)
- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.433, Contamination control.)

4.4.2.1.2 Maximum Gross Weight. See Table 4.4-1, Dimension and Weights.

4.4.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

4.4.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

4.4.3 Restrictions/Specifications

The following three possible approaches are acceptable with respect to addressing inleakage and ensuring that there is no transport of radioactive materials out of the packaging.

- Securely enclose the radioactive contents within the box (e.g., wrap and seal in plastic, etc.) so that any inleaking water cannot come in contact with the radioactive material.

- Seal the box using GEOCEL or its equivalent. If the box is reused, it must be re-coated with at least one coat to cover the seal areas before each shipment.

- Ensure that there is no loose or removable contamination that could be entrained in any liquid and that the radioactive material is not soluble in the liquid. Thus, even if the liquids come in contact with the radioactive material, there could be no transport from the package.

NOTE: There are obviously other possible approaches; however, if an alternative approach is chosen, the basis for the choice must be supported and documented. Using one of these alternatives or an equivalent method allows these wooden boxes to meet this requirement.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

4.4.4 49 CFR 178.350 Regulatory Requirements

Table 4.4-3. Regulatory Compliance Assessment.

4.4.5 Quality Control

Table 4.4-4. Packaging/Acceptance/Use Criteria.

4.4.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling in 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

4.4.6.1 Primary Users

Site/Contact/Phone	Address
MLM	**Mound-MRC**
Don Wikstrom	P.O. Box 32
COMM/FTS 513-865-3919	Mound Road
	Miamisburg, OH 45342

4.4.6.2 Supplier. Manufactured onsite.

4.5 MOUND WOODEN BOX - CONFIGURATION C (DOCKETS: MLM)

Figure 4-10. Configuration C Medium Duty Wooden Box (contents restricted, see Section 4.5.3).

4.5.1 Package Description

Table 4.5-1. Dimensions and Weights.

Table 4.5-2. Materials/Method of Construction.

4.5.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

4.5.2.1 Physical Form

4.5.2.1.1 Solids Only. Two material forms are authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.)
- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.433, Contamination control.)

4.5.2.1.2 Maximum Gross Weight. See the Table 4.5-1, Dimensions and Weights.

4.5.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

4.5.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

4.5.3 Restrictions/Specifications

The following three possible approaches are acceptable with respect to addressing inleakage and ensuring that there is no transport of radioactive materials out of the packaging.

- Securely enclose the radioactive contents within the box (e.g., wrap and seal in plastic, etc.) so that any inleaking water cannot come in contact with the radioactive material.
- Seal the box using GEOCEL or its equivalent. If the box is reused, it must be re-coated with at least one coat to cover the seal areas before each shipment.
- Ensure that there is no loose or removable contamination that could be entrained in any liquid and that the radioactive material is not soluble in the liquid. Thus, even if the liquids come in contact with the radioactive material, there could be no transport from the package.

NOTE: There are obviously other possible approaches; however, if an alternative approach is chosen, the basis for the choice must be supported and documented. Using one of these alternatives or an equivalent method allows these wooden boxes to meet this requirement.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

4.5.4 49 CFR 178.350 Regulatory Requirements

Table 4.5-3. Regulatory Compliance Assessment.

4.5.5 Quality Control

Table 4.5-4. Packaging/Acceptance/Use Criteria.

4.5.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

4.5.6.1 Primary Users

Site/Contact/Phone	Address
MLM	**Mound-MRC**
Don Wikstrom	P.O. Box 32
COMM/FTS 513-865-3919	Mound Road
	Miamisburg, OH 45342

4.5.6.2 Supplier. Manufactured onsite.

4.6 MOUND WOODEN BOX - CONFIGURATION D (DOCKETS: MLM)

Figure 4-11. Configuration D Heavy Duty Wooden Box (contents restricted, see Section 4.6.3).

4.6.1 Package Description

Table 4.6-1. Dimensions and Weights.

Table 4.6-2. Materials/Method of Construction.

4.6.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

4.6.2.1 Physical Form

4.6.2.1.1 Solids Only. Two material forms are authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.)
- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.433, Contamination control.)

4.6.2.1.2 Maximum Gross Weight. See Table 4.6-1, Dimensions and Weights.

4.6.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

4.6.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged

configuration) if such deformations would occur.

4.6.3 Restrictions/Specifications

The following three possible approaches are acceptable with respect to addressing inleakage and ensuring that there is no transport of radioactive materials out of the packaging.

- Securely enclose the radioactive contents within the box (e.g., wrap and seal in plastic, etc.) so that any inleaking water cannot come in contact with the radioactive material.
- Seal the box using GEOCEL or its equivalent. If the box is reused, it must be re-coated with at least one coat to cover the seal areas before each shipment.
- Ensure that there is no loose or removable contamination that could be entrained in any liquid and that the radioactive material is not soluble in the liquid. Thus, even if the liquids come in contact with the radioactive material, there could be no transport from the package.

NOTE: There are obviously other possible approaches; however, if an alternative approach is chosen, the basis for the choice must be supported and documented. Using one of these alternatives or an equivalent method allows these wooden boxes to meet this requirement.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

4.6.4 49 CFR 178.350 Regulatory Requirements

Table 4.6-3. Regulatory Compliance Assessment.

4.6.5 Quality Control

Table 4.6-4. Packaging/Acceptance/Use Criteria.

4.6.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

4.6.6.1 Primary Users

Site/Contact/Phone	Address
MLM	**Mound-MRC**
Don Wikstrom	P.O. Box 32
COMM/FTS 513-865-3919	Mound Road
	Miamisburg, OH 45342

4.6.6.2 Supplier. Manufactured onsite.

4.7 MOUND WOODEN BOX - CONFIGURATION E (DOCKETS: MLM)

Figure 4-12. Configuration E-150 Wooden Box (contents restricted, see Section 4.7.3).

4.7.1 Package Description

Table 4.7-1. Dimensions.

Table 4.7-2. Materials/Method of Construction.

4.7.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

4.7.2.1 Physical Form

4.7.2.1.1 Solids Only. Two material forms are authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.)
- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.433, Contamination control.)

4.7.2.1.2 Maximum Gross Weight

- 150 lb.

4.7.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

4.7.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

4.7.3 Restrictions/Specifications

The following three possible approaches are acceptable with respect to addressing inleakage and ensuring that there is no transport of radioactive materials out of the packaging.

- Securely enclose the radioactive contents within the box (e.g., wrap and seal in plastic, etc.) so that any inleaking water cannot come in contact with the radioactive material.
- Seal the box using GEOCEL or its equivalent. If the box is reused, it must be re-coated with at least one coat to cover the seal areas before each shipment.
- Ensure that there is no loose or removable contamination that could be entrained in any liquid and that the radioactive material is not soluble in the liquid. Thus, even if the liquids come in contact with the radioactive material, there could be no transport from the package.

NOTE: There are obviously other possible approaches; however, if an alternative approach is chosen, the basis for the choice must be supported and documented. Using one of these alternatives or an equivalent method allows these wooden boxes to meet this requirement.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

4.7.4 49 CFR 178.350 Regulatory Requirements

Table 4.7-3. Regulatory Compliance Assessment.

4.7.5 Quality Control

Table 4.7-4. Packaging/Acceptance/Use Criteria.

4.7.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

4.7.6.1 Primary Users

Site/Contact/Phone	Address
MLM	**Mound-MRC**
Don Wikstrom	P.O. Box 32
COMM/FTS 513-865-3919	Mound Road
	Miamisburg, OH 45342

4.7.6.2 Suppliers. Manufactured onsite.

4.8 NLO FAMILY OF BANDED, WOODEN BOXES (DOCKETS: MLM)

Figure 4-13. NLO Family of Banded, Wooden Boxes (contents restricted, see Section 4.8.3).

Figure 4-14. NLO Family of Banded, Wooden Boxes (contents restricted, see Section 4.8.3).

Figure 4-15. NLO Family of Banded, Wooden Boxes (contents restricted, see Section 4.8.3).

Figure 4-16. NLO Family of Banded, Wooden Boxes (contents restricted, see Section 4.8.3).

Figure 4-17. NLO Family of Banded, Wooden Boxes (contents restricted, see Section 4.8.3).

4.8.1 Package Description

Table 4.8-1. Dimensions and Weights.

Table 4.8-2. Materials/Method of Construction.

4.8.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not,

testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

4.8.2.1 Physical Form

4.8.2.1.1 Solids Only. One material form is authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.433, Contamination control.)

4.8.2.1.2 Maximum Gross Weight. See Table 4.8-1, Dimensions and Weights.

4.8.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

4.8.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

4.8.3 Restrictions/Specifications

The following three possible approaches are acceptable with respect to addressing inleakage and ensuring that there is no transport of radioactive materials out of the packaging.

- Securely enclose the radioactive contents within the box (e.g., wrap and seal in plastic, etc.) so that any inleaking water cannot come in contact with the radioactive material.
- Seal the box using GEOCEL or its equivalent. If the box is reused, it must be re-coated with at least one coat to cover the seal areas before each shipment.
- Ensure that there is no loose or removable contamination that could be entrained in any liquid and that the radioactive material is not soluble in the liquid. Thus, even if the liquids come in contact with the radioactive material, there could be no transport from the package.

NOTE: There are obviously other possible approaches; however, if an alternative approach is chosen, the basis for the choice must be supported and documented. Using one of these alternatives or an equivalent method allows these wooden boxes to meet this requirement.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

4.8.4 49 CFR 178.350 Regulatory Requirements

Table 4.8-3. Regulatory Compliance Assessment.

4.8.5 Quality Control

Table 4.8-4. Packaging/Acceptance/Use Criteria.

4.8.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

4.8.6.1 Primary Users

Site/Contact/Phone	Address
Fernald	**Westinghouse Materials Company of Ohio**
L. C. Dolan	P.O. Box 398704
COMM/FTS 513-738-6208	Cincinnati, OH 45239
C. E. Block	
COMM/FTS 513-763-1151	

4.9 Y-12 SERIES B WOODEN BOXES (DOCKETS: MLM)

Figure 4-18. Y-12 Series B Wooden Boxes (contents restricted, see Section 4.9.3).

4.9.1 Package Description

Table 4.9-1. Dimensions.

Table 4.9-2. Materials/Methods of Construction.

4.9.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

4.9.2.1 Physical Form

4.9.2.1.1 Solids Only. One material form is authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.433, Contamination control.)

4.9.2.1.2 Maximum Gross Weight

- 400 lb.

4.9.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

4.9.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

4.9.3 Restrictions/Specifications

The following three possible approaches are acceptable with respect to addressing inleakage and ensuring that there is no transport of radioactive materials out of the packaging.

- Securely enclose the radioactive contents within the box (e.g., wrap and seal in plastic, etc.) so that any inleaking water cannot come in contact with the radioactive material.
- Seal the box using GEOCEL or its equivalent. If the box is reused, it must be re-coated with at least one coat to cover the seal areas before each shipment.
- Ensure that there is no loose or removable contamination that could be entrained in any liquid and that the radioactive material is not soluble in the liquid. Thus, even if the liquids come in contact with the radioactive material, there could be no transport from the package.

NOTE: There are obviously other possible approaches; however, if an alternative approach is chosen, the basis for the choice must be supported and documented. Using one of these alternatives or an equivalent method allows these wooden boxes to meet this requirement.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

4.9.4 49 CFR 178.350 Regulatory Requirements

Table 4.9-3. Regulatory Compliance Assessment.

4.9.5 Quality Control

Table 4.9-4. Packaging/Acceptance/Use Criteria.

4.9.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

4.9.6.1 Primary Users

Site/Contact/Phone	Address
ORNL	**Martin Marietta Energy Systems, Inc.**
H. E. Crowder	P.O. Box Y
COMM/FTS 615-574-2689	Oak Ridge Y-12 Plant
	Oak Ridge, TN 37830

4.10 Y-12 PICTURE FRAME WOODEN BOXES (DOCKETS: MLM, 89-12-7A, 06/91)

Figure 4-19. Y-12 Picture Frame Wooden Box (contents restricted, see Section 4.10.3).

4.10.1 Package Description

Table 4.10-1. Dimensions and Weights.

Table 4.10-2. Materials/Method of Construction.

4.10.1.1 Drawings. MMES Drawing No. T2E-125268 (PF-1 through PF-8) and No. T2E-800530A014 (PF-10).

4.10.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

4.10.2.1 Physical Form

4.10.2.1.1 Solids Only. One material form is authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.433, Contamination control.)

4.10.2.1.2 Maximum Gross Weight. See Table 4.10-1, Dimensions and Weights.

4.10.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

4.10.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

4.10.3 Restrictions/Specifications

The following two possible approaches are acceptable with respect to addressing inleakage and ensuring that there is no transport of radioactive materials out of the packaging.

- Securely enclose the radioactive contents within the box (e.g., wrap and seal in plastic, etc.) so that any inleaking water cannot come in contact with the radioactive material.
- Seal the box using GEOCEL or its equivalent. If the box is reused, it must be re-coated with at least one coat to cover the seal areas before each shipment.

NOTE: There are obviously other possible approaches; however, if an alternative approach is chosen, the basis for the choice must be supported and documented. Using one of these alternatives or an equivalent method allows these wooden boxes to meet this requirement.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

4.10.4 49 CFR 178.350 Regulatory Requirements

Table 4.10-3. Regulatory Compliance Assessment.

4.10.5 Quality Control

Table 4.10-4. Packaging/Acceptance/Use Criteria.

4.10.6 Additional Information

Evaluation and testing of packaging Model Nos. PF-1 through PF-8 were performed at MLM and were documented in Edling 1987. Evaluation and testing of Model PF-10 took place at Westinghouse Hanford as part of Docket 89-12-7A with testing completed in June 1991. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

4.10.6.1 Primary Users

Site/Contact/Phone	Address
ORNL	**Martin Marietta Energy Systems, Inc.**
J. C. Copeland	P.O. Box Y
COMM/FTS 615-574-2689	Oak Ridge Y-12 Plant
	Oak Ridge, TN 37830
H. E. Turner	
COMM/FTS 615-574-2688	

4.11 ROCKY FLATS RA SERIES OF WOODEN BOXES (DOCKETS: MLM)

Figure 4-20. Rocky Flats RA Series Wooden Boxes (contents restricted, see Section 4.11.3).

4.11.1 Package Description

Table 4.11-1. Dimensions.

Table 4.11-2. Materials/Method of Construction.

4.11.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

4.11.2.1 Physical Form

4.11.2.1.1 Solids Only. One material form is authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.433, Contamination control.)

4.11.2.1.2 Maximum Gross Weight

- Configuration 1--900 lb
- Configuration 2--1,250 lb.

4.11.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be

shipped with the materials of the packaging in contact with the payload.

4.11.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

4.11.3 Restrictions/Specifications

The following three possible approaches are acceptable with respect to addressing inleakage and ensuring that there is no transport of radioactive materials out of the packaging.

- Securely enclose the radioactive contents within the box (e.g., wrap and seal in plastic, etc.) so that any inleaking water cannot come in contact with the radioactive material.
- Seal the box using GEOCEL or its equivalent. If the box is reused, it must be re-coated with at least one coat to cover the seal areas before each shipment.
- Ensure that there is no loose or removable contamination that could be entrained in any liquid and that the radioactive material is not soluble in the liquid. Thus, even if the liquids come in contact with the radioactive material, there could be no transport from the package.

NOTE: There are obviously other possible approaches; however, if an alternative approach is chosen, the basis for the choice must be supported and documented. Using one of these alternatives or an equivalent method allows these wooden boxes to meet this requirement.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

4.11.4 49 CFR 178.350 Regulatory Requirements

Table 4.11-3. Regulatory Compliance Assessment.

4.11.5 Quality Control

Table 4.11-4. Packaging/Acceptance/Use Criteria.

4.11.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

4.11.6.1 Primary Users

Site/Contact/Phone	Address
Rocky Flats	**Rocky Flats Plant**
K. Lenarcic	P.O. Box 464
COMM/FTS 303-966-2377	Golden, CO 80402-0464

4.12 WMCO FAMILY OF BANDED, WOODEN BOXES

(DOCKETS: MLM, 89-09-7A, 09/90)

Figure 4-21. WMCO Family of Banded, Wooden Boxes (contents restricted, see Section 4.12.3).

Figure 4-22. WMCO Family of Banded, Wooden Boxes (contents restricted, see Section 4.12.3).

Figure 4-23. WMCO Family of Banded, Wooden Boxes (contents restricted, see Section 4.12.3).

Figure 4-24. WMCO Family of Banded, Wooden Boxes (contents restricted, see Section 4.12.3).

Figure 4-25. WMCO Family of Banded, Wooden Boxes (contents restricted, see Section 4.12.3).

4.12.1 Package Description

Table 4.12-1. Dimensions and Weights.

Table 4.12-2. Materials/Method of Construction.

4.12.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

4.12.2.1 Physical Form

4.12.2.1.1 Solids Only. Restricted to Material Form No. 3 only. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)

4.12.2.1.2 Maximum Gross Weight. See Table 4.12-1, Dimensions and Weights.

4.12.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

4.12.2.3 Radiological. The decrease in distance to the center of the package as a result of exposure to a 4-ft drop was estimated for each model as follows:

Table 4.12-3. Four-Foot Drop Test Estimates.

These estimates were based on comparison with damage that occurred during testing of similar packages. The shipper shall ensure that the radiation level at any surface of the packaging would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

4.12.3 Restrictions/Specifications

The loaded package must be banded as shown in Figures 4-21 through 4-25.

The following three possible approaches are acceptable with respect to addressing inleakage and ensuring that there is no transport of radioactive materials out of the packaging.

- Securely enclose the radioactive contents within the box (e.g., wrap and seal in plastic, etc.) so that any

inleaking water cannot come in contact with the radioactive material.

- Seal the box using GEOCEL or its equivalent. If the box is reused, it must be re-coated with at least one coat to cover the seal areas before each shipment.
- Ensure that there is no loose or removable contamination that could be entrained in any liquid and that the radioactive material is not soluble in the liquid. Thus, even if the liquids come in contact with the radioactive material, there could be no transport from the package.

NOTE: There are other possible approaches; however, if an alternative approach is chosen, the basis for the choice must be supported and documented. Using one of these alternatives or an equivalent method allows these wooden boxes to meet this requirement.

For heavy, bulky materials (e.g., concrete chunks, motors, and pumps), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

4.12.4 49 CFR 178.350 Regulatory Requirements

Table 4.12-4. Regulatory Compliance Assessment.

4.12.5 Quality Control

Table 4.12-5. Packaging/Acceptance/Use Criteria.

4.12.6 Additional Information

Evaluation and testing of the subject packaging took place at MLM in 1989. Westinghouse Hanford developed the final report and other documentation as part of Docket 89-09-7A. A complete test report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

4.12.6.1 Primary Users

Site/Contact/Phone	Address
Feed Materials Production Center (FMPC)	**Westinghouse Materials Company of Ohio (WMCO)**
C. E. Block	P.O. Box 398704
COMM/FTS 513-738-6469	Cincinnati, OH 45239-8704

4.13 ORNL Y-12 SERIES C WOODEN BOXES (DOCKETS: 89-01-7A, 10/90; 90-19-7A, 08/91)

Figure 4-26. ORNL Y-12 Series C Wooden Boxes (contents restricted, see Section 4.13.3).

Figure 4-27. ORNL Y-12 Series C Wooden Boxes.

4.13.1 Package Description

Table 4.13-1. Dimensions and Weights.

Table 4.13-2. Materials/Method of Construction.

4.13.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

4.13.2.1 Physical Form

4.13.2.1.1 Solids Only. Restricted to Material Form No. 3 only. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)

4.13.2.1.2 Maximum Gross Weight

Table 4.13-3. Weights.

4.13.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

4.13.2.3 Radiological. The decrease in distance to the center of the package as a result of the 4-ft drop testing was as follows:

Table 4.13-4. Four-Foot Drop Test Results.

The shipper shall ensure that the radiation level at any surface of the packaging would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

4.13.3 Restrictions/Specifications

The boxes shall have at least two coats of a standard exterior grade paint.

Note that the banding requirements change for various boxes. Band the boxes per drawing requirements.

Separations of 3/8 in., 3/4 in., and 3/4 in. occurred in boxes C-400, C-600, and C-1000, respectively, as a result of the drop test. Each shipper must ensure that the contents are of a size and form that could not escape through separations of this size.

The following three possible approaches are acceptable with respect to addressing inleakage and ensuring that there is no transport of radioactive materials out of the packaging.

- Securely enclose the radioactive contents within the packaging (e.g., wrap and seal in plastic, etc.) so that any inleaking water cannot come in contact with the radioactive material.
- Seal the box using GEOCEL or its equivalent. If the box is reused, it must be re-coated with at least one coat to cover the seal areas before each shipment.
- Ensure that there is no loose or removable contamination that could be entrained in any liquid and that the radioactive material is not soluble in the liquid. Thus, even if the liquids come in contact with the radioactive material, there could be no transport from the package.

NOTE: There are other possible approaches; however, if an alternative approach is chosen, the basis for the choice must be supported and documented. Using one of these alternatives or an equivalent method allows

these wooden boxes to meet this requirement.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

4.13.4 49 CFR 178.350 Regulatory Requirements

Table 4.13-5. Regulatory Compliance Assessment.

4.13.5 Quality Control

Table 4.13-6. Packaging/Acceptance/Use Criteria.

4.13.6 Additional Information

Evaluation and testing of the subject packagings took place at Westinghouse Hanford in 1990 and 1991 as part of DOT-7A Program Dockets No. 89-01-7A and No. 90-19-7A. Mound Laboratory conducted testing of the C-280, -400, -600 and -1000 models. Westinghouse Hanford completed testing of the C-1, -2, and -3 models in October 1990. Complete test reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

4.13.6.1 Primary Users

Site/Contact/Phone	Address
ORNL	**Martin Marietta Energy Systems, Inc.**
E. N. Turner	P.O. Box Y
COMM/FTS 615-576-2688	Oak Ridge Y-12 Plant
	Oak Ridge, TN 37830

1.GEOCEL is a trademark of GEOCEL Corporation.

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5.0 FIBERBOARD CONTAINERS

5.1 12B-65 FIBERBOARD BOXES

Figure 5-1. DOT Specification 12B Fiberboard Box (contents restricted, see Section 5.1.3).

5.1.1 Package Description

Table 5.1-1. Configurations and 4-ft Drop Test Results.

Table 5.1-2. Materials/Method of Construction.

5.1.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

5.1.2.1 Physical Form

5.1.2.1.1 Solids Only. One material form is authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements (e.g., RTV, etc.).

- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.433, Contamination control).

5.1.2.1.2 Maximum Gross Weight

- 65 lb.

5.1.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

5.1.2.3 Radiological. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level prior to the test) as a result of the decrease in distance to the center of the package resulting from the 4-ft drop test. This decrease in distance for each package is given in Table 5.1-1, Configurations and 4-ft Drop Test Results.

5.1.3 Restrictions/Specifications

Contents must be of a size that would not move through the 1.25-in.-diameter hole resulting from the penetration test bar.

Water-resistant tape is required.

Triple-Wall support or equivalent on all sides and ends is required.

Banding with 0.5-in. plastic or equivalent is required.

The following two possible approaches are acceptable with respect to addressing inleakage and ensuring that there is no transport of radioactive materials out of the packaging.

- Securely enclose the radioactive contents within the box (e.g., wrap and seal in plastic, etc.) so that any inleaking water cannot come in contact with the radioactive material.
- Ensure that there is no loose or removable contamination that would be entrained in any liquid and that the radioactive material is not soluble in the liquid. Thus, even if the liquids come in contact with the radioactive material, there could be no transport from the package.

NOTE: There are obviously other possible approaches; however, if an alternative approach is chosen, the basis for the choice must be supported and documented. The use of one of these alternatives or an equivalent method allows these wooden boxes to meet this requirement.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

5.1.4 49 CFR 178.350 Regulatory Requirements

Table 5.1-3. Regulatory Compliance Assessment.

5.1.5 Quality Control

Table 5.1-4. Packaging/Acceptance/Use Criteria.

5.1.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

5.1.6.1 Primary Users

Site/Contact/Phone	Address
MMES H. E. Crowder COMM/FTS 615-574-2689	**Martin Marietta Energy Systems, Inc.** P.O. Box Y Oak Ridge Y-12 Plant Oak Ridge, TN 37830

5.1.6.2 Suppliers

Tape--Polyken Industrial Tape, #837 Clear, 3 in.
Kendall, Ployken Division
Boston, MA 02101

Triple-Wall

Lewisburg Container Corporation
Lewisburg, OH

5.2 LLNL 12B-10 FIBERBOARD BOX

Figure 5-2. LLNL Fiberboard Box.

5.2.1 Package Description

Table 5.2-1. Dimensions.

Table 5.2-2. Materials/Method of Construction.

5.2.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

5.2.2.1 Physical Form

5.2.2.1.1 Solids Only. Three material forms are authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements (e.g., RTV, inner bag, etc.).

- Material Form No. 1: Solids--any particle size.
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.).
- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.433, Contamination control.).

5.2.2.1.2 Maximum Gross Weight

- 10 lb.

5.2.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

5.2.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

5.2.3 Restrictions/Specifications

Contents must be of a size that would not move through the 1.25-in.-diameter hole resulting from the penetration test bar.

Water-resistant tape is required.

5.2.4 49 CFR 178.350 Regulatory Requirements

Table 5.2-3. Regulatory Compliance Assessment.

5.2.5 Quality Control

Table 5.2-4. Packaging/Acceptance/Use Criteria.

5.2.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

5.2.6.1 Primary Users

Site/Contact/Phone	Address
LLNL	**University of California**
Steve Chin	Lawrence Livermore National Laboratory
COMM/FTS 510-422-0470	P.O. Box 808
	Livermore, CA 94550

5.3 TRI-WALL FIBERBOARD BOX

Figure 5-3. Tri-Wall Package Fiberboard Box.

5.3.1 Package Description

Table 5.3-1. Dimensions.

Table 5.3-2. Materials/Method of Construction.

5.3.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

5.3.2.1 Physical Form

5.3.2.1.1 Solids Only. One material form is authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements (e.g., RTV, etc.).

- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.433, Contamination control.).

5.3.2.1.2 Maximum Gross Weight

- 350 lb
  - Packaging = 75 lb
  - Net contents = 275 lb.

5.3.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

5.3.2.3 Radiological. The 4-ft. drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

5.3.3 Restrictions/Specifications

Contents restricted to solid objects with no significant dispersible or removable contamination.

Contents must be of a size that would not move through the 1.25-in.-diameter hole resulting from the penetration test bar.

Water resistant tape is required.

The following two possible approaches are acceptable with respect to addressing inleakage and ensuring that there is no transport of radioactive materials out of the packaging.

- Securely enclose the radioactive contents within the box (e.g., wrap and seal in plastic, etc.) so that any inleaking water cannot come in contact with the radioactive material.
- Ensure that there is no loose or removable contamination that would be entrained in any liquid and that the radioactive material is not soluble in the liquid. Thus, even if the liquids come in contact with the radioactive material, there could be no transport from the package.

NOTE: There are obviously other possible approaches; however, if an alternative approach is chosen, the basis for the choice must be supported and documented. The use of one of these alternatives or an equivalent method allows these boxes to meet this requirement.

For heavy, bulky materials (i.e., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

5.3.4 49 CFR 178.350 Regulatory Requirements

Table 5.3-3. Regulatory Compliance Assessment.

5.3.5 Quality Control

Table 5.3-4. Packaging/Acceptance/Use Criteria.

5.3.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

5.3.6.1 Primary Users

Site/Contact/Phone	Address
MMES	**Martin Marietta Energy Systems, Inc.**
H. E. Crowder	P.O. Box Y
COMM/FTS 615-574-2689	Oak Ridge Y-12 Plant

5.3.6.2 Suppliers

Tape--Polyken Industrial Tape, #837 Clear, 3 in.
Kendall, Polyken Division
Boston, MA 02101

Tri-Wall
Gould Southern

5.4 DOT-21C FIBERBOARD DRUM

Figure 5-4. DOT Specification 21C Fiberboard Drum.

5.4.1 Package Description

Table 5.4-1. Configurations and 4-ft Drop Test Results.

Table 5.4-2. Materials/Method of Construction.

5.4.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

5.4.2.1 Physical Form

5.4.2.1.1 Solids Only. One material form is authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements (e.g., RTV, etc.).

- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.433, Contamination control.).

5.4.2.1.2 Maximum Gross Weight

- 115 lb.

5.4.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

5.4.2.3 Radiological. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level prior to the test) as a result of the decrease in distance to the center of the package resulting from the 4-ft drop test. This decrease in distance for each package is given in Table 5.4.1.

5.4.3 Restrictions/Specifications

Contents must be of a size that would not move through the 1.25-in.-diameter hole resulting from the penetration test bar.

Triple-Wall supports (minimum of five 1-in. pieces on opposite sides of the package).

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

5.4.4 49 CFR 178.350 Regulatory Requirements

Table 5.4-3. Regulatory Compliance Assessment.

5.4.5 Quality Control

Table 5.4-4. Packaging/Acceptance/Use Criteria.

5.4.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

5.4.6.1 Primary Users

Site/Contact/Phone	Address
MMES H. E. Crowder COMM/FTS 615-574-2689	**Martin Marietta Energy Systems, Inc.** P.O. Box Y Oak Ridge Y-12 Plant Oak Ridge, TN 37830

5.4.6.2 Suppliers

Triple-Wall
Lewisburg Container Corporation
Lewisburg, OH

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6.0 UF_6 CYLINDERS

6.1 UF_6 FAMILY OF CYLINDERS (DOCKETS: MLM)

Figure 6-1. UF_6 Cylinder, Model 1S*.

Figure 6-2. UF_6 Cylinder, Model 2S*.

Figure 6-3. UF_6 Cylinder, Modified Model 5A or Model 5B*.

Figure 6-4. UF_6 Cylinder, Model 8A*.

Figure 6-5. UF_6 Cylinder, Model 12A*.

Figure 6-6. UF_6 Cylinder, Model 12B*.

Figure 6-7. UF_6 Cylinder, Model 30A*.

Figure 6-8. UF_6 Cylinder, Model 30B*.

Figure 6-9. UF_6 Cylinder, Model 48G*.

Figure 6-10. UF_6 Cylinder, Model 48H and Model 48Hx*.

Figure 6-11. UF_6 Cylinder, Model 48X*.

Figure 6-12. UF_6 Cylinder, Model 48Y*.

6.1.1 Package Description

Table 6.1-1. Dimensions and Weights.

Table 6.1-2. Materials/Method of Construction.

6.1.2 Authorized Contents graphics

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

6.1.2.1 Physical Form

6.1.2.1.1 Solids. One material form is authorized. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

- UF_6 solid.

6.1.2.1.2 Maximum Gross Weight. See Table 6.1-1, Dimensions and Weights.

6.1.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

6.1.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

6.1.3 Restrictions/Specifications

The packaging shall be operated in accordance with *Uranium Hexafluoride: Handling Procedures and Container Description* (Keller 1966).

6.1.4 49 CFR 178.350 Regulatory Requirements

Table 6.1-3. Regulatory Compliance Assessment.

6.1.5 Quality Control

Table 6.1-4. Packaging/Acceptance/Use Criteria.

6.1.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT 7A Program technical contacts listed in Section 1.1.2.

6.1.6.1 Primary Users

Site/Contact/Phone	Address
MMES	**Paducah Gaseous Diffusion Plant**
B. K. Hook	Martin Marietta Energy Systems, Inc.
COMM/FTS 502-444-6311 x-363	P.O. Box 1410
COMM/FTS 614-289-2331	Paducah, KY 42001

6.2 UF_6 CYLINDERS, ORNL MODIFIED 5A AND 5B (DOCKETS: 89-08-7A, 02/90)

Figure 6-13. UF_6 Cylinder, Modified Model 5A and Model 5B.

6.2.1 Package Description

Table 6.2-1. Dimensions and Weights.

Table 6.2-2. Materials/Method of Construction.

6.2.1.1 Drawings

- Modified 5A: CX-761-M2011, CX-761-M2111, and CX-761-M2123
- Modified 5B: DX-761-2208ME.

6.2.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

6.2.2.1 Physical Form

6.2.2.1.1 Solid

- UF_6.

6.2.2.1.2 Maximum Gross Weight. See Table 6.2-1, Dimension and Weights.

6.2.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

6.2.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

6.2.3 Restrictions/Specifications

The packaging shall be operated in accordance with Keller 1966.

6.2.4 49 CFR 178.350 Regulatory Requirements

Table 6.2-3. Regulatory Compliance Assessment.

6.2.5 Quality Control

Table 6.2-4. Packaging/Acceptance/Use Criteria.

6.2.6 Additional Information

Evaluation and testing of the subject packaging took place at Westinghouse Hanford in 1990 as part of Docket 89-08-7A. Testing was completed in February 1990. A complete evaluation report is available upon request from one of the DOT 7A Program technical contacts listed in Section 1.1.2.

6.2.6.1 Primary Users

Site/Contact/Phone	Address
MMES	**Martin Marietta Energy Systems, Inc.**
R. A. Boelens	P.O. Box 628

COMM/FTS 614-897-2331 Piketon, OH 45661

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7.0 LIQUIDS AND GASES

7.1 LOVELACE MS-24347-7 STEEL DRUM (LIQUIDS) (DOCKETS: MLM)

Figure 7-1. MS-24347-7 Steel Drum (Liquids).

7.1.1 Package Description

Table 7.1-1. Dimensions and Weights.

Table 7.1-2. Materials/Method of Construction.

7.1.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

7.1.2.1 Physical Form. Liquid radioactive materials.

7.1.2.1.1 Maximum Gross Weight

- 6 lb.

7.1.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

7.1.2.3 Radiological. The shipper must ensure that the radiation level at any surface will not increase by more than 20% (relative to the radiation level prior to the test) as a result of the decrease in distance to the center of the package resulting from the side penetration test. This decrease in distance was 1.25 in.

7.1.3 Restrictions/Specifications

The drum lid closure ring bolt shall be tightened with tapping of ring until lugs begin to bend or to come together, typically less than 40 ft-lb.

Twice the absorbent shall be used because a volume of 50 cm^3 cannot be achieved in this bottle.

Shipper must demonstrate at least twice the absorbent capacity for the liquid contents.

For airborne shipments, HM-181 requirements pertinent to reduced external pressure conditions may be invoked, see discussion in Section 1.3.4

7.1.4 49 CFR 178.350 Regulatory Requirements

Table 7.1-3. Regulatory Compliance Assessment.

7.1.5 Quality Control

Table 7.1-4. Packaging/Acceptance/Use Criteria.

7.1.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

7.1.6.1 Primary Users

Site/Contact/Phone	Address
Dr. J. J. Thompson	**Lovelace Biomedical and Environmental Research Institute, Inc.**
COMM/FTS 505-844-2601	P.O. Box 5890 Albuquerque, NM 87185

7.2 LANL 12B-62 FIBERBOARD BOX WITH LEAD SHIELDED INNER PACKAGING (LIQUIDS) (DOCKETS: MLM)

Figure 7-2. LANL Shielded Container Fiberboard Box.

7.2.1 Package Description

Table 7.2-1. Dimensions.

Table 7.2-2. Materials/Method of Construction.

7.2.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

7.2.2.1 Physical Form. Liquid radioactive materials.

7.2.2.1.1 Maximum Gross Weight

- 62 lb.

7.2.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

7.2.2.3 Radiological. The shipper must ensure that the radiation level at any surface will not increase by more than 20% relative to the radiation level prior to the test as a result of the decrease in distance to the

center of the package resulting from the 30-ft drop test. The shielded inner container was displaced approximately 4 in. toward the point of impact (top corner), and the corner itself was compressed.

7.2.3 Restrictions/Specifications

Twice the absorbent shall be used because a volume of 50 cm^3 cannot be achieved.

Shipper must demonstrate at least twice the absorbent capacity for the liquid contents.

For airborne shipments, HM-181 requirements pertinent to reduced external pressure conditions may be invoked, see discussion in Section 1.3.4.

7.2.4 49 CFR 178.350 Regulatory Requirements

Table 7.2-3. Regulatory Compliance Assessment.

7.2.5 Quality Control

Table 7.2-4. Packaging/Acceptance/Use Criteria.

7.2.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

7.2.6.1 Primary Users

Site/Contact/Phone	Address
LANL	**Los Alamos National Laboratory**
N. King	P.O. Box 1663
COMM/FTS 505-667-4127	Los Alamos, NM 87545

7.2.6.2 Tape. Scotch 3M Plastic Tape (2 in.), Product No. 3750-G.

7.3 LLNL GAS CYLINDERS IN A STEEL DRUM (DOCKETS: MLM)

Figure 7-3. LLNL Steel Drum/Gas Cylinder Packagings.

7.3.1 Package Description

Table 7.3-1. Dimensions.

Table 7.3-2. Materials/Method of Construction.

7.3.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual

contents.

7.3.2.1 Physical Form. Gaseous radioactive materials.

7.3.2.1.1 Maximum Gross Weight

- Configuration No. 1 = 68 lb
- Configuration No. 2 = 60 lb.

7.3.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

7.3.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

7.3.3 Restrictions/Specifications

Compliance with 49 CFR 178.36 and 49 CFR 178.42 is required.

No RTV (or equivalent) is required on 17H drums.

7.3.4 49 CFR 178.350 Regulatory Requirements

Table 7.3-3. Regulatory Compliance Assessment.

7.3.5 Quality Control

Table 7.3-4. Packaging/Acceptance/Use Criteria.

7.3.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

7.3.6.1 Primary Users

Site/Contact/Phone	Address
LLNL	**University of California**
Steve Chin	Lawrence Livermore National Laboratory
COMM/FTS 510-422-0470	P.O. Box 808
	Livermore, CA 94550

7.4 ORNL FIBERBOARD BOX--LIQUIDS AND SOLIDS (DOCKETS: MLM)

Figure 7-4. ORNL Fiberboard Box Disposable Container for Radioactive Liquid and Solid Shipments.

7.4.1 Package Description

Table 7.4-1. Dimensions.

Table 7.4-2. Materials/Method of Construction.

7.4.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

7.4.2.1 Physical Form. Liquid or solid radioactive materials.

7.4.2.1.1 Maximum Gross Weight

- 33 lb.

7.4.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

7.4.2.3 Radiological. The shipper must ensure that the radiation level at any surface will not increase by more than 20% (relative to the radiation level prior to the test) as a result of the decrease in distance to the center of the package resulting from the 30-ft drop test. This decrease in distance was 1 in.

7.4.3 Restrictions/Specifications

Twice the absorbent is required if the volume is less than 50 cm^3.

Shipper must demonstrate at least twice the absorbent capacity for the liquid (where used).

For heavy, bulky materials (e.g., concrete chunks, motors, and pumps), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

For airborne shipments, HM-181 requirements pertinent to reduced external pressure conditions may be invoked, see discussion in Section 1.3.4 .

7.4.4 49 CFR 178.350 Regulatory Requirements

Table 7.4-3. Regulatory Compliance Assessment.

7.4.5 Quality Control

Table 7.4-4. Packaging/Acceptance/Use Criteria.

7.4.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

7.4.6.1 Primary Users

Site/Contact/Phone	Address
ORNL R. W. Schaich COMM/FTS 615-574-6991	**Oak Ridge National Laboratory** P.O. Box X Oak Ridge, TN 37830

7.4.6.2 Suppliers

• Fiberboard box	Peachtree Packaging Atlanta, GA
• Metal can	Ellisco-Philadelphia Can Co. Philadelphia, PA
• Duraglass[(1)] bottles 0.5-4.0 oz.	All-Pac, Inc. 1064 Country Club Road Columbus, OH 43227
• Special form capsule Lead shields Glass ampules	ORNL Shops P.O. Box X Oak Ridge, TN
• Purchasing contact	J. W. Hudson P.O. Box X Oak Ridge, TN 615-576-1423

7.5 ORNL FIBERBOARD BOX--LIQUIDS, SOLIDS, OR GASES (DOCKETS: MLM)

Figure 7-5. ORNL Fiberboard Box Disposable Container for Radioactive Gas Shipments.

Figure 7-6. ORNL Fiberboard Box Disposable Container for Radioactive Liquid and Solid Shipments.

7.5.1 Package Description

Table 7.5-1. Dimensions.

Table 7.5-2. Materials/Method of Construction.

7.5.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

7.5.2.1 Physical Form. Liquid, gaseous, or solid radioactive materials.

7.5.2.1.1 Maximum Gross Weight

- 33 lb.

7.5.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

7.5.2.3 Radiological. The shipper must ensure that the radiation level at any surface will not increase by more than 20% (relative to the radiation level prior to the test) as a result of the decrease in distance to the center of the package resulting from the 30-ft drop test. This decrease in distance was 1 in.

7.5.3 Restrictions/Specifications

Twice the absorbent is required if the volume is less than 50 cm^3.

Shipper must demonstrate at least twice the absorbent capacity for the liquid (where used).

For heavy, bulky materials (e.g., concrete chunks, motors, and pumps), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

For airborne shipments, HM-181 requirements pertinent to reduced external pressure conditions may be invoked, see discussion in Section 1.3.4.

7.5.4 49 CFR 178.350 Regulatory Requirements

Table 7.5-3. Regulatory Compliance Assessment.

7.5.5 Quality Control

Table 7.5-4. Packaging/Acceptance/Use Criteria.

7.5.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

7.5.6.1 Primary Users

Site/Contact/Phone	Address
ORNL	**Oak Ridge National Laboratory**
R. W. Schaich	P.O. Box X
COMM/FTS 615-574-6991	Oak Ridge, TN 37830

7.5.6.2 Suppliers

• Special form capsule Lead shields Glass ampules	ORNL Shops P.O. Box X Oak Ridge, TN
• Purchasing contact	J. W. Hudson P.O. Box X

Oak Ridge, TN
COMM/FTS 615-576-1423

7.6 ORNL RETURNABLE (ALUMINUM-CLAD PLYWOOD BOX) SHIELDED SHIPPING CONTAINER (DOCKETS: MLM)

Figure 7-7. ORNL Wooden Box (Aluminum Clad) Returnable Shielded Shipping Container.

7.6.1 Package Description

Table 7.6-1. Dimensions.

Table 7.6-2. Materials/Method of Construction.

7.6.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

7.6.2.1 Physical Form. Liquid and solid radioactive materials.

7.6.2.1.1 Maximum Gross Weight

- 212 lb.

7.6.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

7.6.2.3 Radiological. The 4-ft. drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

7.6.3 Restrictions/Specifications:

For volumes less than 50 cm^3, twice the absorbent is required.

Shipper must demonstrate at least twice the absorbent capacity for the liquid contents.

For heavy, bulky materials (e.g., concrete chunks, motors, and pumps), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/ positioned within the package.

For airborne shipments, HM-181 requirements pertinent to reduced external pressure conditions may be invoked, see discussion in Section 1.3.4.

7.6.4 49 CFR 178.350 Regulatory Requirements

Table 7.6-3. Regulatory Compliance Assessment.

7.6.5 Quality Control

Table 7.6-4. Packaging/Acceptance/Use Criteria.

7.6.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

7.6.6.1 Primary Users

Site/Contact/Phone	Address
ORNL	**Oak Ridge National Laboratory**
R. W. Schaich	P.O. Box X
COMM/FTS 615-574-6991	Oak Ridge, TN 37830

7.7 ORNL RETURNABLE (ALUMINUM REINFORCED PLASTIC BOX) GAS CYLINDER--SHIELDED AND NONSHIELDED SHIPPING CONTAINERS (DOCKETS: MLM)

Figure 7-8. ORNL Gas Cylinder Returnable Plastic Box.

Figure 7-9. ORNL Gas Cylinder Returnable 10-mL Isotope Container.

Figure 7-10. ORNL Gas Cylinder (Returnable).

7.7.1 Package Description

Table 7.7-1. Dimensions.

Table 7.7-2. Materials/Method of Construction.

7.7.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

7.7.2.1 Physical Form. Gaseous radioactive materials.

7.7.2.1.1 Maximum Gross Weight

- 60 lb.

7.7.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

7.7.2.3 Radiological. The 4-ft. drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

7.7.3 Restrictions/Specifications

NOTE: The Type A tests were conducted on the gas cylinders. The outer box is only for convenience in handling and shipping.

7.7.4 49 CFR 178.350 Regulatory Requirements

Table 7.7-3. Regulatory Compliance Assessment.

7.7.5 Quality Control

Table 7.7-4. Packaging/Acceptance/Use Criteria.

7.7.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

7.7.6.1 Primary Users

Site/Contact/Phone	Address
ORNL	**Oak Ridge National Laboratory**
R. W. Schaich	P.O. Box X
COMM/FTS 615-574-6991	Oak Ridge, TN 37830

7.8 ORNL J. L. SHEPHARD GAS CYLINDERS (DOCKETS: MLM)

Figure 7-11. ORNL Gas Cylinder (Returnable).

7.8.1 Package Description

Table 7.8-1. Dimensions and Weights.

Table 7.8-2. Materials/Method of Construction.

7.8.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

7.8.2.1 Physical Form. Gaseous radioactive materials.

7.8.2.1.1 Maximum Gross Weight. See Table 7.8-1, Dimensions and Weights.

7.8.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

7.8.2.3 Radiological. The 4-ft. drop test caused deformations of the package resulting in small decreases in

the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

7.8.3 49 CFR 178.350 Regulatory Requirements

Table 7.8-3. Regulatory Compliance Assessment.

7.8.4 Quality Control

Table 7.8-4. Packaging/Acceptance/Use Criteria.

7.8.5 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

7.8.5.1 Primary Users

Site/Contact/Phone	Address
ORNL	**Oak Ridge National Laboratory**
R. W. Schaich	P.O. Box X
COMM/FTS 615-574-6991	Oak Ridge, TN 37830

7.8.5.2 Supplier

J. L. Shephard and Associates
740 Salem Street
Glendale, CA 91203

7.9 LANL SHIELDED CONTAINER FOR LIQUIDS (LANL-2) (DOCKETS: MLM)

Figure 7-12. LANL Shielded Container Steel Drum (Liquids) (LANL-2).

Figure 7-13. Fenton Hill Pig (Details of Inner Packaging).

7.9.1 Package Description

Table 7.9-1. Dimensions.

Table 7.9-2. Materials/Method of Construction.

7.9.2 Authorized Contents

The shipper shall demonstrate that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

7.9.2.1 Physical Form. Radioactive liquids.

7.9.2.1.1 Maximum Gross Weight

- 495 lb.

7.9.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

7.9.2.3 Radiological. A dent of approximately 4.75 in. resulted from the 30-ft drop test on the top edge. Each shipper must ensure that the radiation level at the surface of the package will not increase by more than 20% (relative to the radiation level of the undamaged configuration) as a result of such a deformation.

7.9.3 Restrictions/Specifications

Bolt closure shall be tightened to a minimum of 40 ft-lb with tapping of ring during tightening per the following procedure:

1. Tighten the bolt to 40 ft-lb torque.
2. Hit the closure ring vigorously with a metal hammer approximately 8 to 9 times, equally spaced around the ring.
3. Repeat the cycle three additional times.
4. Torque the bolt one last time to 40 ft-lb.

The gasket material must have an operating range of -40 °F to +158 °F.

Shipper must demonstrate more than twice the absorbent capacity for the liquid contents because the volume is less than 50 cm^3.

For airborne shipments, HM-181 requirements pertinent to reduced external pressure conditions may be invoked, see discussion in Section 1.3.4

7.9.4 49 CFR 178.350 Regulatory Requirements

Table 7.9-3. Regulatory Compliance Assessment.

7.9.5 Quality Control

Table 7.9-4. Packaging/Acceptance/Use Criteria.

7.9.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT 7A Program technical contacts listed in Section 1.1.2.

7.9.6.1 Primary Users

Site/Contact/Phone	Address
LANL	**Los Alamos National Laboratory**
N. King	P.O. Box 1663
COMM/FTS 505-667-4127	Los Alamos, NM 87545

7.10 WHC LIQUID SAMPLE PACKAGING (DOCKETS: 90-14-7A, 01/91)

Figure 7-14. WHC Liquid Sample Packaging.

7.10.1 Package Description

Table 7.10-1. Dimensions.

Table 7.10-2. Materials/Method of Construction.

7.10.2 Authorized Contents

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 DOT-7A compliance with the actual contents.

7.10.2.1 Physical Form. Contents restricted to liquid radioactive materials.

7.10.2.1.1 Maximum Gross Weight

- 46.75 lb for 1-gal package
- 43.75 lb for 0.5-gal package.

7.10.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

7.10.2.3 Radiological. The decrease in distance to the center of the package was 1.25 in. (maximum) as a result of the 30-ft drop test. The load did not shift within the packaging. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged package configuration) if such a deformation would occur.

7.10.3 Restrictions/Specifications

The closure ring bolt shall be tightened with tapping of the ring to a torque of 30 to 33 ft-lb.

The RTV sealant (RTV 102, White, or equivalent) must be applied to the surface of the gasket in contact with the drum body. The sealant must be allowed to cure 24 hours before transporting. Sealant is not required for smaller volumes of liquid when there is sufficient room in the inner cavity to install suitable absorbent material to absorb twice the volume of the liquid contents.

For airborne shipments, HM-181 requirements pertinent to reduced external pressure conditions may be invoked, see discussion in Section 1.3.4.

7.10.4 49 CFR 178.350 Regulatory Requirements

Table 7.10-3. Regulatory Compliance Assessment.

7.10.5 Quality Control

Table 7.10-4. Packaging/Acceptance/Use Criteria.

7.10.6 Additional Information

Evaluation and testing of the subject packaging took place at Westinghouse Hanford in 1990 as part of Docket 90-14-7A. Testing was completed in January 1991. A complete evaluation report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

7.10.6.1 Primary Users

Site/Contact/Phone	Address
Hanford	**Westinghouse Hanford Company**
T. Romano	P.O. Box 1970
COMM/FTS 509-373-0371	Richland, WA 99352

7.10.6.2 Suppliers

RTV Silicone Foam

Insta-Foam Products, Inc.
1500 Cedarwood Drive
Joliet, Illinois 60435
800-435-9359

7.11 PROCESS-WATER SAMPLE PACKAGING (DOCKETS: 90-22-7A, 06/91)

Figure 7-15. SRP Process-Water Sample Package.

7.11.1 Package Description

Table 7.11-1. Dimensions.

Table 7.11-2. Materials/Method of Construction.

7.11.1.1 Manufacturer/Drawing:

Westinghouse Savannah River,
Dwg. H-HO-G-0100, Rev. 0

7.11.2 Authorized Contents

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 DOT-7A compliance with the actual contents.

7.11.2.1 Physical Form

7.11.2.1.1 Liquids. Radioactive process-water samples--15 L maximum per package. Liquid pH shall be in the range of 2.5 to 11.0.

7.11.2.1.2 Maximum Gross Weight

- 118 lb.

7.11.2.1.3 Maximum Contents Weight

- 36 lb.

7.11.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

7.11.2.3 Radiological. The contents must be such that the assembled package is contact-handled (i.e., with a surface dose rate of 200 mrem/hr or less). See operating instructions for dose and isotopic inventory limits on individual bottles.

The 30-ft drop test caused a deformation of the package resulting in a decrease in the distance from the exterior to the center of the package of 4.0 in. (maximum). The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such a deformation would occur.

7.11.3 Restrictions/Specifications

Operation, maintenance, and reuse of the packaging shall be in accordance with *Process-Water Sample Packaging - Operating Instructions*, Westinghouse Savannah River Company (Horn 1990).

For airborne shipments, HM-181 requirements pertinent to reduced external pressure conditions may be invoked, see discussion in Section 1.3.4.

7.11.4 Pre-use Inspections

The packaging components shall be visually inspected prior to use for any signs of damage (e.g., loose attachment bolts, damaged containment vessel, broken hinges, split seams, etc.). Upon discovery of any such defects, the applicable packaging component shall be repaired or replaced so that it complies with the drawing requirements.

7.11.5 Loading Procedure

1. Remove closure strap by pressing release button.
2. Open truck box lid.
3. Open the aluminum containment vessel by rotating the lid.
   (NOTE: The vessel may be removed from the packaging assembly prior to opening.)
4. Place the HDPE bottles (primary containment) containing the samples into the aluminum containment vessels (secondary containment)
5. Close the aluminum containment vessel by rotating the lid and holding the body stationary.
6. Close the truck box lid.
7. Pull the closure strap tight to secure.
8. Install "tamper-proof" wire seal around buckle on closure strap by inserting through handle.
9. The loaded package is now ready for placement onto a conveyance for transport.

7.11.6 49 CFR 178.350 Regulatory Requirements

Table 7.11-3. Regulatory Compliance Assessment.

7.11.7 Quality Control

Table 7.11-4. Packaging/Acceptance/Use Criteria.

7.11.8 Additional Information

Westinghouse Hanford performed testing and evaluation to qualify the subject packaging system in June 1991 as part of Docket 90-22-7A. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

7.11.8.1 Primary Users

Site/Contact/Phone	Address
SRP	**Westinghouse Savannah River**
R. Horn	Building 723-A
COMM/FTS 803-725-1744	P.O. Box 616
	Aiken, SC 29808

7.12 RF CONTAINER MODEL LWS-1 (DOCKETS: 91-25-7A, 12/91)

Figure 7-16. RF Container Model LWS-1 (Liquids).

7.12.1 Package Description

Table 7.12-1. Dimensions.

Table 7.12-2. Materials/Method of Construction.

7.12.2 Authorized Contents

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 DOT-7A compliance with the actual contents.

7.12.2.1 Physical Form. Contents are liquid radioactive materials authorized when packaged as described.

Package is considered to provide containment plus twice the absorbent required.

7.12.2.1.1 Maximum Gross Weight

- 12 lbs.

7.12.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

7.12.2.3 Radiological. The shipper must ensure that the radiation level at any surface would not increase by

more than 20% (relative to the radiation level prior to the test) as a result of the decrease in distance to the center of the package load resulting from the 30-ft drop test. This decrease in distance to the center of the package was approximately 1 in. The user must also account for the movement of the produce can within the foam inserts, which permit top to bottom motion. No change in position of the produce can resulted in damage to foam inserts. No damage to the foam inserts was observed.

7.12.2.4 Simulated Payload. Ten vials containing 5 ml of RC-77 Fluorescent Penetrant each.

7.12.3 Restrictions/Specifications

Bolt closure ring tightened until lugs begin to bend inward or come together (typically less than 40 ft-lb). During tightening of bolt, tap locking ring.

Sealant is not required.

For vial closure, screw lid on vial to hand-tight torque. Tighten lid on vial using wrench set, Rocky Flats Part Number 33097-02, or equivalent. Using wrench set, retighten vials after approximately 5 min. have elapsed from initial tightening.

7.12.4 49 CFR 178.350 Regulatory Requirements

Table 7.12-3. Regulatory Compliance Assessment.

7.12.5 Quality Control

Table 7.12-4. Packaging/Acceptance/Use Criteria.

7.12.6 Additional Information

Evaluation and testing of the subject packaging took place at Westinghouse Hanford in 1991 as part of Docket 91-25-7A. Testing was completed in December 1991. A complete evaluation report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

7.12.6.1 Primary Users

Site/Contact/Phone	Address
Rocky Flats	**Rocky Flats Plant**
K. Lenarcic	P.O. Box 464
COMM/FTS 303-966-2377	Golden, CO 80402

7.12.6.2 Manufacturers

Vial, Savillex Corp.	**Savillex Corp**
Teflon[(2)] - Perfluoralkoxy	6133 Baker Road
6 ml (1/5 oz) capacity	Minnetonka, MN 55345

7.13 EG&G MOUND COMMERCIAL TRITIUM PACKAGING 10, 50, 150, 300 AND 500 cc (DOCKETS: 92-31-7A, 08/92)

Figure 7-17. EG&G Mound Commercial Tritium Packaging Case.

Figure 7-18. EG&G Mound Commercial Tritium Packaging Cylinder.

7.13.1 Package Description

Table 7.13-1. Dimensions and Weights.

Table 7.13-2. Materials/Method of Construction.

The outside case is molded of heavy General Electric Xenoy 522OU thermoplastic resin. The cases are watertight, airtight, and vapor tight. They meet or exceed mil Specs T-21200, 18015, and 18014. The seal is made of General Electric silicone rubber. The case is purchased from Andiamo, Inc. It measures 21.5 in. x 14.5 in. x 8 in. outside. The case's weight with holding tray in place is 9.55 lb (4.33 kg).

The inner packaging consists of 2-in. layers, top and bottom, of 2-lb-density protective foam.

A styrofoam inner tray custom made to hold each cylinder separately is squeezed between the foam. The tray is 2-in.-thick high density foam.

Each cylinder is equipped with a welded Nupro valve. These valves, P/N SS-4BG-T, are made of 316 stainless steel and are rated at 1,000 psi and 600 °F.

7.13.2 Authorized Contents

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 DOT-7A compliance with the actual contents.

7.13.2.1 Physical Form. Contents are gaseous radioactive materials authorized when packaged as described.

7.13.2.1.1 Maximum Gross Weight:

- 10 cc (10.29 lb)
- 50 cc (10.66 lb)
- 150 cc (11.29 lb)
- 300 cc (11.83 lb)
- 500 cc (12.72 lb).

7.13.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

7.13.2.3 Radiological. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level prior to the test) as a result of the decrease in distance to the center of the package load as a result of the drop test. In one instance (500 cc), there was movement of the inner cylinder of 1 1/2 in., and the maximum dent in the outer packaging was 1/2 in.

7.13.2.4 Simulated Payload. The simulated payload for the testing was air.

7.13.3 Restrictions/Specifications

The maximum authorized pressures are as follows:

- 10 cc (37 psi)
- 50 cc (45 psi)
- 150 cc (39 psi)

- 300 cc (42 psi)
- 500 cc (47 psi).

The bolt is to be inserted into one of the holes on the sides of the handle.

The penetration test did not result in any significant dents in the surface of the package.

As a result of the drop tests, in one instance (500 cc), there was movement of the inner cylinder of 1 1/2 in., and the maximum dent in the outer packaging was 1/2 in. The shipper must ensure that the radiation level at the package surface will not increase by more than 20%.

See the test pressures previously listed. The shipper must determine that the actual contents are closely simulated by the test contents (air). If this is not true or not known, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

7.13.4 49 CFR 178.350 Regulatory Requirements

Table 7.13-3. Regulatory Compliance Assessment.

7.13.5 Quality Control

Table 7.13-4. Packaging/Acceptance/Use Criteria.

7.13.6 Additional Information

Evaluation and testing of the subject packaging took place at MLM in 1991. The information was added to this document under Docket 92-31-7A. A complete evaluation report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

7.13.6.1 Primary Users

Site/Contact/Phone	Address
EG&G Mound	**EG&G Mound Applied Technologies**
Jerry Crawford	P.O. Box 3000
COMM/FTS 513-865-3172	Miamisburg, Ohio 45343

7.14 WHC GROUT SAMPLE PACKAGING (DOCKET: 90-15-7A, 12/92)

Figure 7-19. WHC Grout Sample Packaging.

7.14.1 Package Description

Table 7.14-1. Dimensions and Weights.

Table 7.14-2. Materials/Method of Construction.

7.14.1.1 Manufacturer Drawing

Table 7.14-3. Westinghouse Hanford Company Drawing Information.

7.14.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the payload used during testing. If they are not, then testing and/or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

7.14.2.1 Physical Form.

7.14.2.1.1 Liquids. Contents are liquid radioactive materials authorized when packaged as described. The package is considered to provide double containment. Note: solids also are authorized provided that the payload weight, including the weight of any sample container used, does not exceed 237 g (0.52 lb).

7.14.2.1.2 Maximum Payload Weight. 237 g (0.52 lb) (including weight of sample bottle).

7.14.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

7.14.2.3 Radiological. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if a deformation such as that which occurred during testing should occur.

The 9-m (30-ft) drop test caused a deformation of the package resulting in a decrease in the distance from the exterior to the center of the package of 3.97 cm (1 9/16 in.) (maximum). The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such a deformation would occur.

7.14.2.4 Simulated Payload. The simulated payload for this testing was one 100-ml (4-oz) glass bottle containing a water and fluorescein mixture. Lead shot was placed in the bottle to simulate the weight of material with a higher specific gravity.

7.14.3 Restrictions/Specifications

Tighten the overpack retaining ring bolt and jam nut to 40.8 N-m (30 ft-lb). During tightening of the bolt, tap the locking ring.

Operation, maintenance, and reuse of the packaging shall be in accordance with applicant-provided operating instructions.

A special tool is required to handle the primary container.

For airborne shipments, HM-181 requirements pertinent to reduced external pressure conditions may be invoked. See Section 1.3.4.

The primary container seal is Central Research Laboratories Special Silicone 105 DDTS (outer seal), part number 96.606.

The secondary containment boundary passed a 344.75-kPa (50-psig) pressure differential test. A reduced pressure design verification was conducted by performing a hydrostatic test to the secondary container. The secondary container was filled with distilled water to the extent practicable to minimize the energy available in the event of containment failure. An air line was connected to the lid of the secondary container.

The pressure in the container was increased to 77.224 kPa (11.2 psig) and held for 15 min. No signs of failure were observed. The pressure was then increased to 344.75 kPa (50.0 psig) and held for another 15 min. Again, no signs of failure were observed. The pressure was then released and the container visually checked for loss of water and signs of failure.

Loss of water from the secondary container during the first pressure step would indicate failure of the containment boundary. The maximum pressure that the packaging withstands during the second pressure increase establishes the capability of the package for air shipment or loads that produce pressure increases.

7.14.4 49 CFR 178.350 Regulatory Requirements

Table 7.14-4. Regulatory Compliance Assessment.

7.14.5 Quality Control

Table 7.14-5. Packaging/Acceptance/Use Criteria.

7.14.6 Additional Information

Evaluation and testing of the subject packaging took place at WHC in 1992 as Docket Number 90-15-7A. Testing was completed in December 1992. A complete evaluation report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

7.14.6.1 Primary User

Site/Contact/Phone	Address
Hanford Site	**Westinghouse Hanford Company**
M. S. Mercado	P.O. Box 1970
COMM/FTS 509-376-9129	Richland, WA 99352

7.15 EG&G MOUND LEWIS GAS PACKAGING (DOCKET: 92-30-7A, 07/92)

Figure 7-20. EG&G Mound Lewis Gas Packaging.

Figure 7-21. EG&G Mound Lewis Gas Packaging Cylinder.

7.15.1 Package Description

Table 7.15-1. Dimensions and Weights.

Table 7.15-2. Materials/Method of Construction.

7.15.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, then testing and/or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

7.15.2.1 Physical Form. Contents are gaseous radioactive materials authorized when packaged as described.

7.15.2.1.1 Maximum Gross Weight. 9.49 kg (20.875 lb).

7.15.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

7.15.2.3 Radiological. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if a deformation such as that which occurred during testing should occur.

Dents [one with a maximum of 2.858 cm (1 1/8 in.) dent] resulted from the drop tests and the penetration tests. Each shipper must ensure that the radiation level at the package will not increase by more than 20%. (See Appendix D for more details on the dent sizes.)

7.15.2.4 Simulated Payload. The test contents were air at a beginning pressure of 106.87 kPa (15.5 psi). The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

7.15.3 Restrictions/Specifications

- Authorized pressure is 103.43 kPa (15 psi) or less.
- No RTV or equivalent is required.
- Bolt closure tightened until the lugs begin to move. The minimum effort should be four torquing cycles, referred to as (34 & 4).
    1. Tighten bolt until lugs begin to move.
    2. Hit the closure ring vigorously with a metal hammer, eight to nine times, equally spaced around the closure ring.
    3. Repeat this cycle three additional times.
    4. Torque bolt one last time until lugs begin to move.

7.15.4 49 CFR 178.350 Regulatory Requirements

Table 7.15-3. Regulatory Compliance Assessment.

7.15.5 Quality Control

Table 7.15-4. Packaging/Acceptance/Use Criteria.

7.15.6 Additional Information

Evaluation and testing of the subject packaging took place at MLM in 1987 and was opened as Docket Number 92-30-7A. Testing was completed in March 1987. A complete evaluation report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

7.15.6.1 Primary User

Site/Contact/Phone	Address
EG&G Mound	**EG&G Mound Applied Technologies**
J. Crawford	P.O. Box 3000
COMM/FTS 513-865-3172	Miamisburg, Ohio 45343

7.16 MODIFIED COMMERCIAL TRITIUM PACKAGING 500 cc (DOCKETS: 93-34-7A, 07/93)

Figure 7-22. Modified Commercial Tritium Packaging.

Figure 7-23. Modified Commercial Tritium Packaging Cylinder.

7.16.1 Package Description

Table 7.16-1. Dimensions and Weights.

Table 7.16-2. Materials/Method of Construction.

The outside case is molded of heavy General Electric Xenoy 522OU thermoplastic resin. The cases are watertight, airtight, and vapor tight. They meet or exceed mil Specs T-21200, 18015, and 18014. The seal is made of General Electric silicone rubber. The case is purchased from Andiamo, Inc. It measures 54.61 cm x 36.83 cm x 20.32 cm (21.5 in. x 14.5 in. x 8 in.) outside. The case's weight with holding tray in place is 4.33 kg (9.55 lb).

The inner packaging consists of 5.08-cm (2-in.) layers, top and bottom, of 0.91-kg- (2-lb-) density protective foam.

A styrofoam inner tray custom made to hold each cylinder separately is squeezed between the foam. The tray is 5.08-cm- (2-in.-) thick, high-density foam.

Each cylinder is equipped with a welded Nupro valve. The valve is equipped with a modified handle to permit use of a torque measuring device during closure. There are three valve options depending on customer needs:

- Option 1--If there is a need only for basic gas transport with no concern for isotopic combination, Nupro Part Number SS-4BAW-5417 is recommended. Manufacture and testing shall meet the cleaning, dimensional, and nondestructive examination (NDE) requirements for Nupro P/N SS-4BAW-5417.

- Option 2--If the need is only for basic gas transport with no concern for isotopic combination, and a fully electropolished containment vessel is desired, such is obtainable as Nupro Part Number SS-4BAW-5756. Manufacture and testing are the same as for Nupro P/N SS-4BAW-5417 with the addition of electropolishing.

- Option 3--If there is a need to ensure that isotopic combinations remain stable, the containment vessel requires passivation. Order the unassembled parts for Nupro P/N SS-4BAW-5417 except that a 4BAG valve rather than a 4BAW valve is required. Send the parts to either Quantum Mechanics Corporation or Vactronic Lab Equipment, Inc., for passivation assembly and testing. Assembly and testing shall satisfy the cleaning, dimensional, and NDE requirements for Nupro P/N SS-4BAW-5417, except that the minimum proof pressure is required to be 680 kPa (100 psia) and the minimum leakage test acceptance criteria is to be 7×10^{-8} standard cm^3/s helium. The Quantum Mechanics Corporation address is:

    Quantum Mechanics Corporation
    21885 8th St. E
    P.O. Box 1885
    Sonoma, CA 95476-1885
    (707) 938-5555

The Vactronic Lab Equipment, Inc. address is:

    Vactronic Lab Equipment, Inc.
    160-T Wilbur Place

Bohemia, NY 11716
(516) 567-0520

7.16.2 Authorized Contents

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 DOT-7A compliance with the actual contents.

7.16.2.1 Physical Form. Contents are gaseous radioactive materials authorized when packaged as described.

7.16.2.1.1 Maximum Gross Weight

- 500 cc (5.76 kg [12.7 lb]).

7.16.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

7.16.2.3 Radiological. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level prior to the test) as a result of the decrease in distance to the center of the package load as a result of the drop test. In one instance (500 cc), there was movement of the inner cylinder of 3.8 cm (1 1/2 in.), and the maximum dent in the outer packaging was 1.3 cm (1/2 in.).

7.16.2.4 Simulated Payload. The simulated payload for the testing was air.

7.16.3 Restrictions/Specifications

The maximum authorized pressures for the 500 cc cylinder is 324 kPa (47 psi).

The valve is to be torqued at closure following procedures that incorporate the torquing requirements of 3.4 $\pm$0.2 newton-meter (N-m) (30 $\pm$2 lb-in.) developed by the Westinghouse Savannah River Company.

The bolt is to be inserted into one of the holes on the sides of the handle.

The penetration test did not result in any significant dents in the surface of the package.

As a result of the drop tests, in one instance (500 cc), there was movement of the inner cylinder of 3.8 cm (1 1/2 in.), and the maximum dent in the outer packaging was 1.3 cm (1/2 in.). The shipper must ensure that the radiation level at the package surface will not increase by more than 20%.

See the test pressure previously listed. The shipper must determine that the actual contents are closely simulated by the test contents (air). If this is not true or not known, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

This Modified Commercial Tritium Packaging was demonstrated to comply with the regulatory requirements identified in 49 CFR 178.350 by comparison to the Mound Commercial Tritium Packaging (Docket 92-31-7A). The testing and results identified on the following pages are those that were conducted on the Mound Commercial Tritium Packaging.

The Modified Commercial Tritium design and current Mound design are structurally very similar. Both designs use similar components and materials of the same approximate size and weight. The proposed Modified Commercial Tritium design does not incorporate any design feature that would result in test results that were different than the Mound results.

The Modified Commercial Tritium design and Mound design both use the same outer packaging and Whitey[3] 500 cc cylinder.

The fitting between the valve and cylinder has the smallest structural cross-section. The Modified Commercial Tritium fitting is an adapter union manufactured by Nupro, while the Mound fitting is a straight tube. The Nupro fitting is about 2.0 cm (0.8 in.) longer than the Mound fitting for full penetration butt welds with 100% volumetric NDE, while the Mound design has fillet welds. The Modified Commercial Tritium welds are not at critical stress points, while the Mound welds are. The structural integrity of the Modified Commercial Tritium valve attachment is better ensured than that of the Mound design.

Both the Modified Commercial Tritium design and Mound design use a Nupro B series bellows sealed valve. The Mound angle-pattern valve design is an after-market modified straight-pattern valve with no butt weld capability on the inlet side. The Modified Commercial Tritium design uses a manufacturer supplied with integral butt weld extensions angle-pattern valve. Both valves will behave similarly during testing. Both valves will also respond similarly to vibration since the valve internals are the same.

Since the weight of both designs (cylinder and valve) is approximately the same and the structure design is similar, both designs will have similar vibrational responses. Both designs are enclosed within a shipping case where any small differences in vibration characteristics will be dampened out by the packaging material.

7.16.4 49 CFR 178.350 Regulatory Requirements

Table 7.16-3. Regulatory Compliance Assessment.

7.16.5 Quality Control

Table 7.16-4. Packaging/Acceptance/Use Criteria.

7.16.6 Additional Information

Evaluation and testing of the Mound Commercial Tritium packaging took place at MLM in 1991. The comparison of the Modified Commercial Tritium Packaging to the Mound Commercial Tritium Packaging was conducted by personnel at the Westinghouse Savannah River Company. No testing of the Modified Commercial Tritium Packaging was conducted. The information on the Modified Commercial Tritium Packaging was added to this document under Docket 93-34-7A. A complete comparison report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

7.16.6.1 Primary Users

Site/Contact/Phone	Address
Westinghouse Savannah River Company	**Westinghouse Savannah River Company**
R. J. Gromada	P.O. Box 616
COMM/FTS 803-725-4760	Aiken, SC 29802

7.17 WHC HEDGEHOG CONTAINER (DOCKET: 94-39-7A, 02/95)

Figure 7-24. WHC Hedgehog Container, Outer Case.

Figure 7-25. WHC Hedgehog Container,* 30-mL Version. (*without outer case)

Figure 7-26. WHC Hedgehog Container,* 125-mL Version. (*without outer case)

Figure 7-27. WHC Hedgehog Container,* 250-mL Version. (*without outer case)

Figure 7-28. WHC Hedgehog Container,* 1-L Version. (*without outer case)

7.17.1 Package Description

NOTE: Design measurements noted for this packaging were provided in English and were converted to metric. Measurements are nominal (1 in. = 2.54 cm).

Table 7.17-1. Dimensions (Nominal).

The approximate shielding thickness for each configuration tested is as follows:

- 30-mL version (3.81 cm [1.5 in.])
- 125-mL version (2.54 cm [1.0 in.])
- 250-mL version (1.27 cm [0.5 in.])
- 1-L version (no shielding).

Table 7.17-2. Materials/Method of Construction.

7.17.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the payload used during testing (see Section 7.17.2.4). If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

7.17.2.1 Physical Form. Liquid radioactive materials having a specific gravity up to 2 when packaged as described. Solids are also authorized, in normal or special form. The solid materials are limited in weight, including packaging, to the gross weight of the as-tested liquids and bottles. The packaging provides double containment.

7.17.2.1.1 Maximum Gross Weight (Nominal). The following table provides the weight of the as-tested sample bottle, lid, and simulated contents. In addition, it provides the as-tested simulated content weight. The gross weight of the entire Hedgehog Container is also shown.

Table 7.17-3. Maximum Gross Weights for Packaging Configurations (Nominal).

7.17.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

7.17.2.3 Radiological. 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 shifting of contents needs to be taken into account during transport.

7.17.2.4 Simulated Payload. The simulated payload used was water and carbon steel shot to equal a liquid having a specific gravity of 2.

7.17.3 Restrictions/Specifications

1. The packagings are approved for shipping liquids having a specific gravity of 2 or less, 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 as-tested liquids and bottles. 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. Ensure that the proper orientation of the Hardigg Case is marked. Note that the internal black, ABS load spacer is the bottom of the packaging in which it normally sits. The slit in the lid gasket is located at the bottom of the packaging in which it normally sits.

3. A fluid indicator is incorporated into the sorbent cylinder lining of the SafeSend container. 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.

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

    - Those having a vapor pressure of greater than 130 kPa (18.8 lbs/in.^{2}) 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.

5. A vapor pressure of 130 kPa (18.8 psi) at 55 °C (130 °F) should never be exceeded.

6. Improper tightening of the SafeSend canister may cause leakage or breakage of contents. To ensure proper seal for transporting inner packaging, the SafeSend cap must be tightened until the latch snaps into place. The canister or latch should not be used if damaged.

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

8. When storing the SafeSend container, unscrew the cap one full turn from the latched position.

9. Note that two different screw sizes exist with the stainless steel pig assemblies. The user should refer to the drawings and operating instructions when assembling packaging configurations.

10. The top lid of each pig will be notched. Each pig assembly is identified with a serial number. Do not use if the serial number for the parts of the pig assembly are not identical

11. Pig assembly screws shall be torqued to 1.9 to 2.0 N-m (1.4 to 1.5 ft-lb or 17-18 in.-lb).

12. The 1-L version requires that the bottle remain intact and not break. The shipper must either use the same 1-L bottle that was used during testing (Nalgene, high-density, PVC-coated, wide-mouth glass jar with Teflon-lined phenolic lid) or document that if a different bottle is used, that it is equivalent to what was used during testing.

13. The top portion of the wooden disk assembly must not be in contact with the top of the base of the SafeSend container. If it is, do not use. Check the assembly fit by holding or weighting the spacer down onto the top of the SafeSend lid. Suitable shim material may be used per sponsor's operating instructions.

14. The shipper shall ensure that the radiation level at any surface would not increase by more than 20%.

15. Operation, maintenance, and reuse of packaging shall be in accordance with applicant-provided operating instructions.

For airborne shipments, HM-181 requirements pertinent to reduced external pressure conditions may be included; see discussion in Section 1.3.4.

For heavy, bulky materials (e.g., concrete chunks, motors, and pumps), equipment or materials with sharp corners or protrusions, or material/equipment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

7.17.4 49 CFR 178.350 Regulatory Requirements

Table 7.17-4. Regulatory Compliance Assessment.

7.17.5 Quality Control

Table 7.17-5. Packaging/Acceptance/Use Criteria.

7.17.6 Additional Information

Evaluation and testing of the subject packaging took place at Westinghouse Hanford in 1995 as Docket Number 94-39-7A. A complete test report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

7.17.6.1 Primary Users

Site/Contact/Phone	Address
Hanford Site	**Westinghouse Hanford Company**
M. S. Mercado	P.O. Box 1970
COMM/FTS 509-376-9129	Richland, WA 99352

7.18 WHC 1-L LIQUID SHIPPER (DOCKET: 95-41-7A, 08/95)

Figure 7-29. WHC 1-L Liquid Shipper.

7.18.1 Package Description

NOTE: 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 7.18-1. Dimensions.

Table 7.18-2. Materials/Method of Construction.

7.18.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the payload used during testing (see Section 7.18.2.4). If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

7.18.2.1 Physical Form. Liquid radioactive materials having a specific gravity ≤ 2 when packaged as described. Solids are also authorized, in normal or special form. The solid materials are limited in weight, including packaging, to the gross weight of the as-tested liquid and bottle. The packaging provides double containment.

7.18.2.1.1 Maximum Gross Weight (Nominal). The following table provides the weight of the as-tested bottle, lid, and simulated contents. The gross weight of the assembled packaging is also shown.

Table 7.18-3. Weight (Nominal).

7.18.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

7.18.2.3 Radiological. 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 shifting of contents needs to be taken into account during transport.

7.18.2.4 Simulated Payload. The simulated payload used was water and carbon steel shot to equal a liquid having a specific gravity of 2.

7.18.3 Restrictions/Specifications

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. 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)

3. The 1-L inner bottle shall be inserted into the SafeSend container in an upright position.

4. 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.

5. 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/in.^{2}) 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.

6. A vapor pressure of 130 kPa (18.8 psi) at 55 °C (130 °F) should never be exceeded.

7. 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.

8. 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.

9. When storing the SafeSend container, unscrew the cap one full turn from the latched position.

10. The shipper shall ensure that the radiation level at any surface would not increase by more than 20%.

For airborne shipments, HM-181 requirements pertinent to reduced external pressure conditions may be included; see discussion in Section 1.3.4.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, and SWBs), equipment or materials with sharp corners or protrusions, or material/equipment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package to prevent damage within the packaging.

7.18.4 49 CFR 178.350 Regulatory Requirements

Table 7.18-4. Regulatory Compliance Assessment.

7.18.5 Quality Control

Table 7.18-5. Packaging/Acceptance/Use Criteria.

7.18.6 Additional Information

Evaluation and testing of the subject packaging took place at Westinghouse Hanford in 1995 as Docket Number 95-41-7A. A complete test report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

7.18.6.1 Primary Users

Site/Contact/Phone	Address
Hanford Site	**Westinghouse Hanford Company**
W. Scott Edwards	P.O. Box 1970
(509) 376-2522	Richland, WA 99352

1.Duraglass is a trademark of Owens-Illinois Glass Container, Inc.

2.Teflon is a trademark of E.I. duPont de Nemours and Company.

3.Whitey is a trademark of Whitey Company, a Swagelok Company.

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8.0 MISCELLANEOUS

8.1 LLNL SHIELDED (PREVIOUS SPEC 55) CONTAINER (DOCKETS: MLM)

Figure 8-1. LLNL Shielded (Previously Spec. 55) Container.

8.1.1 Package Description

Table 8.1-1. Dimensions.

Table 8.1-2. Materials/Method of Construction.

8.1.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

8.1.2.1 Physical Form

8.1.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate material form for his particular contents and comply with any special requirements.

- Material Form Number 1: Solids--any particle size.
- Material Form Number 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.).
- Material Form Number 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)

8.1.2.1.2 Maximum Gross Weight. Form Number 1, Number 2, and Number 3:

- 50 lb.

8.1.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

8.1.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

8.1.3 49 CFR 178.350 Regulatory Requirements

Table 8.1-3. Regulatory Compliance Assessments.

8.1.4 Quality Control

Table 8.1-4. Packaging/Acceptance/Use Criteria.

8.1.5 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.1.5.1 Primary Users

Site/Contact/Phone	Address
Nevada Test Site	**Lawrence Livermore National Laboratory**
W. Hyatt	Bldg. 128
COMM/FTS 702-295-6883	Mercury, NV 89023

8.2 ORNL TRANSURANIC SHIPPING CONTAINER (DOCKETS: MLM)

Figure 8-2. ORNL Transuranic Shipping Container (contents restricted, see Section 8.2.2).

8.2.1 Package Description

Table 8.2-1. Dimensions.

Table 8.2-2. Materials/Method of Construction.

8.2.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

8.2.2.1 Physical Form. Authorized only for the following:

- Special form radioactive materials (49 CFR 173.403)
- Inner container that meets the Type A requirements by itself.

8.2.2.1.1 Maximum Gross Weight

- 3,700 lb.

8.2.3 Restrictions/Specifications

Note restrictions on contents in Section 8.2.2.1.

8.2.4 49 CFR 178.350 Regulatory Requirements

Table 8.2-3. Regulatory Compliance Assessment.

8.2.5 Quality Control

Table 8.2-4. Packaging/Acceptance/Use Criteria.

8.2.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.2.6.1 Primary Users

Site/Contact/Phone	Address
ORNL	**Oak Ridge National Laboratory**
R. W. Schaich	P.O. Box X
COMM/FTS 615-574-6991	Oak Ridge, TN 37830

8.3 FEMA CDV-792 SHIELDED OVERPACK (DOCKETS: MLM)

Figure 8-3. FEMA Source Overpack (contents restricted, see Section 8.3.2).

8.3.1 Package Description

Table 8.3-1. Dimensions.

Table 8.3-2. Materials/Method of Construction.

8.3.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

8.3.2.1 Physical Form. Authorized only for the following:

- Special form radioactive materials (49 CFR 173.403)
- Inner container that meets the Type A requirements by itself.

8.3.2.1.1 Maximum Gross Weight

- 200 lb
  - CDV-792 (w/o 791) = 185 lb
  - CDV-791 = 15 lb

  200 lb.

8.3.3 Restrictions/Specifications

Note restrictions on contents in Section 8.3.2.1.

8.3.4 49 CFR 178.350 Regulatory Requirements

Table 8.3-3. Regulatory Compliance Assessment.

8.3.5 Quality Control

Table 8.3-4. Packaging/Acceptance/Use Criteria.

8.3.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.3.6.1 Primary Users

Site/Contact/Phone	Address
ORNL	**Oak Ridge National Laboratory**
R. W. Schaich	P.O. Box X
COMM/FTS 615-574-6991	Oak Ridge, TN 37830

8.4 SNL TRITIUM WASTE PACKAGE STEEL DRUM (DOCKETS: MLM)

Figure 8-4. SNL Tritium Waste Package Steel Drum.

8.4.1 Package Description

Table 8.4-1. Dimensions.

Table 8.4-2. Materials/Method of Construction.

8.4.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

8.4.2.1 Physical Form. Two forms are authorized. Each shipper must determine the most appropriate form for his particular contents.

- Material Form No. 1: Solids--any particle size.
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.).

NOTE: The packaging is specifically designed for disposal of radioactive (tritium) waste.

8.4.2.1.1 Maximum Gross Weight

- 200 lb.

8.4.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

8.4.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

8.4.3 Restrictions/Specifications

Maximum of 12 L of liquid immobilized on the clay absorbent.

8.4.4 49 CFR 178.350 Regulatory Requirements

Table 8.4-3. Regulatory Compliance Assessment.

8.4.5 Quality Control

Table 8.4-4. Packaging/Acceptance/Use Criteria.

8.4.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Revision 1 of this document in 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.4.6.1 Primary Users

Site/Contact/Phone	Address
D. Crooks	**Sandia Livermore**
COMM/FTS 510-294-2233	P.O. Box 969
	Livermore, CA 94550

8.4.6.2 Vendor Data

- Absorbent--Florco, Floridin Company, Pittsburgh, Pennsylvania
- Steel Wool and Asphalt--For details on use and packaging procedures, see *Safety Analysis Report for Packaging a DOT-7A Specification Container for Tritiated Liquid Wastes* (Alford 1980).

8.5 LANL ALUMINUM PACKAGING (LANL-1) (DOCKETS: MLM)

Figure 8-5. LANL Aluminum Packaging (LANL-1) (contents restricted, see Section 8.5.3).

8.5.1 Package Description

Table 8.5-1. Dimensions.

Table 8.5-2. Materials/Methods of Construction.

8.5.1.1 Drawing

Los Alamos National Laboratory, No. 18Y-308060, Sheets 1-4.

8.5.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

8.5.2.1 Physical Form

8.5.2.1.1 Solids Only. Restricted to Material Form No. 3 only. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control)

8.5.2.1.2 Maximum Gross Weight

- 170 lb.

8.5.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

8.5.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

8.5.3 Restrictions/Specifications

The closure bolts shall be torqued to 40 ft-lb.

Gaskets and cushioning materials must have an operating range of -40 °F to 158 °F.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

8.5.4 49 CFR 178.350 Regulatory Requirements

Table 8.5-3. Regulatory Compliance Assessment.

8.5.5 Quality Control

Table 8.5-4. Packaging/Acceptance Criteria.

8.5.6 Additional Information

Evaluation and testing of the subject packaging took place at MLM in 1989. A complete test report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.5.6.1 Primary Users

Site/Contact/Phone	Address
LANL	**Los Alamos National Laboratory**
N. King	P.O. Box 1663
COMM/FTS 505-667-4127	Los Alamos, NM 87545

8.6 REMOTE-HANDLED TRANSURANIC WASTE CONTAINER (DOCKETS: 89-03-7A, 05/90)

Figure 8-6. Remote-Handled Transuranic Waste Container.

8.6.1 Package Description

Table 8.6-1. Dimensions and Weight.

Table 8.6-2. Materials/Method of Construction.

8.6.1.1 Drawings

- Westinghouse WID Operations Drawing Number H-2-91273
  - Sheet No. 1, Rev. D
  - Sheet No. 2, Rev. B
  - Sheet No. 3, Rev. A.

8.6.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

8.6.2.1 Physical Form

8.6.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate material form for his particular contents.

- Material Form No. 1: Solids--any particle size.
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.).
- Material Form No. 3: Solids--objects with no significant or removable contamination. (For definition see 49 CFR 173.443, Contamination control.)

8.6.2.1.2 Maximum Gross Weight

- 5,980 lb--When loaded with three 55-gal drums in the as-tested, approved configuration.
- 5,250 lb--Other material forms.

8.6.2.1.3 Test Contents. The test packages were loaded with the following contents:

Pkg #	Gross Wt. (lb)	Contents

LA01	5,250	Scrap metal of various shapes consisting of pipe, angle iron, equipment, fixtures, etc. A mixture of 0.4 lb of fluorescein and 5 lb of flour was added.
LA02	5,980	Three 55-gal drums. Drum #1 - 1,290 lb of magnetite; Drum #2 - 1,590 lb of lead bricks; and Drum #3 - 1,340 lb of magnetite. A mixture of 0.35 lb of fluorescein and 5 lb of flour was added into the container.

8.6.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

8.6.3 Restrictions/Specifications

Operation of the packaging shall be in accordance with the *User's Manual for the RH Transuranic Waste Container* (Hertelendy 1985).

For heavy, bulky materials (e.g., concrete chunks, motors, and pumps), equipment or materials with sharp corners or protrusions, or material/equipment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

8.6.4 49 CFR 178.350 Regulatory Requirements

Table 8.6-3. Regulatory Compliance Assessment.

8.6.5 Quality Control

Table 8.6-4. Packaging/Acceptance/Use Criteria.

8.6.6 Additional Information

Evaluation and testing of the subject packaging took place at Westinghouse Hanford in 1990 as part of Docket 89-03-7A. Testing was completed in May 1990. A complete test report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.6.6.1 Primary Users

Site/Contact/Phone	Address
WIPP	**Westinghouse/Waste Isolation Division**
Sheila A. Lott	P.O. Box 2078
(505) 885-7438	Carlsbad, NM 88221-2078

8.7 PACKAGING FOR SPECIAL FORM NEUTRON SOURCE (DOCKETS: 91-26-7A, 03/92)

Figure 8-7. Packaging for Special Form Neutron Source.

8.7.1 Package Description

Table 8.7-1. Dimensions and Weight.

Table 8.7-2. Materials.

8.7.1.1 Method of Construction. Welding and brazing of the packaging was accomplished using suitable techniques, materials, and equipment. The cask filler material was cast directly into the shield container through an access that is sealed by the filler plate.

8.7.2 Authorized Contents

The shipper must determine that the actual contents are special form. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

8.7.2.1 Physical Form. Contents are restricted to special form neutron source.

8.7.2.2 Maximum Net Weight

- 576 lb.

8.7.2.3 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

8.7.2.4 Radiological. The decrease in distance to the center of the package was 0.875 in. (maximum) as a result of the 4-ft drop test. The load shifted within the packaging by this amount. The access tube moved within the shielding material, decreasing the distance to the surface. The container end piece bent inward. The shipper must ensure that the radiation level at the surface would not exceed the maximum preshipment surface radiation level by 20% if the package is damaged as in testing. When making the loss-of-shielding calculation, assume loss of all lead shielding.

8.7.3 Restrictions/Specifications

The following restrictions and specifications relating to the authorized contents shall be adhered to.

1. Special form radioactive materials (49 CFR 173.403) or an inner container that meets the Type A requirements by itself.

2. The shipper must ensure that the radiation level at any surface would not exceed the maximum preshipment surface radiation level by 20% if the package is damaged as in testing. During testing, the access tube was shifted within the shielding by 0.875 in. The tube was moved from the access end toward the opposite end.

The shipper is the organization which actually uses the package and is, therefore, responsible to make sure it is used in accordance with its design. As a part of this, the shipper shall ensure that the design is suitable in all respects for the contents to be shipped. The design will dictate many of the limits placed on the contents.

8.7.4 49 CFR 178.350 Regulatory Requirements

Table 8.7-3. Regulatory Compliance Assessment.

8.7.5 Quality Control

Table 8.7-4. Packaging/Acceptance/Use Criteria.

8.7.6 Additional Information

Evaluation and testing of the subject packaging took place at Westinghouse Hanford in 1992 as part of Docket 91-26-7A. Testing was completed in March 1992. A complete evaluation report is available upon

request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.7.6.1 Primary Users

Site/Contact/Phone	Address
Grand Junction	**Chem-Nuclear Geotech, Inc.**
P. D. Henwood	P.O. Box 14000
COMM/FTS 303-248-6660	Grand Junction, CO 81502

8.8 PPPL TRITIUM WASTE PACKAGE STEEL DRUM (DOCKET: 92-29-7A, 01/93)

Figure 8-8. PPPL Tritium Waste Package Steel Drum.

8.8.1 Package Description

Table 8.8-1. Dimensions.

Table 8.8-2. Materials/Method of Construction.

8.8.2 Authorized Contents

- Solids--tritium oxide (water) vapor absorbed on molecular sieve.

8.8.2.1 Physical Form. Two forms are authorized. Each shipper must determine the most appropriate form for his particular contents.

- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.).
- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control).

NOTE: The packaging is specifically designed for disposal of radioactive (tritium) waste.

8.8.2.1.1 Maximum Gross Weight

- 1,000 lb.

8.8.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

8.8.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in a decrease in the distance from the exterior to the center of the package at the bottom chime of 2.5 in. (approximate). The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

8.8.3 Restrictions/Specifications

Maximum of 10 lb of tritium oxide (water) vapor immobilized on 100 lb of molecular sieve.

The shipper must determine that the actual contents are closely simulated by identified contents. If they are not, testing/analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual

contents.

The lid-locking ring bolt shall be tightened to 40 ± 4 ft-lb torque with tapping of ring during tightening. A jam nut shall also be used to prevent unintentional loosening during transport.

The drum gasket material must have an operating range of -40 °F to 158 °F.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

8.8.4 49 CFR 178.350 Regulatory Requirements

Table 8.8-3. Regulatory Compliance Assessment.

8.8.5 Quality Control

Table 8.8-4. Packaging/Acceptance/Use Criteria.

8.8.6 Additional Information

This package was evaluated by comparison with the DOT-17C 55-gal steel drum. Testing was not conducted. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.8.6.1 Primary Users

Site/Contact/Phone	Address
F. J. Tulipano COMM/FTS 609-243-2118 COMM/FTS 212-839-3307	**Princeton Plasma Physics Laboratory** James Forrestal Campus P.O. Box 451 Princeton, New Jersey 08543
S. B. Larson COMM/FTS 609-243-3387	

8.8.6.2 Vendor Data

Absorbent--Molecular Sieve Type 4A, Union Carbide
Industrial Gases Inc., Linde Division
39 Old Ridgebury Road
Danbury, Connecticut 08817-0001

8.9 TRUPACT II TEN-DRUM OVERPACK (DOCKET: 90-16-7A, 10/93)

Figure 8-9. TRUPACT II Ten-Drum Overpack (WIPP).

Figure 8-10. TRUPACT II Ten-Drum Overpack with SWB and Dunnage.

8.9.1 Package Description

Table 8.9-1. Dimensions.

Table 8.9-2. Materials/Method of Construction.

8.9.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

8.9.2.1 Physical Form.

8.9.2.1.1 Solids Only. Five forms are authorized. Each shipper must determine the most appropriate form for his particular contents:

- Material Form No. 1: Solids--any particle size.
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil).
- Material Form No. 3: Solids--objects with no significant or removable contamination. (For definition see 49 CFR 173.443, Contamination Control).
- Material Form No. 4: Solids as described in Form No. 3 above, including large, bulky, dense objects with sharp and obtrusive members or components, but having Form No. 1 and/or No. 2 as dispersible contaminates associated with the material (e.g., steel plates, motors, valves, steel pipes, concrete blocks).
- Material Form No. 5: Drums and other packagings in any arrangement within gross weight limitations.

NOTE: Refer to Section 8.9.3, Restrictions/Specifications, for items fitting the previous descriptions that could result in highly localized forces.

8.9.2.1.2 Maximum Gross Weight

- 3,039 kg (6,700 lb).

8.9.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

8.9.2.3 Radiological. 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 shifting of contents needs to be taken into account during transport.

All drop tests conducted were 1.2 m (4 ft). The following information is from the testing conducted in October 1993. During the center-of-gravity over-top-rim drop test, the lid uplifted 1.87 cm (0.735 in.) outward with a chord of 61 cm (24 in). During the flat-on-side drop test, the side near bumper #4 indented approximately 3.5 cm (1 3/8 in.). The bottom portion of the overpack side panel dented inward approximately 2.70 cm (1 1/16 in.), and with a chord of 40.6 cm (16 in.). During the center-of-gravity on-bottom-edge drop test, the bottom side wall under bumper #4 dented inward 4 cm (1.573 in.). The bottom pan of the overpack buckled up from the underside and into the overpack resulting in a dent approximately 5.4 cm (2 1/8 in.) with a chord of 27.5 cm (1 ft 10 in.). Refer to the test results in Appendix D, Table D-20.a.

Although the TRUPACT II Ten-Drum Overpack (TDOP) failed the drop test when it was filled with the

SWB (July 1990, Test Package 130408), a decision was made not to conduct additional tests with the SWB load. No dunnage was used during the July 1990 test, and the SWB punctured the sidewall of the TDOP. It was determined that if dunnage was used for large bulky objects, like the SWB, the TDOP would be able to withstand the conditions normal to transportation and the forces of impact under the drop test conditions.

8.9.2.4 Simulated Payload. The simulated payload used was 10 55-gal drums filled with hardened concrete.

8.9.3 Restrictions/Specifications

The TDOP shall be operated in accordance with the Westinghouse Waste Isolation Division instruction entitled, *Handling and Maintenance Manual for TRUPACT II Ten-Drum Overpack (TDOP).*

The lid closure bolts must be torqued to a minimum of 50 (+5, -0) ft-lb.

The carbon filters shall be installed from the inside using Loctite(1)

RC-680 and torqued to 5 (+3, -0) ft-lb. A total of 10 filters were installed for testing purposes; however, an evaluation of this packaging as a Type A package was completed by the test sponsor. Results of this evaluation follow:

- If the contents of the TDOP **do not** have the potential for flammable gas generation, **a minimum of one filter shall be installed and the unused filter ports shall be sealed with 1.91 cm (3/4 in.) NPT socket recessed pipe plugs that have been installed from the outside.** The installation of one filter is to ensure that equalization of pressure differential caused by changes in atmospheric pressure, ambient temperature, or exposure to solar heating is maintained.

- If the contents of the TDOP **have** the potential to generate flammable gas, the analysis showed that nine filters in the TDOP are sufficient to maintain the flammable gas concentration below 5% hydrogen after storage for indefinite periods and during shipment.

No reduced pressure test was conducted due to the use of filters in the design.

NOTE: For heavy, bulky materials (e.g., concrete chunks, motors, pumps, and SWBs), equipment or materials with sharp corners or protrusions, or material/equipment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package to prevent damage to the TDOP.

8.9.4 49 CFR 178.350 Regulatory Requirements

Table 8.9-3. Regulatory Compliance Assessment.

8.9.5 Quality Control

Table 8.9-4. Packaging/Acceptance/Use Criteria.

8.9.6 Additional Information

Evaluation and testing of the subject packaging took place at Westinghouse Hanford in 1990 and 1993. A complete test report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.9.6.1 Primary Users

Site/Contact/Phone	Address
Waste Isolation Pilot Plant	**Westinghouse/Waste Isolation Division**
J. A. Golden	P.O. Box 2078
505-234-8859	Carlsbad, NM 88221

8.10 INEL MARK III CONCRETE CONTAINER (DOCKET: 92-33-7A, 10/94)

Figure 8-11. INEL Mark III Concrete Container.

Figure 8-12. Mark III Concrete Container with As-Tested Payload and Bracing.

8.10.1 Package Description

Table 8.10-1. Dimensions.

Table 8.10-2. Materials/Method of Construction.

8.10.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the payload used during testing (see Section 8.10.2.4). If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

8.10.2.1 Physical Form.

8.10.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate form for his particular contents, as follows:

- Material Form Number 1: Solids--any particle size
- Material Form Number 2: Solids--large particle size only (e.g., sand, concrete, debris, soil)
- Material Form Number 3: Solids--objects with no removable or dispersible contamination. (For definition, see 49 CFR 173.443, "Contamination Control.").

NOTE: Refer to Section 8.10.3, "Restrictions/Specifications," for items fitting the previous descriptions that could result in highly localized forces.

8.10.2.1.1 Maximum Gross Weight

Table 8.10-3. Weight.

8.10.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

8.10.2.3 Radiological. 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 shifting of contents needs to be taken into account during transport. See Appendix D, Tables D-20.b and D-20.c, for details of damage to the package during drop testing.

8.10.2.4 Simulated Payload. The simulated payload used during testing was sand and soil, stainless steel

ingots (45.72-cm diameter by 38.1-cm long and/or 45.72-cm diameter by 101.6-cm long [18-in. diameter by 15 in.-long and/or 18-in. diameter by 40-in. long]), and lead bricks. Bracing was used to protect the bottom, sides, and top of the inside of the container. Bracing consisted of plywood sheets, wooden 2 x 4s, and railroad ties. Refer to Figure 8-12 for a diagram of the placement of the payload and bracing during testing.

8.10.3 Restrictions/Specifications

1. Cracks in the polyethylene liner (body and lid) are not acceptable. Weld seam on sealing surface of body and lid liner will be even and smooth, and free from cracks.

2. Clean sealing surfaces prior to lid installation.

3. Apply the polyethylene foam gasket to the container lid according to drawing numbers 445862 and 446074. The gasket in the as-tested configuration consisted of two parts (booster and main gasket), and each part being one continuous piece. Check the gasket to ensure a minimum of 0.9525-cm (3/8-in.) loft. If the loft is less than 0.9525 cm (3/8 in.), a new gasket shall be installed. The gasket shall not be installed until time of permanent container sealing.

4. The shipper shall ensure that the radiation level at any surface would not increase by more than 20%.

5. The user is responsible for ensuring that the packaging does not contain small, highly radioactive materials that could become lodged inside the drain/vent lines that could result in a significant radiation change in the surface of the packaging.

6. To ensure that the bolts seat properly, remove the lid from the Mark III Concrete Container body, and install bolts. Bolts should thread down to within 2.54 cm (1 in.) of the body rim.

7. The vent plug on the lid of the container will be removed prior to installation of the lid due to air pressure being trapped within the container.

8. Lid bolts shall be torqued to 135.58 N-m (100 ft-lbs) in 33.89-N-m (25-ft-lb) increments, and in the pattern specified by the sponsor's instructions.

9. Prior to shipment, verify that valves are closed and that the two drains are closed and that all five plugs are installed.

10. For heavy, bulky materials (e.g., concrete chunks, motors, pumps); equipment/materials with sharp corners or protrusions; or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

11. When the packaging is loaded underwater, the user must ensure that all water has been removed before shipment.

8.10.4 49 CFR 178.350 Regulatory Requirements

Table 8.10-4. Regulatory Compliance Assessment.

8.10.5 Quality Control

Table 8.10-5. Packaging/Acceptance/Use Criteria.

8.10.6 Additional Information

Evaluation and testing of the subject packaging took place at Westinghouse Hanford in 1994 as Docket

Number 92-33-7A. A complete test report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.10.6.1 Primary Users

Site/Contact/Phone	Address
INEL	**Lockheed Idaho Technologies Company (LITCO)**
W. D. Richins (208) 526-0522	P.O. Box 1625 Idaho Falls, Idaho 83415
H. D. Welch (208) 526-0530	
B. C. Spaulding (208) 526-8633	

8.11 INEL ARROW-PAK PACKAGING (By Arrow Construction, Inc.) (DOCKET: 95-40-7A, 10/95)

Figure 8-13. ARROW-PAK Packaging (INEL and Arrow Construction, Inc.).

8.11.1 Package Description

The ARROW-PAK packaging system consists of a Marlex M-8000 Driscopipe,[(2)] Series 8000 (gas) or Series 8600 (industrial) resin pipe, and is sealed with dome-shaped end caps manufactured from the same materials. A patented process permanently seals the two end caps to the pipe body. The patented process involves the use of electrical energy to heat opposing faces of the pipe and end caps, and hydraulic rams to press the heated surfaces together. During the fusion process, the exterior and interior wall surface of the end caps and pipe create beaded edges. The edges protrude away from both the exterior and interior wall surfaces about 0.635-cm (0.25-in). A seam is visible; however, the seam does not run through the internal thickness of these component pieces. The fusion process produces a homogeneous bonding of the end cap to the pipe. The homogeneous bond extends over the full wall thickness of the package.

A total of two plywood spacers were used inside each of the two ARROW-PAK test units that were filled with simulated contents. It should be noted that the use of the plywood spacers is optional. The purpose of these spacers was to hold the simulated contents in place during the fusion process.

Table 8.11-1. Dimensions.

Table 8.11-2. Materials/Method of Construction.

8.11.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the payload used during testing (see Section 8.11.2.4). If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

8.11.2.1 Physical Form.

8.11.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate form for his particular contents.

- Material Form No. 1: Solids--any particle size.
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil).
- Material Form No. 3: Solids--objects with no removable or dispersible contamination. (For definition, see 49 CFR 173.443, "Contamination Control.").

NOTE: Refer to Section 8.11.3, Restrictions/Specifications, for items fitting the previous descriptions that could result in highly localized forces.

8.11.2.1.1 Maximum Gross Weight:

- 519.82 kg (1146.0 lb).

Table 8.11-3. Weight.

8.11.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

8.11.2.3 Radiological. 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 shifting of contents needs to be taken into account during transport. See Appendix D, Table D-20.d, for details of damage to the package during drop testing.

8.11.2.4 Simulated Payload. The simulated payload used in two test units was clean, noncontaminated, and taped lead bricks. Carbon steel shot was added as a filler material. It was estimated that the lead bricks made up 65% of the content fill weight (314.3-kg [693.0-lb]), and the steel shot made up 35% of the content fill weight (169.2-kg [373.0-lb]). Fluorescein was added as a tracer material. The third test unit was basically empty, and fluorescein was added as a tracer material.

8.11.3 Restrictions/Specifications

1. The pipe shall be homogenous throughout and free of visible cracks, holes, voids, foreign inclusions, or other deleterious defects, and shall be identical in color, density, melt index, and other physical properties throughout.
2. The shipper shall ensure that the radiation level at any surface would not increase by more than 20%.
3. During handling, care must be exercised to avoid cutting or gouging the Marlex pipe and/or end caps. When lifting fused sections of pipe, chains or cable-type chokers must be avoided. Nylon slings are preferred. Spreader bars are recommended when lifting long fused sections.
4. The use of the plywood spacers is optional. If the spacers are used, adequate space is required to account for the fusion process. The spacer needs to fit down snugly onto the packaging contents. It may be necessary to wrap the outside edge of the spacer with several layers of tape so that the spacer does not move and shift.
5. The joining method of the end caps to the pipe/tube shall be the butt fusion method, and be in accordance with the pipe manufacturer's recommendations. Socket fusion shall not be used. The fusion equipment used in the joining procedures must meet the manufacturer's temperature requirements of 260 °C (500 °F), alignment, and 1034.2 kPa (150 psi) interfacial fusion pressure.
6. For heavy, bulky materials (e.g., concrete chunks, motors, pumps, and SWBs), equipment or materials with sharp corners or protrusions, or material/equipment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the

package to prevent damage within the packaging.

8.11.4 49 CFR 178.350 Regulatory Requirements

Table 8.11-4. Regulatory Compliance Assessment.

8.11.5 Quality Control

Table 8.11-5. Packaging/Acceptance/Use Criteria.

8.11.6 Additional Information

Evaluation and testing of the subject packaging took place at Westinghouse Hanford in 1995 as Docket Number 95-40-7A. A complete test report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.11.6.1 Primary Users

Site/Contact/Phone	Address
INEL	**Lockheed Idaho Technologies Company (LITCO)**
Dr. Harley Reno	P.O. Box 1625
(208) 526-9865	Idaho Falls, Idaho 83415-2113

Packaging Manufacturer
Arrow Construction, Inc.
216 Gunn Road
P.O. Box 240427
Montgomery, Alabama 36124
(205) 271-6185

*Page correction for Vol. 1 document. This will be Rev. 0-E.

8.12 WHC WRAP-1, 208-L WASTE DRUM [BAGLESS TRANSFER SYSTEM] (DOCKET: 94-35-7A, 08/94)

NOTE: For information regarding current design, test, and evaluation information for the "Modified WRAP 1-Trip 208-L Drum" tested under Docket 99-48-7A in January 2001, see DOE/RL-96-57, Vol. 2, Section 8.2.

Figure 8-14. WHC WRAP-1, 208-L Waste Drum.

Figure 8-15. WHC WRAP-1, 208-L Waste Drum - Sealing Detail.

8.12.1 Package Description

The as-tested WRAP-1 drum is a modified UN-1A2, 208-L (55-gal), filtered, galvanized, steel drum. Modifications consist of the addition of: an inner ring (adhered to the inside of the drum), inner neoprene foam seal, a filtered inner lid (swaged and secured into place with special equipment), and an inner rubber gasket. The special equipment required for loading and closure of this packaging, is defined in WHC-SD-W026-OCD-001, Revision 0, "One-Trip Drum Operating Instruction." Assembly of the as-tested packaging

is shown on Hanford Drawing Number H-2-824300 Revision 0. Drums tested were purchased according to Hanford Standard HS-V-P-0010, Revision C.

Table 8.12-1. Dimensions.

Table 8.12-2. Materials/Method of Construction.

8.12.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the payload used during testing (see Section 8.12.2.4). If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

8.12.2.1 Physical Form.

8.12.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate form for his particular contents:

- Material Form No. 1: Solids--any particle size.
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil).
- Material Form No. 3: Solids--objects with no removable or dispersible contamination. (For definition, see 49 CFR 173.443, "Contamination Control.").

NOTE: Refer to Section 8.12.3, Restrictions/Specifications, for items fitting the previous descriptions that could result in highly localized forces.

8.12.2.1.1 Maximum Gross Weight:

- 454 kg (1000 lb).

8.12.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

8.12.2.3 Radiological. Three drums were drop tested as identified in Table D-20.d. Damage reported for the packagings tested and evaluated under dockets 89-13-7A/90-18-7A and 94-37-7A are identified in Table D-10.a and D-10.b. The 1.2-m (4-ft) drop test caused deformation of the package resulting in a decrease in the distance from the exterior to the center of the package at the bottom chime of approximately 6.35 cm (2.5 in.). 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 shifting of contents needs to be taken into account during transport.

8.12.2.4 Simulated Payload. The simulated payload used during testing was soil/sand and lead bricks. A mixture of flour and fluorescein was used as tracer material and to simulate Material Form Number 1.

8.12.3 Restrictions/Specifications

1. The special equipment required for loading and closure of this packaging is defined in WHC-SD-W026-OCD-001, Revision 0, "One-Trip Drum Operating Instruction." Assembly of the as-tested packaging is shown on Hanford Drawing Number H-2-824300, Revision 0. Drums tested were purchased according to Hanford Standard HS-V-P-0010, Revision C. Sizes and tolerances per Hanford Drawing H-2-824300, Revision 0, must be strictly adhered to and followed.

2. The inner lid must be fitted with a NucFil -013, 3/4-in. - 14 NPT, carbon-activated filter. A 2.54 cm (1 in.) diameter hole is punched into the center of the inner drum lid. The NucFil-013 filter is threaded through the hole and a locking nut is tightened onto the back side of the filter and torqued to 33.9 Nm (25 [±1] lbf·ft).

3. The inner ring shall be adhered and sealed (top and bottom) around its circumference to the drum body with E-6000 black adhesive. This first application of adhesive is allowed to cure for 24 hours. A second application of adhesive occurs above and below the inner ring. Remove any excess adhesive from the top and bottom surface of the ring. Allow second application to cure for 24 hours.

4. The inner seal shall meet the following specifications:

    - Neoprene/sbr foam
    - Adhesive backed and satin finish
    - Density: 3.5 - 5.0 lb/cu ft
    - 25% compression resist: 2.0 - 5.0 psi.

5. Dimension and placement of inner lid gasket is critical for proper drum closure per DOT-7A testing. The gasket should lay flat against the inner lid and inner seal.

6. A NucFil-013 filter is installed into the provided flange on the outer drum lid. The flange is located in the center annulus of the outer lid at least 7.62 cm (3 in.) from the center to avoid interference with the filter in the inner lid. The outer lid filter is torqued to 33.9 Nm (25 [±1] lbf·ft). No sealant or tape is added to enhance this seal.

7. The lid locking ring bolt shall be tightened to 54.24 Nm (40 [±1] lbf ft) torque with tapping of the ring followed by tightening. A jam nut shall also be used to prevent unintentional loosening during transport. The location of the jam nut shall be between the lugs, and the jam nut shall be tightened against the threaded lug.

8. The drum gasket material, the neoprene inner gasket, and the neoprene inner seal shall have an operating range of -40 °C to +70 °C (-40 °F to +158 °F).

9. For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment/materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package. This loading must be evaluated to assure that the packaging, if tested, would not fail.

8.12.4 49 CFR 178.350 Regulatory Requirements

Table 8.12-3. Regulatory Compliance Assessment.

8.12.5 Quality Control

Table 8.12-4. Packaging/Acceptance/Use Criteria.

8.12.6 Additional Information

Drop and vibration and testing of the subject packaging took place at Los Alamos National Laboratory and at Hanford in August 1994 as Docket Number 94-35-7A. Comparison and evaluation of the subject packaging with the DOT-17C, 55-gal steel drums tested and evaluated under dockets 89-13-7A/90-18-7A and 94-37-

7A was performed by Westinghouse Hanford Company in September 1995. A complete test report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.12.6.1 Primary Users

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APPENDIX A

COMPLIANCE WITH STANDARD REQUIREMENTS FOR ALL PACKAGES (49 CFR 173.24)

Pre-HM-181 (pre-October 1994)

Table A-1. Steel Drums--Compliance with Standard Requirements for All Packages (49 CFR 173.24).

Table A-2. Steel Boxes--Compliance with Standard Requirements for All Packages (49 CFR 173.24).

Table A-3. Wooden Boxes--Compliance with Standard Requirements for All Packages (49 CFR 173.24).

Table A-4. Fiberboard Containers--Compliance with Standard Requirements for All Packages (49 CFR 173.24).

Table A-5. UF_6 Cylinders--Compliance with Standard Requirements for All Packages (49 CFR 173.24).

Table A-6. Liquid and Gas Packagings--Compliance with Standard Requirements for All Packages (49 CFR 173.24).

Table A-7. Miscellaneous Packagings--Compliance with Standard Requirements for All Packages (49 CFR 173.24).

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APPENDIX B

COMPLIANCE WITH GENERAL DESIGN REQUIREMENTS (49 CFR 173.411)

Table B-1. Steel Drums--Compliance with General Design Requirements (49 CFR 173.411).

Table B-2. Steel Boxes--Compliance with General Design Requirements (49 CFR 173.411).

Table B-3. Wooden Boxes--Compliance with General Design Requirements (49 CFR 173.411).

Table B-4. Fiberboard Containers--Compliance With General Design Requirements (49 CFR 173.411).

Table B-5. UF_6 Cylinders--Compliance With General Design Requirements (49 CFR 173.411).

Table B-6. Liquid and Gas Packagings--Compliance With General Design Requirements (49 CFR 173.411).

Table B-7. Miscellaneous Packagings--Compliance With General Design Requirements (49 CFR 173.411).

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APPENDIX C

COMPLIANCE WITH ADDITIONAL DESIGN REQUIREMENTS FOR TYPE A PACKAGES (49 CFR 173.412)

Table C-1. Steel Drums--Compliance with Additional Design Requirements for Type A Packages (49 CFR 173.412).

C1.0 SUMMARY OF PRESSURE TESTS ON EVALUATED STEEL DRUMS

Paragraph 173.412(i) in effect requires a pressure differential of 0.75 atm (11.2 psig) across the surfaces of the containment system acting from the inside to the outside. In all of the steel drum packagings, the containment system is defined as the drum itself. To achieve the pressure differential, the inside of the packaging was pressurized to 11.2 psig using compressed air and held for approximately 5 min. The pass/fail criteria were as follows:

1. No release of contents as determined by the absence of any detectable air flow or fluorescein after the test.
2. The retention of pressure, 11.2 ± 0.3 psig. This was held for approximately 5 min.
3. No structural distortion which would cause an increase exceeding 20% in the dose rate at the surface of the package as compared to the dose rate prior to beginning the test.

The 17C 55-gal drums with vent clips and with high-efficiency filters installed in the lids were tested. In this case the criteria became just containment (no release of contents) since the packaging will not hold pressure. This last statement is technically correct; however, in the instance above (vent clips and filters in lid), the pressure was raised to 11.2 psig and held for 5 min. by adjusting the inward flow to equal the loss through the vent clip and/or filter. This was over-testing because there are no realistic conditions of normal transport in which a pressure differential of this magnitude could arise in a matter of seconds. In the unlikely event of such a pressure change over longer periods of time, the vent clip or filter would allow the pressures to equilibrate before differentials approaching 11.2 psig could be reached. The table below provides detailed information concerning the testing of the steel drums and the results.

Table C-2. Steel Drums--"Reduced Pressure" Tests Summary.

Table C-3. Steel Boxes--Compliance With Additional Design Requirements for Type A Packages

(49 CFR 173.412).

C2.0 SUMMARY OF PRESSURE TESTS ON EVALUATED STEEL BOXES

The containment system is defined as the box itself. To achieve the pressure differential, the inside of the packaging (steel box) was pressurized to 11.2 psig using compressed air, compressed nitrogen, or water, as described in Table C-4. In all cases, the pressure was held for approximately 5 min. The pass/fail criteria were essentially the same as given in Table C-2, with the exception of the Capital Industry test, which used water. In this case, obviously no flour or fluorescein was used; however, the absence of a visible water leak (and retention of water pressure) was really a more sensitive test than detection of fluorescein. Note that this test applies only to the nonfiltered packagings because reasonably this differential could not be expected to be encountered in transportation with a filtered packaging.

Table C-4. Steel Boxes--"Reduced Pressure" Tests Summary.

Table C-5. Wooden Boxes--Compliance With Additional Design Requirements for Type A Packages (49 CFR 173.412).

C3.0 SUMMARY OF PRESSURE TESTS ON EVALUATED WOODEN BOXES

This test method, raising the internal pressure to 9 to 11 psi and maintaining it for several minutes, is very conservative. This is because, in transport, any pressure differential encountered would be equilibrated very slowly, and the strong driving force encountered in this test would not exist.

Table C-6. Wooden Boxes--"Reduced Pressure" Tests Summary.

Table C-7. Fiberboard Containers--Compliance With Additional Design Requirements for Type A Packages (49 CFR 173.412).

Table C-8. UF_6 Cylinders--Compliance With Additional Design Requirements for Type A Packages (49 CFR 173.412).

Table C-9. Calculated Safety Factor for UF_6 Cylinders.

Table C-10. Liquid and Gas Packagings--Compliance With Additional Design Requirements for Type A Packages (49 CFR 173.412).

Table C-11. Liquid and Gas Packagings--"Reduced Pressure" Tests Summary.

Table C-12. Packages Meeting 49 CFR 173.412(k) Criterion.

Table C-13. Miscellaneous Packagings--Compliance With Additional Design Requirements for Type A Packages (49 CFR 173.412).

Table C-14. Miscellaneous Packagings Containment System Analysis.

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APPENDIX D
SUMMARY OF TYPE A PACKAGING TESTS (49 CFR 173.465)

D1.0 INTRODUCTION

The purpose of this section is to provide more details concerning the Type A packaging tests that were conducted or against which the packages were analyzed for compliance. The tests involved are as follow:

1. Water spray
2. Free drop
3. Compression
4. Penetration.

These tests, test methods, and determination of pass/fail criteria are discussed at length in Section 1.0.

D1.1 49 CFR 173.465(a)

(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.

Requirement D-1. Water Spray Test.	
49 CFR 173.465	**Discussion**
(b) Water Spray Test	Major Points
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	(1) Must precede each test (2) 2 in./hr (3) 1-hr duration Comments This is usually a conditioning of a package, rather than a test as such. One would not expect a loss of contents or significant increase in dose rate resulting from just the water spray test. However, consideration must be given to the possibility of water

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.	leakage into the package with subsequent transport of radioactive contents out as leakage.
	Designer, tester, and evaluator to do and shipper responsibility to ensure.

D1.2 PACKAGING CATEGORY--STEEL DRUMS

In evaluating steel drums against this requirement, one would consider the following:

- The effect the water spray would have on the ability of the steel drums to meet the other Specification 7A performance requirements
- The potential for inleakage of water with the subsequent potential for transport of the radioactive contents out of the packagings
- Because these same packagings are air-leak tight, prevention of the inleakage of water under such passive conditions as a water spray (rain) is expected.

As shown in Tables D-1.a and D-1.b, nine different types of steel drums (a total of 26 different packagings) were subjected to this test. In all cases, as one would expect based on materials and methods of construction, closure mechanisms, gaskets, and the painted surfaces, the water spray had no effect that could possibly be interpreted as decreasing the ability of the steel drums to meet all Specification 7A performance criteria. This is not surprising since there are years of experience demonstrating that lengthy exposures to rain have not had a negative effect on containment integrity. In addition, in each of the 26 individual tests, a careful inspection demonstrated there was no inleakage of water as a result of these tests. Because these same packagings are air-leak tight, one would also expect them to prevent the inleakage of water under such passive conditions as a water spray (rain).

As a final point of mainly academic discussion, because the steel drums are air-leak tight to begin with, in the unlikely event of an inleakage of water, it would be equally unlikely that this expected minute quantity of water would leak out. Thus, based on the test data below and after comparison of the similarity in materials and methods of construction of the untested steel drums, one can readily conclude that these steel drums meet this requirement.

Table D-1.a. Water Spray Test Results for Steel Drums.

Table D-1.b. Water Spray Test Results for Steel Drums.

D1.3 PACKAGING CATEGORY--STEEL BOXES

In evaluating steel boxes against this requirement, one would consider the following:

- The effect the water spray would have on the ability of the steel boxes to meet the other Specification 7A performance requirements
- The potential for inleakage of water with the subsequent potential for transport of the radioactive contents out of the packagings
- Because these same packagings are air-leak tight, prevention of the inleakage of water under such passive conditions as a water spray (rain) is expected.

In all cases but one (the Argonne National Laboratory - West [ANL-W] 7A-960 steel box), as one would

expect based on materials and methods of construction, closure mechanisms, gaskets, and painted surfaces, the water spray would have no effect that could be interpreted as decreasing the ability of the steel boxes to meet all Specification 7A performance criteria. This is not surprising since there are years of experience demonstrating that lengthy exposures to rain have no negative effect on containment integrity. Because these same packagings are air-leak tight, one would also expect them to prevent the inleakage of water under such passive conditions as a water spray (rain).

As a final point of mainly academic discussion, because the steel boxes are air-leak tight to begin with, in the unlikely event of an inleakage of water, it would be equally unlikely that this expected minute quantity of water would leak out. Thus, based on the information below and after comparison of the similarity in materials and methods of construction of the steel boxes, one can readily conclude that all the steel boxes meet this requirement (with the exception of the ANL-W 7A-960, as discussed in Table D-2).

Table D-2. Water Spray Test Results for Steel Boxes.

D1.4 PACKAGING CATEGORY--WOODEN BOXES

In evaluating wooden boxes against this requirement, one would consider the following:

- The effect the water spray would have on the ability of the wooden boxes to meet the other Specification 7A performance requirements
- The potential for inleakage of water with the subsequent potential for transport of radioactive contents out of the packagings.

As shown in Table D-3, 14 different types of wooden boxes (a total of 24 different packagings) were subjected to this test. In all cases, as one would expect based on materials and methods of construction, closure mechanisms, and caulking/glue, the water spray had no effect that could be interpreted as decreasing the ability of the wooden boxes to meet the remaining Specification 7A performance criteria. This is not surprising since there are years of experience demonstrating that exposure to rain has not had a significant effect on containment integrity.

With respect to the potential for inleakage of water, some boxes constructed of normal exterior grade plywood did allow small amounts of water to penetrate. For test purposes, the insides of the test boxes were lined with paper, and the box was subjected to the water spray test for 1 hr and allowed to sit for 2 hr. At the end of this period, the paper was inspected for spots which would indicate the presence of water.

Table D-3. Water Spray Test Results for ANL and LLNL Wooden Boxes.

Table D-4. Water Spray Test Results for Mound Wooden Boxes.

Table D-5. Water Spray Test Results for Wooden Boxes.

D1.5 WATER INLEAKAGE--WOODEN BOXES

As shown in Table D-4, small amounts of water did appear at times on the paper, indicating an inleakage of water. The majority of the inleakage occurred at the corners and at some points in the seams; however, a few spots occurred that indicated inleakage through the walls themselves. Three possible approaches are described that are acceptable with respect to addressing this inleakage and ensuring that there is no transport of radioactive materials out of the packaging.

- Securely enclose the radioactive contents within the box so that any inleaking water cannot come in contact with the radioactive material.

- Seal the box using GEOCEL or its equivalent. If the box is reused, it must be re-coated with at least one coat to cover the seal areas before each shipment.

- Ensure that there is no loose or removable contamination that could be entrained in any liquid and that the radioactive material is not soluble in the liquid. Thus, even if the liquids come in contact with the radioactive material, there could be no transport from the package.

NOTE: These three approaches are presented in the Restrictions/Specifications sections for each of the evaluated packagings in Section 4.0. There are obviously other possible approaches; however, if an alternative approach is chosen, the basis for the choice must be supported and documented. The use of one of these alternatives or an equivalent allows these wooden boxes to meet this requirement.

Table D-6. Water Spray Test Results for Fiberboard Containers.

D1.6 WATER INLEAKAGE--FIBERBOARD CONTAINERS

The following two possible approaches are acceptable with respect to addressing this potential inleakage and ensuring that there is no transport of radioactive materials out of the packaging.

- Securely enclose the radioactive contents within the box so that any inleaking water cannot come in contact with the radioactive material.

- Ensure that there is no loose or removable contamination which could be entrained in any liquid and that the radioactive material is not soluble in the liquid. Thus, even if the liquids come in contact with the radioactive material, there could be no transport from the package.

NOTE: These two approaches are presented in the Restrictions/Specifications section for each of the evaluated packagings in Section 5.0. There are obviously other possible approaches; however, if an alternative approach is chosen, the basis for the choice must be supported and documented. The use of one of these alternatives or an equivalent method allows these fiberboard packagings to meet this requirement.

Table D-7. Water Spray Test Results for UF_6 Cylinders.

Table D-8. Water Spray Test Results for Liquid and Gas Packagings.

Table D-9. Water Spray Test Results for Miscellaneous Packagings.

Requirement D-2. Free Drop Test.

49 CFR 173.465	Discussion
(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).	Major Points (1) 4-ft drop (2) Manner to cause maximum damage Comments (1) The orientation causing maximum damage may not be readily apparent. Typically, the following guidelines should be considered: (a) Drums - side drop with bolt closure ring (BCR) at impact point; - Angle drop (approximately 45° on BCR and on bottom

at intersection of chime and side seam);

(b) Boxes - Top (lid) corner near features, such as lifting rings and filters, if any exist;

(c) Approximate center of gravity over impact point.

(2) A quick release device is required to ensure no change in package orientation.

(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:

Straightforward

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
>15,000	>33,000	1	0.3

Comments

Designer, tester, and evaluator to do and shipper responsibility to ensure.

(3) For Fissile Class II packagings, the free drop specified in subparagraph (1) or (2) of this paragraph shall be preceded by a free 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.

For packagings to be used for Fissile Class II shipments, further testing and evaluation per subparagraph (3) are required.

(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 meters (1 foot).

Designer, tester, evaluator to do and shipper responsibility to ensure.

(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 meters (1 foot).

Designer, tester, evaluator to do and shipper responsibility to ensure.

(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.

As a rule of thumb, an essentially nonyielding surface is one at least five times the mass of the impacting object.

Tester and evaluator to do and shipper responsibility to ensure.

Table D-10.a. Free Drop Test Results for Steel Drums.

Table D-10.b. Free Drop Test Results for Steel Drums.

Table D-10.c. Free Drop Test Results for Steel Drums.

Table D-10.d. Free Drop Test Results for Steel Drums.

Table D-10.e. Free Drop Test Results for Steel Drums.

Table D-11.a. Free Drop Test Results for Steel Boxes.

Table D-11.b. Free Drop Test Results for Steel Boxes

Table D-12. Free Drop Test Results for ANL and LLNL Wooden Boxes.

Table D-13.a. Free Drop Test Results for Wooden Boxes.

Table D-13.b. Free Drop Test Results for Wooden Boxes.

Table D-14. Free Drop Test Results for NLO Family of Banded Wooden Boxes.

Table D-15. Free Drop Test Results for Fiberboard Boxes.

Table D-16. Free Drop Test Results for DOT-21C Fiberboard Drums.

Table D-17. Free Drop Test Results for UF_6 Cylinders.

Table D-18.a. Additional Free Drop Test Results for Liquid and Gas Packagings.

Table D-18.b. Additional Drop Test Results for Liquid and Gas Packagings.

Table D-18.c. Additional Free Drop Test Results for Liquid and Gas Packagings.

Table D-19.a. Free Drop Test Results for Liquid and Gas Packagings.

Table D-19.b. Free Drop Test Results for Liquid and Gas Packagings.

Table D-20.a. Free Drop Test Results for Miscellaneous Packagings.

Table D-20.b. Free Drop Test Results for Miscellaneous Packagings.

Table D-20.c. Free Drop Test Results for Miscellaneous Packagings.

Table D-20.d. Free Drop Test Results for Miscellaneous Packagings.

Table D-21. Corner Free Drop Test Results for Wooden Boxes.

Table D-22. Corner Free Drop Test Results for Fiberboard Boxes.

Table D-23. Corner Free Drop Test Results for DOT-21C Fiberboard Drums.

Requirement D-3. Compression Test.

49 CFR 173.465	Discussion
(d) Compression Test The compression test shall last for a period of at least 24 hours and consist of a compressive load equivalent	Major Points (1) 5 times actual weight (2) 265 lb/ft^2 times the area of package

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.

Comments

(1) Be alert. For packages with a large top surface area, the 265 lb/ft^2 can quickly become very large.

(2) Any decreases in distances to package surfaces should be documented for use in evaluating the "no significant dose rate increase" requirement.

Tester and evaluator to do and shipper responsibility to ensure.

Table D-24. Compression Test Results for Steel Drums.

Table D-25. Compression Test Results for Steel Boxes.

Table D-26. Compression Test Results for Wooden Boxes.

Table D-27. Compression Test Results for Fiberboard Containers.

Table D-28. Compression Test Results for UF_6 Cylinders.

Table D-29. Compression Test Results for Liquid and Gas Packagings.

Table D-30. Compression Test Results for Miscellaneous Packagings.

Requirement D-4. Penetration Test.

49 CFR 173.465	Discussion
(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:	Major Points (1) 13-lb bar (2) 1 m (3.3 ft) (3) Most vulnerable point
(1) A bar 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	Comments Penetration of the outer packaging(s) is not necessarily a cause for failure. The question is, "Did the test result in a loss of contents?" For outer packaging components not meeting this requirement, one could specify an inner component(s) that will meet the requirement or design protective devices to ensure that the bar cannot reach the primary containment system.

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).	Tester and evaluator to do and shipper responsibility to ensure.

Table D-31. Penetration Test Results for Steel Drums.

Table D-32. Penetration Test Results for Steel Boxes.

Table D-33. Penetration Test Results for Wooden Boxes.

Table D-34. Penetration Test Results for Fiberboard Containers.

Table D-35. Penetration Test Results for UF_6 Cylinders.

Table D-36. Penetration Test Results for Liquid and Gas Packagings.

Table D-37. Penetration Test Results for Miscellaneous Packagings.

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APPENDIX E

COMPLIANCE WITH VIBRATION STANDARDS

(49 CFR 178.608)

E1.0 INTRODUCTION

The purpose of this section is to provide more details concerning the packaging tests that were conducted for compliance with the vibration standard for testing packages (49 CFR 178.608).

This vibration test standard is being applied to Type A packages to demonstrate compliance with 49 CFR 173.412 (e), which states:

". . . each Type A packaging shall be designed so that . . . (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."

This test, test method, and determination of pass/fail criteria are discussed in Section 1.0.

Requirement E-1. Vibration Test.	
49 CFR 178.608	**Discussion**
(a) Each packaging must be capable of withstanding, without rupture or leakage, the vibration test procedure outlined in this section.	Major Points
(b) Test method. (1) Three sample packagings, selected at random, 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	(1) Three sample packagings. (2) Vibrating platform has vertical or rotary double-amplitude of one inch. (3) Packagings free to move vertically, bounce, and rotate. (4) One-hour duration.

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) 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 Materials Safety.	(5) Pass a piece of material 1.6-mm (0.063-in.) thick between package and the platform.
(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.	Manufacturer and shipper responsible to ensure that package is capable of passing test.

Table E-1. Steel Drums--Compliance With Vibration Standard (49 CFR 178.608).

Table E-2. Steel Boxes--Compliance With Vibration Standard (49 CFR 178-608).

Table E-3. Wooden Boxes--Compliance With Vibration Standard (49 CFR 178-608).

Table E-4. Fiberboard Containers--Compliance With Vibration Standard (49 CFR 178-608).

Table E-5. UF_6 Cylinders--Compliance With Vibration Standard (49 CFR 178-608).

Table E-6. Liquid and Gas Packagings--Compliance With Vibration Standard (49 CFR 178-608).

Table E-7. Miscellaneous Packagings--Compliance with Vibration Standard (49 CFR 178-608).

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APPENDIX F

COMPLIANCE WITH GENERAL REQUIREMENTS FOR PACKAGES AND PACKAGING (49 CFR 173.24)

Post-HM-181 (post-October 1994)

Table F-1. Steel Drums--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). Post-HM-181 (Post-October 1994).

Table F-2. Steel Boxes--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). Post-HM-181 (Post-October 1994).

Table F-3. Wooden Boxes--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). Post-HM-181 (Post-October 1994).

Table F-4. Fiberboard Containers--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). Post-HM-181 (Post-October 1994).

Table F-5. UF_6--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). Post-HM-181 (Post-October 1994).

Table F-6. Liquid and Gas Packagings--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). Post-HM-181 (Post-October 1994).

Table F-7. Miscellaneous Packagings--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). Post-HM-181 (Post-October 1994).

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APPENDIX G

COMPLIANCE WITH ADDITIONAL GENERAL REQUIREMENTS FOR NON-BULK PACKAGING AND PACKAGES (49 CFR 173.24a)

Post-HM-181 (post-October 1994)

Table G-1. Steel Drums--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). Post-HM-181 (Post-October 1994).

Table G-2. Steel Boxes--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). Post-HM-181 (Post-October 1994).

Table G-3. Wooden Boxes--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). Post-HM-181 (Post-October 1994).

Table G-4. Fiberboard Containers--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). Post HM-181 (Post-October 1994).

Table G-5. UF_6--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). Post-HM-181 (Post-October 1994).

Table G-6. Liquid and Gas Packagings--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). Post-HM-181 (Post-October 1994).

Table G-7. Miscellaneous Packagings--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). Post-HM-181 (Post-October 1994).

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APPENDIX H

COMPLIANCE WITH ADDITIONAL GENERAL REQUIREMENTS FOR BULK PACKAGINGS (49 CFR 173.24b)

Post-HM-181 (post-October 1994)

Table H-1. Steel Drums--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). Post-HM-181 (Post-October 1994).

Table H-2. Steel Boxes--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). Post-HM-181 (Post-October 1994).

Table H-3. Wooden Boxes--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). Post-HM-181 (Post-October 1994).

Table H-4. Fiberboard Containers--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). Post-HM-181 (Post-October 1994).

Table H-5. UF_6--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). Post-HM-181 (Post-October 1994).

Table H-6. Liquid and Gas Packagings--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). Post-HM-181 (Post-October 1994).

Table H-7. Miscellaneous Packagings--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). Post-HM-181 (Post-October 1994).

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APPENDIX I
U.S. DEPARTMENT OF TRANSPORTATION LETTER OF CONCURRENCE

Figure I-1. U.S. Department of Transportation Letter of Concurrence.

US Department
of Transportation

**Research and
Special Programs
Administration**

400 Seventh Street S.W.
Washington, D.C. 20590

APR 21 1992

Michael E. Wangler, Director
Transportation and Packaging Safety Division
EH-33.3
U.S. Department of Energy
Washington, DC 20585

Dear Mr. Wangler:

This letter refers to your request for our review of the revision to your document entitled "Test and Evaluation Document for DOT Specification 7A Type A Packagings" DOE/DP/00052-H1. This document is intended to assist shippers in satisfying some of the requirements for documenting the results of testing of DOT Specification 7A packaging.

We have reviewed the subject document and concur with its purpose and contents. The document will provide DOE contractors and other radioactive materials shippers with information about the types of packaging components that can be used with various DOT specification packagings, the results of tests performed on the various packaging configurations, and quality control requirements for using the packagings. This information is essential for a program that offers a broad range of Type A packages for radioactive materials transported by a number of shippers.

We continue to concur with the restrictions that you place on using the document. Historically, some shippers have assumed that this type of document, as extracted or by itself, provides the complete documentation required by 49 CFR 173.415 for offering a Type A package for transportation. You emphasize that in addition to having this report, the shipper must also maintain documentation on other aspects of the shipment. These aspects include a comparison of the physical properties of the actual content of the package to those surrogate materials used for testing, and the implementation of a quality control program to ensure that package use complies with the applicable DOE and DOT requirements. This documentation is required for shippers to meet DOT requirements.

Thank you for the opportunity to review your document.

Sincerely,

Alan I. Roberts
Associate Administrator for
Hazardous Materials Safety

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APPENDIX J

REQUIREMENTS FOR DOT-SPECIFICATION PACKAGINGS (PRE-HM-181)

Table J-1	49 CFR 178.24a	Specification 2E; inside polyethylene bottle [1]
Table J-2	49 CFR 178.32	Specification 2N; inside containers, metal cans [1]
Table J-3	49 CFR 178.34	Specification 2R; inside containment vessel [1]
Table J-4	49 CFR 178.83	Specification 5C; steel barrels or drums [1]
Table J-5	49 CFR 178.99	Specification 6C; steel barrels or drums [1]
Table J-6	49 CFR 178.115	Specification 17C; steel drums [1]
Table J-7	49 CFR 178.118	Specification 17H; steel drums [1]
Table J-8	49 CFR 178.205	Specification 12B; fiberboard boxes [1]
Table J-9	49 CFR 178.206	Specification 12C; fiberboard boxes [1]
Table J-10	49 CFR 178.250	Specification 55; metal-encased, lead or uranium metal-shielded, radioactive materials container [2]

[1] Code of Federal Regulations, 49 CFR, Parts 178 to 199, *Transportation*, October 1, 1989.

[2] *Agent T. C. George's Tariff No. 23, Hazardous Materials Regulations of the Department of Transportation Including Specifications for Shipping Containers*, Issued August 3, 1969; Effective September 3, 1969.

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Table F-8. Free Drop Test Results for Steel Drums.

Specific packaging	Weight kg (lb)	Test Unit/Orientation/Results/Comments
Myers Model G5501	417.3 (920)	44-TU-07: Pass. Included NucFil-013[1] filter. Dropped flat onto the side at the welded seam, bolt, and filter locations. The drum indented a distance of 29.21 cm (11.5 in.) across the bottom of the drum. The drum pushed inward 5.08 cm (2 in.) along the bottom, and flattened along the bottom rolling hoop a distance of 25.40 by 10.16 cm (10 by 4 in.). Indentations measuring 3.80 cm (1.50 in.) and 3.175 cm (1.25 in.) occurred on each side of the W axis. The top of the drum ring pushed outward at the bolt location 0.635 cm (0.25 in.) and 10.16 cm (4 in.) across. No release of contents.
	410.0 (904)	44-TU-08 - Drop #1: Pass. Included NucFil-013 filter. Dropped onto the top at the bolt and filter locations, cog over the impact point. Damage occurred 44.45 cm (17.50 in.) across and 7.62 cm (3 in.) inward from the drum at the point of impact. The drum pushed outward 1.27 cm (0.50 in.) along the top rolling hoop due to the bolt being pushed down into the drum. No release of contents.
	410.0 (904)	44-TU-08 - Drop #2: Pass. Included NucFil-013 filter. Dropped onto the bottom rim and the welded seam, cog over the impact point. Because of damage that occurred to test unit 44-TU-09, this test unit was dropped a second time to ensure the integrity of the drum design. Damage occurred at the area of impact and measured 25.40 to 43.18 cm (10 to 17 in.) across the bottom. The bottom sidewall folded in approximately 5.08 cm (2 in.) toward the bottom of the drum. The bottom of the drum pushed outward from the sidewall to the center bottom of the drum a distance of approximately 19.05 cm (7.50 in.). No release of contents.

	415.4 (916)	44-TU-09: Pass. Included NucFil-013 filter. Dropped onto the bottom rim and welded seam, cog over the impact point. At the area of impact, the drum indented a distance of 40.64 cm (16 in.) across the bottom, and folded inward a distance of 7.62 cm (3 in.). The bottom edge of the drum rim split, measuring 4.445 cm (1.75 in.) in length and separating approximately 0.635 cm (0.25 in.). No release of contents.
	420.0 (926)	44-TU-10: Pass. Included NucFil-013 filter. Dropped flat onto the bottom. The drum pushed outward evenly along the entire bottom of the drum. No release of contents.
Myers Model 5526	411.8 (908)	44-TU-01: Pass. Included NucFil-013 filter. Dropped flat onto the side at the welded seam, bolt, and filter locations. The drum indented a distance of 35.56 cm (14 in.) across the bottom. The drum pushed outward 7.62 cm (3 in.) along the bottom, and flattened a distance measuring 25.40 by 7.62 cm (10 by 3 in.) along the side. No release of contents.
	418.2 (922)	44-TU-02: Pass. Included plain lid. Dropped flat onto the side at the welded seam and bolt locations. The drum flattened a distance of 35.56 cm (14 in.) at the area of impact. The drum pushed outward 2.54 cm (1 in.) along the bottom. The side of the drum indented and flattened slightly. No release of contents.
	410.9 (906)	44-TU-03. Pass. Included 3/4-in. plug. Drop onto the top at the bolt and plug location, cog over the impact point. Damage to the lid measured a distance of 45.72 cm (18 in.) across, and pushed inward 22.86 cm (9 in.) to the center of the lid. The drum crushed 33.02 cm (13 in.) across at the top to the first rolling hoop. The rolling hoop flattened a distance of 3.81 cm (1.50 in.). The drum pushed inward approximately 1.27 cm (0.50 in.) at the first rolling hoop at the area of impact. No release of contents.
	418.2 (922)	44-TU-04. Pass. Included plain lid. Dropped onto the top at the bolt location, cog over the impact point. Damage to the lid measured a distance of 45.72 cm (18 in.) across and 12.70 cm (5 in.) from the top edge. The bolt pushed inward at the area of impact. The upper portion of the drum flattened 44.45 cm (17.50 in.) across the area of impact. No release of contents.
	418.2 (922)	44-TU-05: Pass. Included plain lid. Dropped onto bottom rim at seam, cog over the impact point. At the area of impact, the bottom rim puckered slightly on each side of the W axis. The entire bottom of the drum pushed outward 45.72 cm (18 in.) across and pushed inward 15.24 cm (6 in.). No release of contents.
	415.4 (916)	44-TU-06: Pass. Included plain lid. Dropped flat onto the bottom. The drum indented a distance of 35.56 cm (14 in.) across the bottom of the drum. The drum pushed outward slightly, evenly across the entire bottom of the drum. No release of contents.

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1 NucFil is a trademark of Nuclear Filter Technology, Incorporated.

cog = center of gravity.

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Table F-26. Stacking Test Results for Miscellaneous Packagings.			
Specific packaging	**Authorized gross weight kg (lb)**	**Stack test weight kg (lb)**	**Test Unit/ Results/Comments**
Stagecoach Model 320162, V1.1	***NOTE: The compressive load was determined by using five times the estimated weight of the packaging as it is greater than the weight of the vertically projected area of the packaging. The compressive weight was applied for a 24-hour period.***		
Stagecoach Model 320162, V1.1	1360.77 (3000)	6876.46 (15,160)	This test was applied to test unit 7A-49-TU-01. This test unit was filled with simulated contents to a gross weight of 1404.3 kg (3,096 lb) (without pallet). The water spray test and penetration bar drop test were conducted on this test unit prior to conducting the stack test. The W Axis side wall bent and pushed outward approximately 21.88 cm (8.75 in.). The height was originally recorded as 110 cm (44 in.). After the test, the height was recorded as 70.63 cm (28.25 in.) at the W Axis; 57.5 cm (23 in.) at the X Axis; 55.63 through 69.38 cm (22.25 through 27.75 in.) at the Y Axis; and 76.25 cm (30.5 in.) at the Z Axis. The external dimensions at the side wall seams basically remained the same at 110 cm (44 in.). The cardboard inside the cover compressed from the original thickness of 1.25 cm (0.50 in) to 0.63 cm (0.25 in.). The side walls basically remained at the same thickness at 2.5 cm (1 in.). Additional damage consisted of the lid stitching ripping 62.5 cm (25 in.) along one side. The top of the side wall stitching ripped 93.98 cm (37 in.) at this same side, and the cardboard pushed up through the Velcro* secured "pocket." There was no release of contents.
Specific packaging	**Authorized gross weight kg (lb)**	**Stack test weight kg (lb)**	**Test Unit/ Results/Comments**
Modified WRAP 1-Trip, 208-L Drum			None tested. The authorized gross weight of this packaging is 454 kg (1000 lb). Due to the materials of construction and previous stack

			testing that has been performed on steel drums, as documented in DOE/RL-96-57, Vol. 1, it is evaluated that this drum design meets the stack test requirement for a compressive load of 2268 kg (5000 lb). The stack test was performed on DOT-17H drums to a compressive load of 2313.3 kg (5,100 lb) with no effect upon the performance of the drum, and no release of contents.
*Velcro is a registered trademark of Velcro Industries B.V., Amsterdam, Netherlands.			

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8.0 MISCELLANEOUS

8.1 LLNL SHIELDED (PREVIOUS SPEC 55) CONTAINER (DOCKETS: MLM)

Figure 8-1. LLNL Shielded (Previously Spec. 55) Container.

8.1.1 Package Description

Table 8.1-1. Dimensions.

Table 8.1-2. Materials/Method of Construction.

8.1.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

8.1.2.1 Physical Form

8.1.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate material form for his particular contents and comply with any special requirements.

- Material Form Number 1: Solids--any particle size.
- Material Form Number 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.).
- Material Form Number 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control.)

8.1.2.1.2 Maximum Gross Weight. Form Number 1, Number 2, and Number 3:

- 50 lb.

8.1.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

8.1.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

8.1.3 49 CFR 178.350 Regulatory Requirements

Table 8.1-3. Regulatory Compliance Assessments.

8.1.4 Quality Control

Table 8.1-4. Packaging/Acceptance/Use Criteria.

8.1.5 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.1.5.1 Primary Users

Site/Contact/Phone	Address
Nevada Test Site	**Lawrence Livermore National Laboratory**
W. Hyatt	Bldg. 128
COMM/FTS 702-295-6883	Mercury, NV 89023

8.2 ORNL TRANSURANIC SHIPPING CONTAINER (DOCKETS: MLM)

Figure 8-2. ORNL Transuranic Shipping Container (contents restricted, see Section 8.2.2).

8.2.1 Package Description

Table 8.2-1. Dimensions.

Table 8.2-2. Materials/Method of Construction.

8.2.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

8.2.2.1 Physical Form. Authorized only for the following:

- Special form radioactive materials (49 CFR 173.403)
- Inner container that meets the Type A requirements by itself.

8.2.2.1.1 Maximum Gross Weight

- 3,700 lb.

8.2.3 Restrictions/Specifications

Note restrictions on contents in Section 8.2.2.1.

8.2.4 49 CFR 178.350 Regulatory Requirements

Table 8.2-3. Regulatory Compliance Assessment.

8.2.5 Quality Control

Table 8.2-4. Packaging/Acceptance/Use Criteria.

8.2.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.2.6.1 Primary Users

Site/Contact/Phone	Address
ORNL	**Oak Ridge National Laboratory**
R. W. Schaich	P.O. Box X
COMM/FTS 615-574-6991	Oak Ridge, TN 37830

8.3 FEMA CDV-792 SHIELDED OVERPACK (DOCKETS: MLM)

Figure 8-3. FEMA Source Overpack (contents restricted, see Section 8.3.2).

8.3.1 Package Description

Table 8.3-1. Dimensions.

Table 8.3-2. Materials/Method of Construction.

8.3.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

8.3.2.1 Physical Form. Authorized only for the following:

- Special form radioactive materials (49 CFR 173.403)
- Inner container that meets the Type A requirements by itself.

8.3.2.1.1 Maximum Gross Weight

- 200 lb
  - CDV-792 (w/o 791) = 185 lb
  - CDV-791 = 15 lb

  200 lb.

8.3.3 Restrictions/Specifications

Note restrictions on contents in Section 8.3.2.1.

8.3.4 49 CFR 178.350 Regulatory Requirements

Table 8.3-3. Regulatory Compliance Assessment.

8.3.5 Quality Control

Table 8.3-4. Packaging/Acceptance/Use Criteria.

8.3.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Edling 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.3.6.1 Primary Users

Site/Contact/Phone	Address
ORNL	**Oak Ridge National Laboratory**
R. W. Schaich	P.O. Box X
COMM/FTS 615-574-6991	Oak Ridge, TN 37830

8.4 SNL TRITIUM WASTE PACKAGE STEEL DRUM (DOCKETS: MLM)

Figure 8-4. SNL Tritium Waste Package Steel Drum.

8.4.1 Package Description

Table 8.4-1. Dimensions.

Table 8.4-2. Materials/Method of Construction.

8.4.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

8.4.2.1 Physical Form. Two forms are authorized. Each shipper must determine the most appropriate form for his particular contents.

- Material Form No. 1: Solids--any particle size.
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.).

NOTE: The packaging is specifically designed for disposal of radioactive (tritium) waste.

8.4.2.1.1 Maximum Gross Weight

- 200 lb.

8.4.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

8.4.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

8.4.3 Restrictions/Specifications

Maximum of 12 L of liquid immobilized on the clay absorbent.

8.4.4 49 CFR 178.350 Regulatory Requirements

Table 8.4-3. Regulatory Compliance Assessment.

8.4.5 Quality Control

Table 8.4-4. Packaging/Acceptance/Use Criteria.

8.4.6 Additional Information

Evaluation and testing of this packaging were performed at MLM and were documented in Revision 1 of this document in 1987. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.4.6.1 Primary Users

Site/Contact/Phone	Address
D. Crooks	**Sandia Livermore**
COMM/FTS 510-294-2233	P.O. Box 969
	Livermore, CA 94550

8.4.6.2 Vendor Data

- Absorbent--Florco, Floridin Company, Pittsburgh, Pennsylvania
- Steel Wool and Asphalt--For details on use and packaging procedures, see *Safety Analysis Report for Packaging a DOT-7A Specification Container for Tritiated Liquid Wastes* (Alford 1980).

8.5 LANL ALUMINUM PACKAGING (LANL-1) (DOCKETS: MLM)

Figure 8-5. LANL Aluminum Packaging (LANL-1) (contents restricted, see Section 8.5.3).

8.5.1 Package Description

Table 8.5-1. Dimensions.

Table 8.5-2. Materials/Methods of Construction.

8.5.1.1 Drawing

Los Alamos National Laboratory, No. 18Y-308060, Sheets 1-4.

8.5.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

8.5.2.1 Physical Form

8.5.2.1.1 Solids Only. Restricted to Material Form No. 3 only. Each shipper must determine the most appropriate form for his particular contents and comply with any special requirements.

- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control)

8.5.2.1.2 Maximum Gross Weight

- 170 lb.

8.5.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

8.5.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in small decreases in the distance from the exterior to the center of the package. The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

8.5.3 Restrictions/Specifications

The closure bolts shall be torqued to 40 ft-lb.

Gaskets and cushioning materials must have an operating range of -40 °F to 158 °F.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

8.5.4 49 CFR 178.350 Regulatory Requirements

Table 8.5-3. Regulatory Compliance Assessment.

8.5.5 Quality Control

Table 8.5-4. Packaging/Acceptance Criteria.

8.5.6 Additional Information

Evaluation and testing of the subject packaging took place at MLM in 1989. A complete test report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.5.6.1 Primary Users

Site/Contact/Phone	Address
LANL	**Los Alamos National Laboratory**
N. King	P.O. Box 1663
COMM/FTS 505-667-4127	Los Alamos, NM 87545

8.6 REMOTE-HANDLED TRANSURANIC WASTE CONTAINER (DOCKETS: 89-03-7A, 05/90)

Figure 8-6. Remote-Handled Transuranic Waste Container.

8.6.1 Package Description

Table 8.6-1. Dimensions and Weight.

Table 8.6-2. Materials/Method of Construction.

8.6.1.1 Drawings

- Westinghouse WID Operations Drawing Number H-2-91273
  - Sheet No. 1, Rev. D
  - Sheet No. 2, Rev. B
  - Sheet No. 3, Rev. A.

8.6.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

8.6.2.1 Physical Form

8.6.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate material form for his particular contents.

- Material Form No. 1: Solids--any particle size.
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.).
- Material Form No. 3: Solids--objects with no significant or removable contamination. (For definition see 49 CFR 173.443, Contamination control.)

8.6.2.1.2 Maximum Gross Weight

- 5,980 lb--When loaded with three 55-gal drums in the as-tested, approved configuration.
- 5,250 lb--Other material forms.

8.6.2.1.3 Test Contents. The test packages were loaded with the following contents:

Pkg #	Gross Wt. (lb)	Contents

LA01	5,250	Scrap metal of various shapes consisting of pipe, angle iron, equipment, fixtures, etc. A mixture of 0.4 lb of fluorescein and 5 lb of flour was added.
LA02	5,980	Three 55-gal drums. Drum #1 - 1,290 lb of magnetite; Drum #2 - 1,590 lb of lead bricks; and Drum #3 - 1,340 lb of magnetite. A mixture of 0.35 lb of fluorescein and 5 lb of flour was added into the container.

8.6.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

8.6.3 Restrictions/Specifications

Operation of the packaging shall be in accordance with the *User's Manual for the RH Transuranic Waste Container* (Hertelendy 1985).

For heavy, bulky materials (e.g., concrete chunks, motors, and pumps), equipment or materials with sharp corners or protrusions, or material/equipment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

8.6.4 49 CFR 178.350 Regulatory Requirements

Table 8.6-3. Regulatory Compliance Assessment.

8.6.5 Quality Control

Table 8.6-4. Packaging/Acceptance/Use Criteria.

8.6.6 Additional Information

Evaluation and testing of the subject packaging took place at Westinghouse Hanford in 1990 as part of Docket 89-03-7A. Testing was completed in May 1990. A complete test report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.6.6.1 Primary Users

Site/Contact/Phone	Address
WIPP	**Westinghouse/Waste Isolation Division**
Sheila A. Lott	P.O. Box 2078
(505) 885-7438	Carlsbad, NM 88221-2078

8.7 PACKAGING FOR SPECIAL FORM NEUTRON SOURCE (DOCKETS: 91-26-7A, 03/92)

Figure 8-7. Packaging for Special Form Neutron Source.

8.7.1 Package Description

Table 8.7-1. Dimensions and Weight.

Table 8.7-2. Materials.

8.7.1.1 Method of Construction. Welding and brazing of the packaging was accomplished using suitable techniques, materials, and equipment. The cask filler material was cast directly into the shield container through an access that is sealed by the filler plate.

8.7.2 Authorized Contents

The shipper must determine that the actual contents are special form. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

8.7.2.1 Physical Form. Contents are restricted to special form neutron source.

8.7.2.2 Maximum Net Weight

- 576 lb.

8.7.2.3 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

8.7.2.4 Radiological. The decrease in distance to the center of the package was 0.875 in. (maximum) as a result of the 4-ft drop test. The load shifted within the packaging by this amount. The access tube moved within the shielding material, decreasing the distance to the surface. The container end piece bent inward. The shipper must ensure that the radiation level at the surface would not exceed the maximum preshipment surface radiation level by 20% if the package is damaged as in testing. When making the loss-of-shielding calculation, assume loss of all lead shielding.

8.7.3 Restrictions/Specifications

The following restrictions and specifications relating to the authorized contents shall be adhered to.

1. Special form radioactive materials (49 CFR 173.403) or an inner container that meets the Type A requirements by itself.

2. The shipper must ensure that the radiation level at any surface would not exceed the maximum preshipment surface radiation level by 20% if the package is damaged as in testing. During testing, the access tube was shifted within the shielding by 0.875 in. The tube was moved from the access end toward the opposite end.

The shipper is the organization which actually uses the package and is, therefore, responsible to make sure it is used in accordance with its design. As a part of this, the shipper shall ensure that the design is suitable in all respects for the contents to be shipped. The design will dictate many of the limits placed on the contents.

8.7.4 49 CFR 178.350 Regulatory Requirements

Table 8.7-3. Regulatory Compliance Assessment.

8.7.5 Quality Control

Table 8.7-4. Packaging/Acceptance/Use Criteria.

8.7.6 Additional Information

Evaluation and testing of the subject packaging took place at Westinghouse Hanford in 1992 as part of Docket 91-26-7A. Testing was completed in March 1992. A complete evaluation report is available upon

request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.7.6.1 Primary Users

Site/Contact/Phone	Address
Grand Junction	**Chem-Nuclear Geotech, Inc.**
P. D. Henwood	P.O. Box 14000
COMM/FTS 303-248-6660	Grand Junction, CO 81502

8.8 PPPL TRITIUM WASTE PACKAGE STEEL DRUM (DOCKET: 92-29-7A, 01/93)

Figure 8-8. PPPL Tritium Waste Package Steel Drum.

8.8.1 Package Description

Table 8.8-1. Dimensions.

Table 8.8-2. Materials/Method of Construction.

8.8.2 Authorized Contents

- Solids--tritium oxide (water) vapor absorbed on molecular sieve.

8.8.2.1 Physical Form. Two forms are authorized. Each shipper must determine the most appropriate form for his particular contents.

- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil, etc.).
- Material Form No. 3: Solids--objects with no significant dispersible or removable contamination. (For definition, see 49 CFR 173.443, Contamination control).

NOTE: The packaging is specifically designed for disposal of radioactive (tritium) waste.

8.8.2.1.1 Maximum Gross Weight

- 1,000 lb.

8.8.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

8.8.2.3 Radiological. The 4-ft drop test caused deformations of the package resulting in a decrease in the distance from the exterior to the center of the package at the bottom chime of 2.5 in. (approximate). The shipper must ensure that the radiation level at any surface would not increase by more than 20% (relative to the radiation level of the undamaged configuration) if such deformations would occur.

8.8.3 Restrictions/Specifications

Maximum of 10 lb of tritium oxide (water) vapor immobilized on 100 lb of molecular sieve.

The shipper must determine that the actual contents are closely simulated by identified contents. If they are not, testing/analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual

contents.

The lid-locking ring bolt shall be tightened to 40 ± 4 ft-lb torque with tapping of ring during tightening. A jam nut shall also be used to prevent unintentional loosening during transport.

The drum gasket material must have an operating range of -40 °F to 158 °F.

For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment or materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

8.8.4 49 CFR 178.350 Regulatory Requirements

Table 8.8-3. Regulatory Compliance Assessment.

8.8.5 Quality Control

Table 8.8-4. Packaging/Acceptance/Use Criteria.

8.8.6 Additional Information

This package was evaluated by comparison with the DOT-17C 55-gal steel drum. Testing was not conducted. Complete evaluation reports are available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.8.6.1 Primary Users

Site/Contact/Phone	Address
F. J. Tulipano COMM/FTS 609-243-2118 COMM/FTS 212-839-3307	**Princeton Plasma Physics Laboratory** James Forrestal Campus P.O. Box 451 Princeton, New Jersey 08543
S. B. Larson COMM/FTS 609-243-3387	

8.8.6.2 Vendor Data

Absorbent--Molecular Sieve Type 4A, Union Carbide
Industrial Gases Inc., Linde Division
39 Old Ridgebury Road
Danbury, Connecticut 08817-0001

8.9 TRUPACT II TEN-DRUM OVERPACK (DOCKET: 90-16-7A, 10/93)

Figure 8-9. TRUPACT II Ten-Drum Overpack (WIPP).

Figure 8-10. TRUPACT II Ten-Drum Overpack with SWB and Dunnage.

8.9.1 Package Description

Table 8.9-1. Dimensions.

Table 8.9-2. Materials/Method of Construction.

8.9.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the test contents. If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

8.9.2.1 Physical Form.

8.9.2.1.1 Solids Only. Five forms are authorized. Each shipper must determine the most appropriate form for his particular contents:

- Material Form No. 1: Solids--any particle size.
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil).
- Material Form No. 3: Solids--objects with no significant or removable contamination. (For definition see 49 CFR 173.443, Contamination Control).
- Material Form No. 4: Solids as described in Form No. 3 above, including large, bulky, dense objects with sharp and obtrusive members or components, but having Form No. 1 and/or No. 2 as dispersible contaminates associated with the material (e.g., steel plates, motors, valves, steel pipes, concrete blocks).
- Material Form No. 5: Drums and other packagings in any arrangement within gross weight limitations.

NOTE: Refer to Section 8.9.3, Restrictions/Specifications, for items fitting the previous descriptions that could result in highly localized forces.

8.9.2.1.2 Maximum Gross Weight

- 3,039 kg (6,700 lb).

8.9.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

8.9.2.3 Radiological. 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 shifting of contents needs to be taken into account during transport.

All drop tests conducted were 1.2 m (4 ft). The following information is from the testing conducted in October 1993. During the center-of-gravity over-top-rim drop test, the lid uplifted 1.87 cm (0.735 in.) outward with a chord of 61 cm (24 in). During the flat-on-side drop test, the side near bumper #4 indented approximately 3.5 cm (1 3/8 in.). The bottom portion of the overpack side panel dented inward approximately 2.70 cm (1 1/16 in.), and with a chord of 40.6 cm (16 in.). During the center-of-gravity on-bottom-edge drop test, the bottom side wall under bumper #4 dented inward 4 cm (1.573 in.). The bottom pan of the overpack buckled up from the underside and into the overpack resulting in a dent approximately 5.4 cm (2 1/8 in.) with a chord of 27.5 cm (1 ft 10 in.). Refer to the test results in Appendix D, Table D-20.a.

Although the TRUPACT II Ten-Drum Overpack (TDOP) failed the drop test when it was filled with the

SWB (July 1990, Test Package 130408), a decision was made not to conduct additional tests with the SWB load. No dunnage was used during the July 1990 test, and the SWB punctured the sidewall of the TDOP. It was determined that if dunnage was used for large bulky objects, like the SWB, the TDOP would be able to withstand the conditions normal to transportation and the forces of impact under the drop test conditions.

8.9.2.4 Simulated Payload. The simulated payload used was 10 55-gal drums filled with hardened concrete.

8.9.3 Restrictions/Specifications

The TDOP shall be operated in accordance with the Westinghouse Waste Isolation Division instruction entitled, *Handling and Maintenance Manual for TRUPACT II Ten-Drum Overpack (TDOP).*

The lid closure bolts must be torqued to a minimum of 50 (+5, -0) ft-lb.

The carbon filters shall be installed from the inside using Loctite(1)

RC-680 and torqued to 5 (+3, -0) ft-lb. A total of 10 filters were installed for testing purposes; however, an evaluation of this packaging as a Type A package was completed by the test sponsor. Results of this evaluation follow:

- If the contents of the TDOP **do not** have the potential for flammable gas generation, **a minimum of one filter shall be installed and the unused filter ports shall be sealed with 1.91 cm (3/4 in.) NPT socket recessed pipe plugs that have been installed from the outside.** The installation of one filter is to ensure that equalization of pressure differential caused by changes in atmospheric pressure, ambient temperature, or exposure to solar heating is maintained.

- If the contents of the TDOP **have** the potential to generate flammable gas, the analysis showed that nine filters in the TDOP are sufficient to maintain the flammable gas concentration below 5% hydrogen after storage for indefinite periods and during shipment.

No reduced pressure test was conducted due to the use of filters in the design.

NOTE: For heavy, bulky materials (e.g., concrete chunks, motors, pumps, and SWBs), equipment or materials with sharp corners or protrusions, or material/equipment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package to prevent damage to the TDOP.

8.9.4 49 CFR 178.350 Regulatory Requirements

Table 8.9-3. Regulatory Compliance Assessment.

8.9.5 Quality Control

Table 8.9-4. Packaging/Acceptance/Use Criteria.

8.9.6 Additional Information

Evaluation and testing of the subject packaging took place at Westinghouse Hanford in 1990 and 1993. A complete test report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.9.6.1 Primary Users

Site/Contact/Phone	Address
Waste Isolation Pilot Plant	**Westinghouse/Waste Isolation Division**
J. A. Golden	P.O. Box 2078
505-234-8859	Carlsbad, NM 88221

8.10 INEL MARK III CONCRETE CONTAINER (DOCKET: 92-33-7A, 10/94)

Figure 8-11. INEL Mark III Concrete Container.

Figure 8-12. Mark III Concrete Container with As-Tested Payload and Bracing.

8.10.1 Package Description

Table 8.10-1. Dimensions.

Table 8.10-2. Materials/Method of Construction.

8.10.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the payload used during testing (see Section 8.10.2.4). If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

8.10.2.1 Physical Form.

8.10.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate form for his particular contents, as follows:

- Material Form Number 1: Solids--any particle size
- Material Form Number 2: Solids--large particle size only (e.g., sand, concrete, debris, soil)
- Material Form Number 3: Solids--objects with no removable or dispersible contamination. (For definition, see 49 CFR 173.443, "Contamination Control.").

NOTE: Refer to Section 8.10.3, "Restrictions/Specifications," for items fitting the previous descriptions that could result in highly localized forces.

8.10.2.1.1 Maximum Gross Weight

Table 8.10-3. Weight.

8.10.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

8.10.2.3 Radiological. 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 shifting of contents needs to be taken into account during transport. See Appendix D, Tables D-20.b and D-20.c, for details of damage to the package during drop testing.

8.10.2.4 Simulated Payload. The simulated payload used during testing was sand and soil, stainless steel

ingots (45.72-cm diameter by 38.1-cm long and/or 45.72-cm diameter by 101.6-cm long [18-in. diameter by 15 in.-long and/or 18-in. diameter by 40-in. long]), and lead bricks. Bracing was used to protect the bottom, sides, and top of the inside of the container. Bracing consisted of plywood sheets, wooden 2 x 4s, and railroad ties. Refer to Figure 8-12 for a diagram of the placement of the payload and bracing during testing.

8.10.3 Restrictions/Specifications

1. Cracks in the polyethylene liner (body and lid) are not acceptable. Weld seam on sealing surface of body and lid liner will be even and smooth, and free from cracks.

2. Clean sealing surfaces prior to lid installation.

3. Apply the polyethylene foam gasket to the container lid according to drawing numbers 445862 and 446074. The gasket in the as-tested configuration consisted of two parts (booster and main gasket), and each part being one continuous piece. Check the gasket to ensure a minimum of 0.9525-cm (3/8-in.) loft. If the loft is less than 0.9525 cm (3/8 in.), a new gasket shall be installed. The gasket shall not be installed until time of permanent container sealing.

4. The shipper shall ensure that the radiation level at any surface would not increase by more than 20%.

5. The user is responsible for ensuring that the packaging does not contain small, highly radioactive materials that could become lodged inside the drain/vent lines that could result in a significant radiation change in the surface of the packaging.

6. To ensure that the bolts seat properly, remove the lid from the Mark III Concrete Container body, and install bolts. Bolts should thread down to within 2.54 cm (1 in.) of the body rim.

7. The vent plug on the lid of the container will be removed prior to installation of the lid due to air pressure being trapped within the container.

8. Lid bolts shall be torqued to 135.58 N-m (100 ft-lbs) in 33.89-N-m (25-ft-lb) increments, and in the pattern specified by the sponsor's instructions.

9. Prior to shipment, verify that valves are closed and that the two drains are closed and that all five plugs are installed.

10. For heavy, bulky materials (e.g., concrete chunks, motors, pumps); equipment/materials with sharp corners or protrusions; or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package.

11. When the packaging is loaded underwater, the user must ensure that all water has been removed before shipment.

8.10.4 49 CFR 178.350 Regulatory Requirements

Table 8.10-4. Regulatory Compliance Assessment.

8.10.5 Quality Control

Table 8.10-5. Packaging/Acceptance/Use Criteria.

8.10.6 Additional Information

Evaluation and testing of the subject packaging took place at Westinghouse Hanford in 1994 as Docket

Number 92-33-7A. A complete test report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.10.6.1 Primary Users

Site/Contact/Phone	Address
INEL	**Lockheed Idaho Technologies Company (LITCO)**
W. D. Richins (208) 526-0522	P.O. Box 1625 Idaho Falls, Idaho 83415
H. D. Welch (208) 526-0530	
B. C. Spaulding (208) 526-8633	

8.11 INEL ARROW-PAK PACKAGING (By Arrow Construction, Inc.) (DOCKET: 95-40-7A, 10/95)

Figure 8-13. ARROW-PAK Packaging (INEL and Arrow Construction, Inc.).

8.11.1 Package Description

The ARROW-PAK packaging system consists of a Marlex M-8000 Driscopipe,[(2)] Series 8000 (gas) or Series 8600 (industrial) resin pipe, and is sealed with dome-shaped end caps manufactured from the same materials. A patented process permanently seals the two end caps to the pipe body. The patented process involves the use of electrical energy to heat opposing faces of the pipe and end caps, and hydraulic rams to press the heated surfaces together. During the fusion process, the exterior and interior wall surface of the end caps and pipe create beaded edges. The edges protrude away from both the exterior and interior wall surfaces about 0.635-cm (0.25-in). A seam is visible; however, the seam does not run through the internal thickness of these component pieces. The fusion process produces a homogeneous bonding of the end cap to the pipe. The homogeneous bond extends over the full wall thickness of the package.

A total of two plywood spacers were used inside each of the two ARROW-PAK test units that were filled with simulated contents. It should be noted that the use of the plywood spacers is optional. The purpose of these spacers was to hold the simulated contents in place during the fusion process.

Table 8.11-1. Dimensions.

Table 8.11-2. Materials/Method of Construction.

8.11.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the payload used during testing (see Section 8.11.2.4). If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

8.11.2.1 Physical Form.

8.11.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate form for his particular contents.

- Material Form No. 1: Solids--any particle size.
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil).
- Material Form No. 3: Solids--objects with no removable or dispersible contamination. (For definition, see 49 CFR 173.443, "Contamination Control.").

NOTE: Refer to Section 8.11.3, Restrictions/Specifications, for items fitting the previous descriptions that could result in highly localized forces.

8.11.2.1.1 Maximum Gross Weight:

- 519.82 kg (1146.0 lb).

Table 8.11-3. Weight.

8.11.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

8.11.2.3 Radiological. 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 shifting of contents needs to be taken into account during transport. See Appendix D, Table D-20.d, for details of damage to the package during drop testing.

8.11.2.4 Simulated Payload. The simulated payload used in two test units was clean, noncontaminated, and taped lead bricks. Carbon steel shot was added as a filler material. It was estimated that the lead bricks made up 65% of the content fill weight (314.3-kg [693.0-lb]), and the steel shot made up 35% of the content fill weight (169.2-kg [373.0-lb]). Fluorescein was added as a tracer material. The third test unit was basically empty, and fluorescein was added as a tracer material.

8.11.3 Restrictions/Specifications

1. The pipe shall be homogenous throughout and free of visible cracks, holes, voids, foreign inclusions, or other deleterious defects, and shall be identical in color, density, melt index, and other physical properties throughout.
2. The shipper shall ensure that the radiation level at any surface would not increase by more than 20%.
3. During handling, care must be exercised to avoid cutting or gouging the Marlex pipe and/or end caps. When lifting fused sections of pipe, chains or cable-type chokers must be avoided. Nylon slings are preferred. Spreader bars are recommended when lifting long fused sections.
4. The use of the plywood spacers is optional. If the spacers are used, adequate space is required to account for the fusion process. The spacer needs to fit down snugly onto the packaging contents. It may be necessary to wrap the outside edge of the spacer with several layers of tape so that the spacer does not move and shift.
5. The joining method of the end caps to the pipe/tube shall be the butt fusion method, and be in accordance with the pipe manufacturer's recommendations. Socket fusion shall not be used. The fusion equipment used in the joining procedures must meet the manufacturer's temperature requirements of 260 °C (500 °F), alignment, and 1034.2 kPa (150 psi) interfacial fusion pressure.
6. For heavy, bulky materials (e.g., concrete chunks, motors, pumps, and SWBs), equipment or materials with sharp corners or protrusions, or material/equipment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the

package to prevent damage within the packaging.

8.11.4 49 CFR 178.350 Regulatory Requirements

Table 8.11-4. Regulatory Compliance Assessment.

8.11.5 Quality Control

Table 8.11-5. Packaging/Acceptance/Use Criteria.

8.11.6 Additional Information

Evaluation and testing of the subject packaging took place at Westinghouse Hanford in 1995 as Docket Number 95-40-7A. A complete test report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.11.6.1 Primary Users

Site/Contact/Phone	Address
INEL	**Lockheed Idaho Technologies Company (LITCO)**
Dr. Harley Reno	P.O. Box 1625
(208) 526-9865	Idaho Falls, Idaho 83415-2113

Packaging Manufacturer
Arrow Construction, Inc.
216 Gunn Road
P.O. Box 240427
Montgomery, Alabama 36124
(205) 271-6185

*Page correction for Vol. 1 document. This will be Rev. 0-E.

8.12 WHC WRAP-1, 208-L WASTE DRUM [BAGLESS TRANSFER SYSTEM] (DOCKET: 94-35-7A, 08/94)

NOTE: For information regarding current design, test, and evaluation information for the "Modified WRAP 1-Trip 208-L Drum" tested under Docket 99-48-7A in January 2001, see DOE/RL-96-57, Vol. 2, Section 8.2.

Figure 8-14. WHC WRAP-1, 208-L Waste Drum.

Figure 8-15. WHC WRAP-1, 208-L Waste Drum - Sealing Detail.

8.12.1 Package Description

The as-tested WRAP-1 drum is a modified UN-1A2, 208-L (55-gal), filtered, galvanized, steel drum. Modifications consist of the addition of: an inner ring (adhered to the inside of the drum), inner neoprene foam seal, a filtered inner lid (swaged and secured into place with special equipment), and an inner rubber gasket. The special equipment required for loading and closure of this packaging, is defined in WHC-SD-W026-OCD-001, Revision 0, "One-Trip Drum Operating Instruction." Assembly of the as-tested packaging

is shown on Hanford Drawing Number H-2-824300 Revision 0. Drums tested were purchased according to Hanford Standard HS-V-P-0010, Revision C.

Table 8.12-1. Dimensions.

Table 8.12-2. Materials/Method of Construction.

8.12.2 Authorized Contents

The shipper must determine that the actual contents are closely simulated by the payload used during testing (see Section 8.12.2.4). If they are not, testing or analysis must be conducted and documented to demonstrate DOT-7A compliance with the actual contents.

8.12.2.1 Physical Form.

8.12.2.1.1 Solids Only. Three forms are authorized. Each shipper must determine the most appropriate form for his particular contents:

- Material Form No. 1: Solids--any particle size.
- Material Form No. 2: Solids--large particle size only (e.g., sand, concrete, debris, soil).
- Material Form No. 3: Solids--objects with no removable or dispersible contamination. (For definition, see 49 CFR 173.443, "Contamination Control.").

NOTE: Refer to Section 8.12.3, Restrictions/Specifications, for items fitting the previous descriptions that could result in highly localized forces.

8.12.2.1.1 Maximum Gross Weight:

- 454 kg (1000 lb).

8.12.2.2 Chemical Form. The shipper must evaluate and ensure chemical compatibility of the material to be shipped with the materials of the packaging in contact with the payload.

8.12.2.3 Radiological. Three drums were drop tested as identified in Table D-20.d. Damage reported for the packagings tested and evaluated under dockets 89-13-7A/90-18-7A and 94-37-7A are identified in Table D-10.a and D-10.b. The 1.2-m (4-ft) drop test caused deformation of the package resulting in a decrease in the distance from the exterior to the center of the package at the bottom chime of approximately 6.35 cm (2.5 in.). 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 shifting of contents needs to be taken into account during transport.

8.12.2.4 Simulated Payload. The simulated payload used during testing was soil/sand and lead bricks. A mixture of flour and fluorescein was used as tracer material and to simulate Material Form Number 1.

8.12.3 Restrictions/Specifications

1. The special equipment required for loading and closure of this packaging is defined in WHC-SD-W026-OCD-001, Revision 0, "One-Trip Drum Operating Instruction." Assembly of the as-tested packaging is shown on Hanford Drawing Number H-2-824300, Revision 0. Drums tested were purchased according to Hanford Standard HS-V-P-0010, Revision C. Sizes and tolerances per Hanford Drawing H-2-824300, Revision 0, must be strictly adhered to and followed.

2. The inner lid must be fitted with a NucFil -013, 3/4-in. - 14 NPT, carbon-activated filter. A 2.54 cm (1 in.) diameter hole is punched into the center of the inner drum lid. The NucFil-013 filter is threaded through the hole and a locking nut is tightened onto the back side of the filter and torqued to 33.9 Nm (25 [±1] lbf·ft).

3. The inner ring shall be adhered and sealed (top and bottom) around its circumference to the drum body with E-6000 black adhesive. This first application of adhesive is allowed to cure for 24 hours. A second application of adhesive occurs above and below the inner ring. Remove any excess adhesive from the top and bottom surface of the ring. Allow second application to cure for 24 hours.

4. The inner seal shall meet the following specifications:

    - Neoprene/sbr foam
    - Adhesive backed and satin finish
    - Density: 3.5 - 5.0 lb/cu ft
    - 25% compression resist: 2.0 - 5.0 psi.

5. Dimension and placement of inner lid gasket is critical for proper drum closure per DOT-7A testing. The gasket should lay flat against the inner lid and inner seal.

6. A NucFil-013 filter is installed into the provided flange on the outer drum lid. The flange is located in the center annulus of the outer lid at least 7.62 cm (3 in.) from the center to avoid interference with the filter in the inner lid. The outer lid filter is torqued to 33.9 Nm (25 [±1] lbf·ft). No sealant or tape is added to enhance this seal.

7. The lid locking ring bolt shall be tightened to 54.24 Nm (40 [±1] lbf ft) torque with tapping of the ring followed by tightening. A jam nut shall also be used to prevent unintentional loosening during transport. The location of the jam nut shall be between the lugs, and the jam nut shall be tightened against the threaded lug.

8. The drum gasket material, the neoprene inner gasket, and the neoprene inner seal shall have an operating range of -40 °C to +70 °C (-40 °F to +158 °F).

9. For heavy, bulky materials (e.g., concrete chunks, motors, pumps, etc.), equipment/materials with sharp corners or protrusions, or material/containment geometries that could result in highly localized forces, the shipper must ensure that the contents are securely fastened/positioned within the package. This loading must be evaluated to assure that the packaging, if tested, would not fail.

8.12.4 49 CFR 178.350 Regulatory Requirements

Table 8.12-3. Regulatory Compliance Assessment.

8.12.5 Quality Control

Table 8.12-4. Packaging/Acceptance/Use Criteria.

8.12.6 Additional Information

Drop and vibration and testing of the subject packaging took place at Los Alamos National Laboratory and at Hanford in August 1994 as Docket Number 94-35-7A. Comparison and evaluation of the subject packaging with the DOT-17C, 55-gal steel drums tested and evaluated under dockets 89-13-7A/90-18-7A and 94-37-

7A was performed by Westinghouse Hanford Company in September 1995. A complete test report is available upon request from one of the DOT-7A Program technical contacts listed in Section 1.1.2.

8.12.6.1 Primary Users

Site/Contact/Phone	Address
Hanford Site	**Fluor Hanford**
K. Leist	P.O. Box 1000
(509) 376-0325	Richland, Washington 99352
J. Weidert	
(509) 376-8132	

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1. Loctite is a trademark of Loctite Corporation.

2. Marlex and Driscopipe are trademarks of Phillips Petroleum Company.

3. NucFil is a trademark of Nuclear Filter Technology, Inc.

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Table G-7. Miscellaneous Packagings--Compliance with Vibration Standard (49 CFR 178.608).		
Specific packaging	**Weight kg (lb)**	**Test Unit/Results/Comments**
Stagecoach Model 320162, V1.1	1360.77 (3000)	This test was not conducted. An independent test facility conducted a vibration test on a similar freestanding, flexible material packaging design manufactured by U.F. Strainrite. The design passed vibration testing with no release of contents. Based on the similar designs and the method of construction used for the two packagings, one can readily conclude that the packaging configuration being tested meets this performance requirement. In addition, this type of flexible material packaging has been used and produced for about a decade without any incidents during transportation. The polyethylene fabric used in the Stagecoach underwent several ASTM test procedures to determine its strength and associated ratings. This fabric will function effectively over the -40 to 70 °C (-40 to 158 °F) temperature range. In addition, the corrugated fiberboard used in the Stagecoach underwent several strength tests for industry ratings. In general, polyethylene has been found to have excellent radiation stability.
Modified WRAP 1-Trip, 208-L Drum	***NOTE: The original external lids for all three test units identified below were replaced due to the unacceptable placement of the Neoprene gasket sheet to the underside of the external lid. The test units were loaded with simulated contents, closed as for transport, and transported to the vibration facility located in the 300 Area of the Hanford Site. Prior to conducting the vibration test, the torque for the external filters and bolted closure rings were checked. The external filter for all three test units required slight tightening, and the bolted closures did not require further tightening. Upon conclusion of the vibration test, the bolted closure ring did not loosen on any of the test units. However, the external filter on two of the test units required slight tightening, and the filter on one of the test units required tightening by about one-quarter turn. Therefore, a suitable thread-locking compound shall be applied around the external filter threads prior to transport.***	

Modified WRAP 1-Trip, 208-L Drum	491.7 (1084)	7A-48-TU-04: Pass. This test unit utilized the 3M Scotch-Weld[1] adhesive for the inner ring. There was no visible release of contents and no changes within the packaging. Upon conclusion of testing, the drum was rolled on its side and a light water spray mist applied to ensure no release of contents. It was observed that the bolted closure remained secure and tight; however the external filter required slight tightening. See "Note" above.
	490.8 (1082)	7A-48-TU-06: Pass. This test unit utilized the EP-1225 adhesive for the inner ring. There was no visible release of contents and no changes within the packaging. Upon conclusion of testing, the drum was rolled on its side and a light water spray mist applied to ensure no release of contents. It was observed that the bolted closure remained secure and tight; however the external filter required slight tightening. See "Note" above.
	500.8 (1104)	7A-48-TU-12: Pass. This test unit utilized the EP-1225 adhesive for the inner ring, and the optional D-seal located along the top outer perimeter of the inner lid. There was no visible release of contents. Upon conclusion of testing, the drum was rolled on its side and a light water spray mist applied to ensure no release of contents. It was observed that the bolted closure remained secure and tight; however the external filter required tightening by about one-quarter turn. See "Note" above. In addition, some of the carbon material from the external drumhead filter flaked out of the filter and was visible on the inner lid. There were no further changes within the packaging.
[1]3M and Scotch-Weld are trademarks of the Minnesota Mining and Manufacturing Company.		

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Table F-19. Free Drop Test Results for Miscellaneous Packagings.		
Specific Packaging	**Weight kg (lb)**	**Test Unit/Orientation/ Results/Comments**
Stagecoach Model 320162, V1.1	***NOTE: Based on the mass of the packaging, a drop height of 1.2 m (4 ft) was used. Testing was conducted with and without the package banded to a wooden pallet. Three different pallet styles were added to designated test units to ensure that the pallet did not interfere with the integrity of the package. Due to the flexibility of the packaging, it was found that 4 metal bands secured the package better than 2 bands, therefore, 4 bands are recommended if used.*** ***Although the packaging is freestanding and flexible in nature, and compresses and shifts, the external dimensions as measured at the side wall seams remained the same at 110 cm (44 in.) for all the noted drop tests.***	
Stagecoach Model 320162, V1.1	1405.2 (3098)	7A-49-TU-02: Drop #1 -- Pass. This test unit incorporated Pallet Style A. The water spray test preceded this drop test. The pallet was double-banded to this test unit. The package was dropped flat onto the top of the container. There was no visible damage except for slight marring and cuts into the external fabric due to the banding. There were also stresses/pulls in the fabric at the stitched seams in the upper portion of the container. There was no release of contents. 7A-49-TU-02: Drop #2 -- Pass. This test unit incorporated Pallet Style A. Because of the difficulty in rigging the flexible package during the preceding drop test, the test unit was banded with an additional 2 metal bands, for a total of 4 bands. The second drop for this package was center of gravity over the bottom edge to impact at the seam of the package and edge of the pallet. Damage consisted of a 2.5 cm (1 in.) tear in the external layer of fabric. It is believed that this tear was from use of a forklift that was used to assist in orienting the package. Pallet damage to the opposite side of impact consisted of a 10 cm (4 in.) cut and a 15 cm (6 in.) cut along one edge due to the banding. The pallet damage was very minimal on the side of impact. There was no release of contents.

	1495.9 (3298)	7A-49-TU-03: Drop #1 - Pass. This test unit incorporated Pallet Style B. Four metal bands secured the package to the pallet. The package was dropped center of gravity over the top corner to impact the front of the package at a top corner seam. The top duffel closure pulled out approximately 35 cm (14 in.) at a side wall seam area. The inner 6-mil bag did not show any signs of stress or damage. During rigging, one end of the pallet completely broke. There was no release of contents. 7A-49-TU-03: Drop #2 - Pass. This test unit incorporated Pallet Style B. Four metal bands secured the package to the pallet. The package was dropped center of gravity over the bottom edge to impact at the seam of the package and edge of the pallet. In the area where the top duffel closure pulled out at the side wall seam area from the previous drop, the cardboard pushed through the Velcro[1] seamed closure approximately 37.5 cm (15 in.). This style of pallet was damaged severely during rigging operations. The plywood sheeting cracked and warped/bowed due to the weight of the package. There was no visible release of contents
	1399.8 (3086)	7A-49-TU-04: Pass. This test unit incorporated Pallet Style C. Four metal bands secured the package to the pallet. This test unit was dropped center of gravity over the bottom corner to impact a bottom corner seam and the corner of the pallet. The only visible damage was a slight tear at the top seam through the external layer of fabric. The pallet broke up during rigging, and shifted/leaned toward one side after the drop test. There was no visible release of contents.
	1368.0 (3016)	7A-49-TU-05: Pass. This test unit did not include a pallet. This test unit was dropped center of gravity over the bottom edge to impact at the bottom seam. At the area of impact, some stitching pulled loose (one row-intermittent). Near the top duffel and side wall seam, cardboard poked through the external layer of fabric. There was no visible release of contents.
Modified WRAP 1-Trip, 208-L Drum	***NOTE: Based on the weight of the drum design, a drop height of 1.4m (4 ft) was conducted. Only Assembly -010 was tested as the addition of the inner 10-mil nylon-reinforced polyethylene bag would enhance the design of the Assembly -020 configuration. Test units that included the two different inner ring adhesives and the optional D-seal were chosen. Visual observation and a light water spray mist were used to identify any leak detection after the performance of each drop test.***	
Specific Packaging	**Weight kg (lb)**	**Test Unit/Orientation/Results/Comments**
Modified WRAP 1-Trip, 208-L Drum	490.8 (1082)	7A-48-TU-01: Pass. This test unit utilized the 3M Scotch-Weld[2] adhesive for the inner ring. The penetration bar drop was conducted on this test unit prior to conducting this drop test. This test unit was dropped center of gravity over the top edge to impact at the bolted closure and the

		welded seam. The top of the drum crushed downward and inward at the bolt location and into the first rolling hoop. The top of the drumhead was pushed upward in a curved pattern a distance of 51 cm (20 in.) across the drumhead. Flattening along the welded side wall of the drum beginning at the top of the drum, measured a distance of 15 cm (6 in.). The overall change in the drum height along the top curved area of impact was 5.5 cm (2.2 in.). There was no visible release of contents.
	487.2 (1074)	7A-48-TU-02: Pass. This test unit utilized the 3M Scotch-Weld adhesive for the inner ring. This test unit was dropped center of gravity over the bottom edge to impact at the welded seam. The bottom of the drum flattened and bulged outward along the bottom rim. The bulging measured outward from 5 to 6 cm (2 to 2.5 in.) across the flattened area. The damage observed at the area of impact appeared very equal and somewhat triangular shaped. Damage from the bottom rim and along the welded seam measured a distance of 8 to 10 cm (3.25 to 4 in.). There was no damage observed to the top portion of the drum. There was no visible release of contents.
	477.2 (1052)	7A-48-TU-03: Pass. This test unit utilized the 3M Scotch-Weld adhesive for the inner ring. This test unit was dropped flat onto its side to impact the welded seam and closure bolt. The drum flattened a distance of 37 cm (14.5 in.) along the bottom rim of the drum. Bulging outward along the base of the drum measured 0.6 to 3.2 cm (0.25-in. to 1.25-in.). The closure bolt pushed inward slightly at the area of impact. The drum flattened slightly along the entire length of the welded seam. There was no visible release of contents.
	485.3 (1070)	7A-48-TU-09: Pass. This test unit utilized the EP-1225 adhesive for the inner ring. This test unit was dropped center of gravity over the top edge to impact at the bolted closure and the welded seam. Damage observed for this test unit was similar to that of TU-01, but not as extreme. The top of the bolted closure pushed downward slightly, and the lid of the drum pushed outward in a curved pattern. The change in the drum height along the area of impact measured 4.90 cm (1.93 in.). The bottom rim along the area of impact flattened slightly. There was no visible release of contents.
	486.3 (1072)	7A-48-TU-10: Pass. This test unit utilized the EP-1225 adhesive for the inner ring. This test unit was dropped center of gravity over the bottom edge to impact at the welded seam. Damage observed for this test unit was similar to that of TU-02. The bottom of the drum flattened across the area of impact a distance of 38 cm (15 in.) as measured along the bottom rim. The bottom of the drum bulged outward 5 to 6 cm (2 to 2.5-in.). The damage observed at the area of impact appeared very equal and somewhat triangular shaped. Damage from the bottom rim

		and along the welded seam measured a distance of 8 to 10 cm (3.25 to 4 in.). There was no damage observed to the top portion of the drum. There was no visible release of contents.
	496.2 (1094)	7A-48-TU-08: Pass. This test unit utilized the EP-1225 adhesive for the inner ring. This test unit was dropped flat onto its side to impact the welded seam and bolted closure. This test unit had similar damage as TU-03. Flattening along the entire distance of the welded seam was observed. The base of the drum bulged outward a maximum distance of 4 cm (1.5 in.). The closure bolt pushed in towards the side of the drum at the area of impact. There was no visible release of contents.
	494.4 (1090)	7A-48-TU-11: Pass. This test unit utilized the EP-1225 adhesive for the inner ring, and the optional D-seal located along the top outer perimeter of the inner lid. This test unit was dropped center of gravity over the top edge to impact the bolted closure and the welded seam. Similar damage was observed to this test unit as that of TU-01 and TU-09. At the area of impact, the top of TU-11 pushed downward and inward at the bolted closure and first rolling hoop along the welded seam. The top of the drum bulged outward slightly in a curved pattern. The distance measured across this pattern measured 56 cm (22 in.). The drumhead raised upward slightly near the external filter location. The bottom rim of the drum flattened slightly across a distance of 15 cm (6 in.). There was no visible release of contents.
	485.3 (1070)	7A-48-TU-13: Pass. This test unit utilized the EP-1225 adhesive for the inner ring, and the optional D-seal located along the top outer perimeter of the inner lid. This test unit was dropped flat onto its side to impact the welded seam and bolted closure. Similar damage was observed to this test unit as that of TU-03 and TU-08. The welded seam of TU-13 flattened along the entire length of the drum. The bottom rim of the drum bulged outward 6 cm (2.25 in.). The external drum lid pushed upward at the point of impact and appeared to flatten in an accordion-like pattern approximately 4.4 cm (1.75 in.) from the closure bolt. The closure bolt pushed into the side of the drum. The closure ring pushed upward 0.6 cm (0.25-in.) at the bolted area. There was no visible release of contents.

[1]Velcro is a registered trademark of Velcro Industires B.V., Amsterdam, Netherlands.

[2]3M and Scotch-Weld are registered trademarks of the Minnesota Mining and Manufacturing Company.

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Table A-1. Steel Drums--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). HM-169A (effective April 1, 1996).

Regulatory requirement: 49 CFR 173.24	Action required/by whom	Packaging category--steel drums
(a) Applicability. Except as otherwise provided in this subchapter, the provisions of this section apply to--	To be considered during package design evaluation. Shipper responsibility to ensure.	All packagings described have been tested and/or evaluated and meet DOT-7A Type A packaging criteria.
(1) Bulk and non-bulk packagings;		
(2) New packagings and packagings which are reused; and		
(3) Specification and non-specification packagings.		
(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;	To be considered during package design evaluation. Shipper responsibility to ensure.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.410, .412, .465, and/or .466 as demonstrated in Section 2.0 and Appendices D, E, and F.
(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;	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging	NOTE: Shipper responsibility to consider and evaluate, if necessary, the effect of the content.

	effectiveness.	
(3) There will be no mixture of gases or vapors in the package that could, through any credible spontaneous increase of heat or pressure, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(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 172.101 Table and conforms to applicable requirements in the special provisions of Column 7 of the 172.101 Table and, for specification packagings (but not including UN standard packagings manufactured outside the United States), the specification requirements in parts 178 and 179 of this subchapter; or	Shipper responsibility to ensure that packagings used are in compliance with the design.	All packagings described have been qualified to meet Specification 7A requirements in accordance with 49 CFR 178.350.
(2) The packaging is permitted under, and conforms to, provisions contained in 171.11, 171.12, 171.12a, 173.3, 173.4, 173.5, 173.7, 173.27, or 176.11 of this subchapter.	Shipper responsibility to ensure that packagings used are in compliance with the design.	All packagings described have been qualified to meet Specification 7A requirements in accordance with 49 CFR 178.350.
(d) *Specification packagings and UN standard packagings manufactured outside the U.S.*--		
(1) *Specification packagings.* A specification packaging, including a UN standard packaging manufactured in the United States, must conform in all details to the applicable specification or standard in part 178 or part 179 of this subchapter.	Shipper responsibility to ensure that packagings used are in compliance with the design.	All packaging described have been qualified to meet Specification 7A packaging requirements in accordance with 49 CFR 178.350.
(2) *UN standard packagings manufactured outside the United States.* A UN standard packaging manufactured outside the United States, in accordance with national or international regulations based on the UN Recommendations on the Transport of Dangerous	Shipper responsibility to ensure that packagings used are in compliance with the design.	All packaging described have been qualified to meet Specification 7A packaging requirements in accordance with 49 CFR 178.350.

Goods, may be imported and used and is considered to be an authorized packaging under the provisions of paragraph (c)(1) of this section, subject to the following conditions and limitations:		
(i) The packaging fully conforms to applicable provisions in the UN Recommendations on the Transport of Dangerous Goods and the requirements of this subpart, including reuse provisions;		
(ii) The packaging is capable of passing the prescribed tests in part 178 of this subchapter applicable to that standard; and		
(iii) The competent authority of the country of manufacture provides reciprocal treatment for UN standard packagings manufactured in the U.S.		
(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.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Packaging materials and contents must be such that there will be so significant chemical or galvanic reaction between the materials and contents of the package.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(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,	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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 173.132 and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than--	Designer to do and shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(A) 18 °C (64 °F) for 180 days in accordance with Test Method 1 in Appendix B of this part;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(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.	Shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(4) Mixed contents. Hazardous materials may not be packed or mixed together in the same outer packaging with other hazardous or	Shipper responsibility to ensure.	Shipper responsibility to ensure.

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, poisonous, or asphyxiant gases; or (iii) Formation of unstable or corrosive materials.		
(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.	Shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(g) Venting. Venting of packagings, to reduce internal pressure that 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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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 172.101 Table or by the applicable bulk packaging specification in part 178 of this subchapter.		
(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 173.24a(d) and 173.24b(a), respectively.	Designer to do and shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(2) *Compressed gases and cryogenic liquids.* Filling limits for compressed gases and cryogenic liquids are specified in 173.301 through 173.306 for cylinders and 173.314 through 173.319 for bulk packagings.	Designer to do and shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids or gasses. Shipper responsibility to ensure.
(i) Air transportation. Packages offered or intended for transportation by aircraft must conform to the general requirements for transportation by aircraft in 173.27, except as provided in 171.11 of this subchapter.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

DOT = U.S. Department of Transportation.
UN = United Nations.

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Table A-2. Steel Boxes--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). HM-169A (effective April 1, 1996).

Regulatory requirement: 49 CFR 173.24	Action required/by whom	Packaging category--steel boxes
(a) Applicability. Except as otherwise provided in this subchapter, the provisions of this section apply to--	To be considered during package design evaluation. Shipper responsibility to ensure.	All packagings described have been tested and/or evaluated and meet DOT-7A Type A packaging criteria.
(1) Bulk and non-bulk packagings;		
(2) New packagings and packagings which are reused; and		
(3) Specification and non-specification packagings.		
(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;	To be considered during package design evaluation. Shipper responsibility to ensure.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.410, .412, .465, and/or .466 as demonstrated in Section 3.0 and Appendices D, E, and F.
(2) The effectiveness of the package will not be substantially reduced; for example, impact resistance, strength, packaging compatibility, etc., must be maintained	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong	NOTE: Shipper responsibility to consider and evaluate, if necessary, the effect of the contents.

for the minimum and maximum temperatures encountered during transportation;	consideration is effect of contents on packaging effectiveness.	
(3) There will be no mixture of gases or vapors in the package that could, through any credible spontaneous increase of heat or pressure, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(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 172.101 Table and conforms to applicable requirements in the special provisions of Column 7 of the 172.101 Table and, for specification packagings (but not including UN standard packagings manufactured outside the United States), the specification requirements in parts 178 and 179 of this subchapter; or	Shipper responsibility to ensure that packagings used are in compliance with the design.	All packagings described have been qualified to meet Specification 7A requirements in accordance with 49 CFR 178.350.
(2) The packaging is permitted under, and conforms to, provisions contained in 171.11, 171.12, 171.12a, 173.3, 173.4, 173.5, 173.7, 173.27, or 176.11 of this subchapter.		
(d) *Specification packagings and UN standard packagings manufactured outside the U.S.*--		
(1) *Specification packagings.* A specification packaging, including a UN standard packaging manufactured in the United States, must conform in all details to the applicable specification or standard in part 178 or part 179 of this subchapter.	Shipper responsibility to ensure that packagings used are in compliance with the design.	All packagings described have been qualified to meet Specification 7A requirements in accordance with 49 CFR 178.350.
(2) *UN standard packagings manufactured outside the United States.* A UN standard packaging manufactured outside the United States, in accordance with national or international regulations based on the UN Recommendations on the Transport of Dangerous Goods, may be imported and used and is considered to be an authorized packaging under the provisions of paragraph (c)(1) of this section, subject to the following conditions and limitations:	Shipper responsibility to ensure that packagings used are in compliance with the design.	All packagings described have been qualified to meet Specification 7A requirements in accordance with 49 CFR 178.350.

(i) The packaging fully conforms to applicable provisions in the UN Recommendations on the Transport of Dangerous Goods and the requirements of this subpart, including reuse provisions;		
(ii) The packaging is capable of passing the prescribed tests in part 178 of this subchapter applicable to that standard; and		
(iii) The competent authority of the country of manufacture provides reciprocal treatment for UN standard packagings manufactured in the U.S.		
(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.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Packaging materials and contents must be such that there will be so significant chemical or galvanic reaction between the materials and contents of the package.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer to do and shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.

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 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;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	
(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.	Shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(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--	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) Combustion or dangerous evolution of heat;		
(ii) Evolution of flammable, poisonous, or asphyxiant gases; or		
(iii) Formation of unstable or corrosive materials.		
(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.	Shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(g) Venting. Venting of packagings, to reduce internal pressure that may develop by the evolution of gas from the contents, is permitted only when--	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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 172.101 Table or by the applicable bulk packaging specification in part 178 of this subchapter.		
(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.	Designer to do and shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.

Requirements for outage and filling limits for non-bulk and bulk packaging are specified in 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 173.301 through 173.306 for cylinders and 173.314 through 173.319 for bulk packagings.	Designer to do and shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids or gasses. Shipper responsibility to ensure.
(i) Air transportation. Packages offered or intended for transportation by aircraft must conform to the general requirements for transportation by aircraft in 173.27, except as provided in 171.11 of this subchapter.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
DOT = U.S. Department of Transportation. UN = United Nations.		

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Table A-3. Wooden Boxes--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). HM-169A (effective April 1, 1996).

Regulatory requirement: 49 CFR 173.24	Action required/by whom	Packaging category--wooden boxes
(a) Applicability. Except as otherwise provided in this subchapter, the provisions of this section apply to--		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(1) Bulk and non-bulk packagings;	To be considered during package design evaluation. Shipper responsibility to ensure.	
(2) New packagings and packagings which are reused; and		
(3) Specification and non-specification packagings.		
(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;	To be considered during package design evaluation. Shipper responsibility to ensure.	
(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;	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	
(3) There will be no mixture of gases or vapors in the package that could, through any credible spontaneous increase of heat or pressure, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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 172.101 Table and conforms to applicable requirements in the special provisions of Column 7 of the 172.101 Table and, for specification packagings (but not including UN standard packagings manufactured outside the United States), the specification requirements in parts 178 and 179 of this subchapter; or (2) The packaging is permitted under, and conforms to, provisions contained in 171.11, 171.12, 171.12a, 173.3, 173.4, 173.5, 173.7, 173.27, or 176.11 of this subchapter.	Shipper responsibility to ensure that packagings used are in compliance with the design.	
(d) *Specification packagings and UN standard packagings manufactured outside the U.S.*-- (1) *Specification packagings.* A specification packaging, including a UN standard packaging manufactured in the United States, must conform in all details to the applicable specification or standard in part 178 or part 179 of this subchapter. (2) *UN standard packagings manufactured outside the United States.* A UN standard packaging manufactured outside the United States, in accordance with national or international regulations based on the UN Recommendations on the Transport of Dangerous Goods, may be imported and used and is considered to be an authorized packaging under the provisions of paragraph (c)(1) of this section, subject to the following conditions and limitations: (i) The packaging fully conforms to applicable provisions in the UN Recommendations on the Transport of Dangerous Goods and the requirements of this subpart, including reuse provisions;	Shipper responsibility to ensure that packagings used are in compliance with the design.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(ii) The packaging is capable of passing the prescribed tests in part 178 of this subchapter applicable to that standard; and		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

(iii) The competent authority of the country of manufacture provides reciprocal treatment for UN standard packagings manufactured in the U.S.		
(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.	Shipper responsibility to ensure.	
(2) Packaging materials and contents must be such that there will be so significant chemical or galvanic reaction between the materials and contents of the package.	Shipper responsibility to ensure.	
(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.	Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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 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;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this

		packaging type.
(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.	Shipper responsibility to ensure.	
(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, poisonous, or asphyxiant gases; or (iii) Formation of unstable or corrosive materials.	Shipper responsibility to ensure.	
(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.	Shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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.	Designer to do and shipper responsibility to ensure.	
(2) Except as otherwise provided in this subchapter, a closure (including gaskets or	Designer to do and shipper responsibility to ensure.	

other closure components, if any) used on a specification packaging must conform to all applicable requirements of the specification.		
(g) Venting. Venting of packagings, to reduce internal pressure that may develop by the evolution of gas from the contents, is permitted only when--		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(1) Transportation by aircraft is not involved;	Designer to do and shipper responsibility to ensure.	
(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 172.101 Table or by the applicable bulk packaging specification in part 178 of this subchapter.		
(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 173.24a(d) and 173.24b(a), respectively.	Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(2) *Compressed gases and cryogenic liquids.* Filling limits for compressed gases and cryogenic liquids are specified in 173.301 through 173.306 for cylinders and 173.314 through 173.319 for bulk packagings.	Designer to do and shipper responsibility to ensure.	
(i) Air transportation. Packages offered or intended for transportation by aircraft must conform to the general requirements for transportation by aircraft in 173.27,	Shipper responsibility to ensure.	

except as provided in 171.11 of this subchapter.

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UN = United Nations.

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Table A-4. Fiberboard Containers--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). HM-169A (effective April 1, 1996).

Regulatory requirement: 49 CFR 173.24	Action required/by whom	Packaging category--fiberboard containers
(a) Applicability. Except as otherwise provided in this subchapter, the provisions of this section apply to--		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(1) Bulk and non-bulk packagings;	To be considered during package design evaluation. Shipper responsibility to ensure.	
(2) New packagings and packagings which are reused; and		
(3) Specification and non-specification packagings.		
(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;	To be considered during package design evaluation. Shipper responsibility to ensure.	
(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;	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	
(3) There will be no mixture of gases or vapors in the package that could, through any credible spontaneous increase of heat or pressure, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

(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 172.101 Table and conforms to applicable requirements in the special provisions of Column 7 of the 172.101 Table and, for specification packagings (but not including UN standard packagings manufactured outside the United States), the specification requirements in parts 178 and 179 of this subchapter; or

(2) The packaging is permitted under, and conforms to, provisions contained in 171.11, 171.12, 171.12a, 173.3, 173.4, 173.5, 173.7, 173.27, or 176.11 of this subchapter.

Shipper responsibility to ensure that packagings used are in compliance with the design.

(d) *Specification packagings and UN standard packagings manufactured outside the U.S.*--

Shipper responsibility to ensure that packagings used are in compliance with the design.

NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

(1) *Specification packagings.* A specification packaging, including a UN standard packaging manufactured in the United States, must conform in all details to the applicable specification or standard in part 178 or part 179 of this subchapter.

(2) *UN standard packagings manufactured outside the United States.* A UN standard packaging manufactured outside the United States, in accordance with national or international regulations based on the UN Recommendations on the Transport of Dangerous Goods, may be imported and used and is considered to be an authorized packaging under the provisions of paragraph (c)(1) of this section, subject to the following conditions and limitations:

(i) The packaging fully conforms to applicable provisions in the UN Recommendations on the Transport of Dangerous Goods and the requirements of this subpart, including reuse provisions;

(ii) The packaging is capable of passing

NOTE: Packaging category

the prescribed tests in part 178 of this subchapter applicable to that standard; and		compliance information will be added for this packaging type upon completion of testing for this packaging type.
(iii) The competent authority of the country of manufacture provides reciprocal treatment for UN standard packagings manufactured in the U.S.		
(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.	Shipper responsibility to ensure.	
(2) Packaging materials and contents must be such that there will be so significant chemical or galvanic reaction between the materials and contents of the package.	Shipper responsibility to ensure.	
(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.	Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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 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;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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.	Shipper responsibility to ensure.	
(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;	Shipper responsibility to ensure.	
(ii) Evolution of flammable, poisonous, or asphyxiant gases; or		
(iii) Formation of unstable or corrosive materials.		
(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.	Shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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	Designer to do and shipper responsibility to ensure.	

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.	Designer to do and shipper responsibility to ensure.	
(g) Venting. Venting of packagings, to reduce internal pressure that may develop by the evolution of gas from the contents, is permitted only when--		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(1) Transportation by aircraft is not involved;	Designer to do and shipper responsibility to ensure.	
(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 172.101 Table or by the applicable bulk packaging specification in part 178 of this subchapter.		
(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 173.24a(d) and 173.24b(a), respectively.	Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(2) *Compressed gases and cryogenic liquids.* Filling limits for compressed gases and cryogenic liquids are specified	Designer to do and shipper responsibility to ensure.	

in 173.301 through 173.306 for cylinders and 173.314 through 173.319 for bulk packagings.	
(i) Air transportation. Packages offered or intended for transportation by aircraft must conform to the general requirements for transportation by aircraft in 173.27, except as provided in 171.11 of this subchapter.	Shipper responsibility to ensure.
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Table A-5. UF_6 Cylinders--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). HM-169A (effective April 1, 1996).

Regulatory requirement: 49 CFR 173.24	Action required/by whom	Packaging category--UF_6 cylinders
(a) Applicability. Except as otherwise provided in this subchapter, the provisions of this section apply to--		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(1) Bulk and non-bulk packagings;	To be considered during package design evaluation. Shipper responsibility to ensure.	
(2) New packagings and packagings which are reused; and		
(3) Specification and non-specification packagings.		
(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;	To be considered during package design evaluation. Shipper responsibility to ensure.	
(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;	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	
(3) There will be no mixture of gases or vapors in the package that could, through any credible spontaneous increase of heat or pressure, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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 172.101 Table and conforms to applicable requirements in the special provisions of Column 7 of the 172.101 Table and, for specification packagings (but not including UN standard packagings manufactured outside the United States), the specification requirements in parts 178 and 179 of this subchapter; or	Shipper responsibility to ensure that packagings used are in compliance with the design.	
(2) The packaging is permitted under, and conforms to, provisions contained in 171.11, 171.12, 171.12a, 173.3, 173.4, 173.5, 173.7, 173.27, or 176.11 of this subchapter.		
(d) *Specification packagings and UN standard packagings manufactured outside the U.S.*--	Shipper responsibility to ensure that packagings used are in compliance with the design.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(1) *Specification packagings.* A specification packaging, including a UN standard packaging manufactured in the United States, must conform in all details to the applicable specification or standard in part 178 or part 179 of this subchapter.		
(2) *UN standard packagings manufactured outside the United States.* A UN standard packaging manufactured outside the United States, in accordance with national or international regulations based on the UN Recommendations on the Transport of Dangerous Goods, may be imported and used and is considered to be an authorized packaging under the provisions of paragraph (c)(1) of this section, subject to the following conditions and limitations:		
(i) The packaging fully conforms to applicable provisions in the UN Recommendations on the Transport of Dangerous Goods and the requirements of this subpart, including reuse provisions;		
(ii) The packaging is capable of passing the prescribed tests in part 178 of this		NOTE: Packaging category compliance information will

subchapter applicable to that standard; and		be added for this packaging type upon completion of testing for this packaging type.
(iii) The competent authority of the country of manufacture provides reciprocal treatment for UN standard packagings manufactured in the U.S.		
(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.	Shipper responsibility to ensure.	
(2) Packaging materials and contents must be such that there will be so significant chemical or galvanic reaction between the materials and contents of the package.	Shipper responsibility to ensure.	
(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.	Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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 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;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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.	Shipper responsibility to ensure.	
(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;	Shipper responsibility to ensure.	
(ii) Evolution of flammable, poisonous, or asphyxiant gases; or		
(iii) Formation of unstable or corrosive materials.		
(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.	Shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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	Designer to do and shipper responsibility to ensure.	

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.	Designer to do and shipper responsibility to ensure.	
(g) Venting. Venting of packagings, to reduce internal pressure that may develop by the evolution of gas from the contents, is permitted only when--		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(1) Transportation by aircraft is not involved;	Designer to do and shipper responsibility to ensure.	
(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 172.101 Table or by the applicable bulk packaging specification in part 178 of this subchapter.		
(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 173.24a(d) and 173.24b(a), respectively.	Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(2) *Compressed gases and cryogenic liquids.* Filling limits for compressed gases and cryogenic liquids are specified in 173.301 through 173.306 for cylinders	Designer to do and shipper responsibility to ensure.	

and 173.314 through 173.319 for bulk packagings.	
(i) Air transportation. Packages offered or intended for transportation by aircraft must conform to the general requirements for transportation by aircraft in 173.27, except as provided in 171.11 of this subchapter.	Shipper responsibility to ensure.

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Table A-6. Liquid and Gas Packagings--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). HM-169A (effective April 1, 1996).

Regulatory requirement: 49 CFR 173.24	Action required/by whom	Packaging category--liquids and gas
(a) Applicability. Except as otherwise provided in this subchapter, the provisions of this section apply to--		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(1) Bulk and non-bulk packagings;	To be considered during package design evaluation. Shipper responsibility to ensure.	
(2) New packagings and packagings which are reused; and		
(3) Specification and non-specification packagings.		
(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;	To be considered during package design evaluation. Shipper responsibility to ensure.	
(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;	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	
(3) There will be no mixture of gases or vapors in the package that could, through any credible spontaneous increase of heat or pressure, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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 172.101 Table and conforms to applicable requirements in the special provisions of Column 7 of the 172.101 Table and, for specification packagings (but not including UN standard packagings manufactured outside the United States), the specification requirements in parts 178 and 179 of this subchapter; or	Shipper responsibility to ensure that packagings used are in compliance with the design.	
(2) The packaging is permitted under, and conforms to, provisions contained in 171.11, 171.12, 171.12a, 173.3, 173.4, 173.5, 173.7, 173.27, or 176.11 of this subchapter.		
(d) *Specification packagings and UN standard packagings manufactured outside the U.S.*--	Shipper responsibility to ensure that packagings used are in compliance with the design.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(1) *Specification packagings.* A specification packaging, including a UN standard packaging manufactured in the United States, must conform in all details to the applicable specification or standard in part 178 or part 179 of this subchapter.		
(2) *UN standard packagings manufactured outside the United States.* A UN standard packaging manufactured outside the United States, in accordance with national or international regulations based on the UN Recommendations on the Transport of Dangerous Goods, may be imported and used and is considered to be an authorized packaging under the provisions of paragraph (c)(1) of this section, subject to the following conditions and limitations:		
(i) The packaging fully conforms to applicable provisions in the UN Recommendations on the Transport of Dangerous Goods and the requirements of this subpart, including reuse provisions;		
(ii) The packaging is capable of passing the prescribed tests in part 178 of this		NOTE: Packaging category compliance information will

subchapter applicable to that standard; and		be added for this packaging type upon completion of testing for this packaging type.
(iii) The competent authority of the country of manufacture provides reciprocal treatment for UN standard packagings manufactured in the U.S.		
(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.	Shipper responsibility to ensure.	
(2) Packaging materials and contents must be such that there will be so significant chemical or galvanic reaction between the materials and contents of the package.	Shipper responsibility to ensure.	
(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.	Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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 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;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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.	Shipper responsibility to ensure.	
(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;	Shipper responsibility to ensure.	
(ii) Evolution of flammable, poisonous, or asphyxiant gases; or		
(iii) Formation of unstable or corrosive materials.		
(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.	Shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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	Designer to do and shipper responsibility to ensure.	

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.	Designer to do and shipper responsibility to ensure.	
(g) Venting. Venting of packagings, to reduce internal pressure that may develop by the evolution of gas from the contents, is permitted only when--		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(1) Transportation by aircraft is not involved;	Designer to do and shipper responsibility to ensure.	
(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 172.101 Table or by the applicable bulk packaging specification in part 178 of this subchapter.		
(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 173.24a(d) and 173.24b(a), respectively.	Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(2) *Compressed gases and cryogenic liquids.* Filling limits for compressed gases and cryogenic liquids are specified in 173.301 through 173.306 for cylinders	Designer to do and shipper responsibility to ensure.	

and 173.314 through 173.319 for bulk packagings.	
(i) Air transportation. Packages offered or intended for transportation by aircraft must conform to the general requirements for transportation by aircraft in 173.27, except as provided in 171.11 of this subchapter.	Shipper responsibility to ensure.

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Table A-7. Miscellaneous Packagings--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). HM-169A (effective April 1, 1996).

Regulatory requirement: 49 CFR 173.24	Action required/by whom	Packaging category--miscellaneous
(a) Applicability. Except as otherwise provided in this subchapter, the provisions of this section apply to--	To be considered during package design evaluation. Shipper responsibility to ensure.	All packagings described have been tested and/or evaluated and meet DOT-7A Type A packaging criteria.
(1) Bulk and non-bulk packagings;		
(2) New packagings and packagings which are reused; and		
(3) Specification and non-specification packagings.		
(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;	To be considered during package design evaluation. Shipper responsibility to ensure.	All packagings meet the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.410, .412, .465, and/or .466 as demonstrated in Section 8.0 and Appendices D, E, and F.
(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;	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	NOTE: Shipper responsibility to consider and evaluate, if necessary, the effect of the contents.
(3) There will be no mixture of gases or vapors in the package that could, through any credible spontaneous	Shipper responsibility to ensure.	Shipper responsibility to ensure.

increase of heat or pressure, significantly reduce the effectiveness of the packaging.		
(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 172.101 Table and conforms to applicable requirements in the special provisions of Column 7 of the 172.101 Table and, for specification packagings (but not including UN standard packagings manufactured outside the United States), the specification requirements in parts 178 and 179 of this subchapter; or	Shipper responsibility to ensure that packagings used are in compliance with the design.	All packagings described have been qualified to meet Specification 7A requirements in accordance with 49 CFR 178.350.
(2) The packaging is permitted under, and conforms to, provisions contained in 171.11, 171.12, 171.12a, 173.3, 173.4, 173.5, 173.7, 173.27, or 176.11 of this subchapter.	Shipper responsibility to ensure that packagings used are in compliance with the design.	All packagings described have been qualified to meet Specification 7A requirements in accordance with 49 CFR 178.350.
(d) *Specification packagings and UN standard packagings manufactured outside the U.S.*--		
(1) *Specification packagings.* A specification packaging, including a UN standard packaging manufactured in the United States, must conform in all details to the applicable specification or standard in part 178 or part 179 of this subchapter.	Shipper responsibility to ensure that packagings used are in compliance with the design.	All packagings described have been qualified to meet Specification 7A requirements in accordance with 49 CFR 178.350.
(2) UN standard packagings manufactured outside the United States. A UN standard packaging manufactured outside the United States, in accordance with national or international regulations based on the UN Recommendations on the Transport of Dangerous Goods, may be imported and used and is considered to be an authorized packaging under the provisions of paragraph (c)(1) of this section, subject to the following conditions and limitations:	Shipper responsibility to ensure that packagings used are in compliance with the design.	All packagings described have been qualified to meet Specification 7A requirements in accordance with 49 CFR 178.350.
(i) The packaging fully conforms to		

applicable provisions in the UN Recommendations on the Transport of Dangerous Goods and the requirements of this subpart, including reuse provisions; (ii) The packaging is capable of passing the prescribed tests in part 178 of this subchapter applicable to that standard; and (iii) The competent authority of the country of manufacture provides reciprocal treatment for UN standard packagings manufactured in the U.S.		
(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.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Packaging materials and contents must be such that there will be so significant chemical or galvanic reaction between the materials and contents of the package.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer to do and shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.

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 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;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(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.	Shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(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--	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) Combustion or dangerous evolution of heat;		
(ii) Evolution of flammable, poisonous, or asphyxiant gases; or		
(iii) Formation of unstable or corrosive materials.		
(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.	Shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.

(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(g) Venting. Venting of packagings, to reduce internal pressure that may develop by the evolution of gas from the contents, is permitted only when--	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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 172.101 Table or by the applicable bulk packaging specification in part 178 of this subchapter.		
(h) Outage and filling limits--		
(1) *General*. When filling packagings and receptacles for liquids, sufficient	Designer to do and shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping

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 173.24a(d) and 173.24b(a), respectively.		liquids. Shipper responsibility to ensure.
(2) *Compressed gases and cryogenic liquids.* Filling limits for compressed gases and cryogenic liquids are specified in 173.301 through 173.306 for cylinders and 173.314 through 173.319 for bulk packagings.	Designer to do and shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids or gasses. Shipper responsibility to ensure.
(i) Air transportation. Packages offered or intended for transportation by aircraft must conform to the general requirements for transportation by aircraft in 173.27, except as provided in 171.11 of this subchapter.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table B-1. Steel Drums--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). HM-169A (effective April 1, 1996).

Regulatory requirement: 49 CFR 173.24a	Action required/by whom	Packaging category--steel drums
(a) Packaging design. Except as provided in 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.	Designer to do and shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) *Metallic devices*. Nails, staples, and other metallic devices shall not protrude	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

into the interior of the outer packaging in such a manner as to be likely to damage inner packagings or receptacles.		
(5) *Vibration*. Each non-bulk package must be capable of withstanding, without rupture or leakage, the vibration test procedure specified in 178.608 of this subchapter.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure. For specific vibration test data, refer to Appendix G, Table G-1.
(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:	Designer to do and shipper responsibility to ensure that the material being shipped falls within the envelope of acceptable materials based on design and testing. Type A packagings are not required to be marked with specific gravity.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(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;	This is not applicable as a Type A packaging does not incorporate packing groups.	
(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	This is not applicable as a Type A packaging does not incorporate packing groups.	
(iii) A Packing Group II	This is not applicable as	

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.	a Type A packaging does not incorporate packing groups.	
(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:	Designer to do and shipper responsibility to ensure that the material being shipped falls within the envelope of acceptable materials based on design and testing.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(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.	This not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	
(ii) A single or composite non-bulk packaging which	This is not applicable to Type A packagings as	

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.	Type A packagings do not incorporate packing groups.	
(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 Type A packagings as Type A packagings do not incorporate packing groups.	
(4) Packagings tested as prescribed in 178.605 of this subchapter and marked with the hydrostatic test pressure as prescribed in 178.503(a)(5) of this subchapter may be used for liquids only when the vapor pressure of the liquid confirms to one of the following:	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(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	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.

paragraph (d) 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	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(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. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(5) No hazardous material may remain on the outside of a package after filling.	This is modified for a Type A packaging (see 49 CFR 173.443). Shipper responsibility to ensure.	Shipper responsibility to ensure.
(c) Mixed contents.		
(1) An outer non-bulk packaging may contain more than one hazardous material only when--	For entire subsection (c), designer to do and shipper responsibility to ensure. For Type A packagings that are to contain other nonradioactive material, the package must meet both Type A and the required performance requirements.	Shipper responsibility to ensure.
(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;		Shipper responsibility to ensure.
(ii) The package as prepared for shipment meets the performance tests prescribed in part 178 of		Shipper responsibility to ensure.

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		Shipper responsibility to ensure.
(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 172.101 Table. The permitted maximum net quantity must be calculated in kilograms if a package contains both a liquid and a solid.		Shipper responsibility to ensure.
(2) A packaging containing inner packagings of Division 6.2 materials may not contain other hazardous materials, except dry ice.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(d) Liquids must not completely fill a receptacle at a temperature of 55 °C (131 °F) or less.	Designer to do and shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.

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Table B-2. Steel Boxes--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). HM-169A (effective April 1, 1996).

Regulatory requirement: 49 CFR 173.24a	Action required/by whom	Packaging category--steel boxes
(a) Packaging design. Except as provided in 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.	Designer to do and shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

packagings.		
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(5) *Vibration*. Each non-bulk package must be capable of withstanding, without rupture or leakage, the vibration test procedure specified in 178.608 of this subchapter.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure. For specific vibration test data, refer to Appendix G, Table G-2.
(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:	Type A packagings are not required to be marked with specific gravity. Designer to do and shipper responsibility to ensure that the material being shipped falls within the envelope of acceptable materials based on design and testing.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(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;	This is not applicable as a Type A packaging does not incorporate packing groups.	
(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	This is not applicable as a Type A packaging does not incorporate packing groups.	
(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	This is not applicable as a Type A packaging does not incorporate packing groups.	

marked on the packaging, provided all the performance criteria can still be met with the higher specific gravity material.		
(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:	Designer to do and shipper responsibility to ensure that the material being shipped falls within the envelope of acceptable materials based on design and testing.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(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.	This not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	
(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.	This is not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	
(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	This is not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	

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.		
(4) Packagings tested as prescribed in 178.605 of this subchapter and marked with the hydrostatic test pressure as prescribed in 178.503(a)(5) of this subchapter may be used for liquids only when the vapor pressure of the liquid confirms to one of the following:	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(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 (d) of this section and a filling temperature of 15 °C (59 °F)], will not exceed two-thirds of the marked test pressure;	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(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	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(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. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(5) No hazardous material may remain on the outside of a package after filling.	This is modified for a Type A packaging (see 49 CFR 173.443). Shipper responsibility to ensure.	Shipper responsibility to ensure.
(c) Mixed contents.		

(1) An outer non-bulk packaging may contain more than one hazardous material only when--	For entire subsection (c), designer to do and shipper responsibility to ensure. For Type A packagings that are to contain other nonradioactive material, the package must meet both Type A and the required performance requirements.	Shipper responsibility to ensure.
(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;		Shipper responsibility to ensure.
(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;		Shipper responsibility to ensure.
(iii) Corrosive materials (except ORM-D) in bottles are further packed in securely closed inner receptacles before packing in outer packagings; and		Shipper responsibility to ensure.
(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 172.101 Table. The permitted maximum net quantity must be calculated in kilograms if a package contains both a liquid and a solid.		Shipper responsibility to ensure.
(2) A packaging containing inner packagings of Division 6.2 materials may not contain other hazardous materials, except dry ice.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(d) Liquids must not completely fill a receptacle at a temperature of 55 °C (131 °F) or less.	Designer to do and shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.

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Table B-3. Wooden Boxes--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). HM-169A (effective April 1, 1996).

Regulatory requirement: 49 CFR 173.24a	Action required/by whom	Packaging category--wooden boxes
(a) Packaging design. Except as provided in 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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(5) *Vibration*. Each non-bulk package must be capable of withstanding, without rupture or leakage, the vibration test procedure specified in 178.608 of this subchapter.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure. For specific vibration test data, refer to Appendix G, Table G-3.
(b) Non-bulk packaging filling limits.		
(1) A single or composite non-bulk packaging may be filled with a liquid	Designer to do and shipper responsibility to ensure	Shipper responsibility to ensure.

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:	that the material being shipped falls within the envelope of acceptable materials based on design and testing. Type A packagings are not required to be marked with specific gravity.	
(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;	This is not applicable as a Type A packaging does not incorporate packing groups.	
(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	This is not applicable as a Type A packaging does not incorporate packing groups.	
(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 as a Type A packaging does not incorporate packing groups.	
(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:	Designer to do and shipper responsibility to ensure that the material being shipped falls within the envelope of acceptable materials based on design and testing.	Shipper responsibility to ensure.
(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	This not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	

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.	This is not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	
(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 Type A packagings as Type A packagings do not incorporate packing groups.	
(4) Packagings tested as prescribed in 178.605 of this subchapter and marked with the hydrostatic test pressure as prescribed in 178.503(a)(5) of this subchapter may be used for liquids only when the vapor pressure of the liquid confirms to one of the following:	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(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 (d) of this section and a filling temperature of 15 °C (59 °F)], will not exceed two-thirds of the marked test pressure;	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(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	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(iii) The vapor pressure at 55 °C (131 °F) must be less than two-thirds of the sum of	This is not applicable to Type A packaging.	Shipper responsibility to ensure.

the marked test pressure plus 100 kPa (15 psi).	Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	
(5) No hazardous material may remain on the outside of a package after filling.	This is modified for a Type A packaging (see 49 CFR 173.443). Shipper responsibility to ensure.	Shipper responsibility to ensure.
(c) Mixed contents.		
(1) An outer non-bulk packaging may contain more than one hazardous material only when--	For entire subsection (c), designer to do and shipper responsibility to ensure. For Type A packagings that are to contain other nonradioactive material, the package must meet both Type A and the required performance requirements.	Shipper responsibility to ensure.
(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;		Shipper responsibility to ensure.
(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;		Shipper responsibility to ensure.
(iii) Corrosive materials (except ORM-D) in bottles are further packed in securely closed inner receptacles before packing in outer packagings; and		Shipper responsibility to ensure.
(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 172.101 Table. The permitted maximum net quantity must be calculated in kilograms if a package contains both a liquid and a solid.		Shipper responsibility to ensure.
(2) A packaging containing inner packagings of Division 6.2 materials may not contain other hazardous materials, except dry ice.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

(d) Liquids must not completely fill a receptacle at a temperature of 55 °C (131 °F) or less.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table B-4. Fiberboard Containers--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). HM-169A (effective April 1, 1996).

Regulatory requirement: 49 CFR 173.24a	Action required/by whom	Packaging category--fiberboard containers
(a) Packaging design. Except as provided in 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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(5) *Vibration*. Each non-bulk package must be capable of withstanding, without rupture or leakage, the vibration test procedure specified in 178.608 of this subchapter.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure. For specific vibration test data, refer to Appendix G, Table G-4.
(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:	Designer to do and shipper responsibility to ensure that the material being shipped falls within the envelope of acceptable materials based on design and testing. Type A packagings are not required to be marked with specific gravity.	Shipper responsibility to ensure.
(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;	This is not applicable as a Type A packaging does not incorporate packing groups.	
(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	This is not applicable as a Type A packaging does not incorporate packing groups.	
(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 as a Type A packaging does not incorporate packing groups.	
(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:	Designer to do and shipper responsibility to ensure that the material being shipped falls within the envelope of acceptable materials based on design and testing.	Shipper responsibility to ensure.
(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	This not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	

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.	This is not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	
(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 Type A packagings as Type A packagings do not incorporate packing groups.	
(4) Packagings tested as prescribed in 178.605 of this subchapter and marked with the hydrostatic test pressure as prescribed in 178.503(a)(5) of this subchapter may be used for liquids only when the vapor pressure of the liquid confirms to one of the following:	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(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 (d) of this section and a filling temperature of 15 °C (59 °F)], will not exceed two-thirds of the marked test pressure;	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(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	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(iii) The vapor pressure at 55 °C (131 °F)	This is not applicable to Type	Shipper responsibility to

must be less than two-thirds of the sum of the marked test pressure plus 100 kPa (15 psi).	A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	ensure.
(5) No hazardous material may remain on the outside of a package after filling.	This is modified for a Type A packaging (see 49 CFR 173.443). Shipper responsibility to ensure.	Shipper responsibility to ensure.
(c) Mixed contents.		
(1) An outer non-bulk packaging may contain more than one hazardous material only when--	For entire subsection (c), designer to do and shipper responsibility to ensure. For Type A packagings that are to contain other nonradioactive material, the package must meet both Type A and the required performance requirements.	Shipper responsibility to ensure.
(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;		Shipper responsibility to ensure.
(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;		Shipper responsibility to ensure.
(iii) Corrosive materials (except ORM-D) in bottles are further packed in securely closed inner receptacles before packing in outer packagings; and		Shipper responsibility to ensure.
(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 172.101 Table. The permitted maximum net quantity must be calculated in kilograms if a package contains both a liquid and a solid.		Shipper responsibility to ensure.
(2) A packaging containing inner packagings of Division 6.2 materials may not contain other hazardous materials, except dry ice.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(d) Liquids must not completely fill a	Designer to do and shipper	Shipper responsibility to

receptacle at a temperature of 55 °C (131 °F) or less.

responsibility to ensure.

ensure.

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Table B-5. UF_6 Cylinders--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). HM-169A (effective April 1, 1996).

Regulatory requirement: 49 CFR 173.24a	Action required/by whom	Packaging category--UF_6 cylinders
(a) Packaging design. Except as provided in 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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(5) *Vibration*. Each non-bulk package must be capable of withstanding, without rupture or leakage, the vibration test procedure specified in 178.608 of this subchapter.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure. For specific vibration test data, refer to Appendix G, Table G-5.
(b) Non-bulk packaging filling limits.		
(1) A single or composite non-bulk	Designer to do and shipper	Shipper responsibility to ensure.

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:	responsibility to ensure that the material being shipped falls within the envelope of acceptable materials based on design and testing. Type A packagings are not required to be marked with specific gravity.	
(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;	This is not applicable as a Type A packaging does not incorporate packing groups.	
(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	This is not applicable as a Type A packaging does not incorporate packing groups.	
(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 as a Type A packaging does not incorporate packing groups.	
(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:	Designer to do and shipper responsibility to ensure that the material being shipped falls within the envelope of acceptable materials based on design and testing.	Shipper responsibility to ensure.
(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	This not applicable to Type A packagings as Type A packagings do not incorporate packing	

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.	groups.	
(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.	This is not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	
(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 Type A packagings as Type A packagings do not incorporate packing groups.	
(4) Packagings tested as prescribed in 178.605 of this subchapter and marked with the hydrostatic test pressure as prescribed in 178.503(a)(5) of this subchapter may be used for liquids only when the vapor pressure of the liquid confirms to one of the following:	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(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 (d) of this section and a filling temperature of 15 °C (59 °F)], will not exceed two-thirds of the marked test pressure;	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(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	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(iii) The vapor pressure at 55 °C (131 °F)	This is not applicable to	Shipper responsibility to ensure.

must be less than two-thirds of the sum of the marked test pressure plus 100 kPa (15 psi).	Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	
(5) No hazardous material may remain on the outside of a package after filling.	This is modified for a Type A packaging (see 49 CFR 173.443). Shipper responsibility to ensure.	Shipper responsibility to ensure.
(c) Mixed contents.		
(1) An outer non-bulk packaging may contain more than one hazardous material only when--	For entire subsection (c), designer to do and shipper responsibility to ensure. For Type A packagings that are to contain other nonradioactive material, the package must meet both Type A and the required performance requirements.	Shipper responsibility to ensure.
(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;		Shipper responsibility to ensure.
(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;		Shipper responsibility to ensure.
(iii) Corrosive materials (except ORM-D) in bottles are further packed in securely closed inner receptacles before packing in outer packagings; and		Shipper responsibility to ensure.
(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 172.101 Table. The permitted maximum net quantity must be calculated in kilograms if a package contains both a liquid and a solid.		Shipper responsibility to ensure.
(2) A packaging containing inner packagings of Division 6.2 materials may not contain other hazardous materials, except dry ice.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

(d) Liquids must not completely fill a receptacle at a temperature of 55 °C (131 °F) or less.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table B-6. Liquid and Gas Packagings--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). HM-169A (effective April 1, 1996).

Regulatory requirement: 49 CFR 173.24a	Action required/by whom	Packaging category--liquids and gas
(a) Packaging design. Except as provided in 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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(5) *Vibration*. Each non-bulk package must be capable of withstanding, without rupture or leakage, the vibration test procedure specified in 178.608 of this subchapter.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure. For specific vibration test data, refer to Appendix G, Table G-6.
(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:	Designer to do and shipper responsibility to ensure that the material being shipped falls within the envelope of acceptable materials based on design and testing. Type A packagings are not required to be marked with specific gravity.	Shipper responsibility to ensure.
(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;	This is not applicable as a Type A packaging does not incorporate packing groups.	
(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	This is not applicable as a Type A packaging does not incorporate packing groups.	
(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 as a Type A packaging does not incorporate packing groups.	
(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:	Designer to do and shipper responsibility to ensure that the material being shipped falls within the envelope of acceptable materials based on design and testing.	Shipper responsibility to ensure.
(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	This not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	

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.	This is not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	
(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 Type A packagings as Type A packagings do not incorporate packing groups.	
(4) Packagings tested as prescribed in 178.605 of this subchapter and marked with the hydrostatic test pressure as prescribed in 178.503(a)(5) of this subchapter may be used for liquids only when the vapor pressure of the liquid confirms to one of the following:	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(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 (d) of this section and a filling temperature of 15 °C (59 °F)], will not exceed two-thirds of the marked test pressure;	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(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	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(iii) The vapor pressure at 55 °C (131 °F)	This is not applicable to Type	Shipper responsibility to

must be less than two-thirds of the sum of the marked test pressure plus 100 kPa (15 psi).	A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	ensure.
(5) No hazardous material may remain on the outside of a package after filling.	This is modified for a Type A packaging (see 49 CFR 173.443). Shipper responsibility to ensure.	Shipper responsibility to ensure.
(c) Mixed contents.		
(1) An outer non-bulk packaging may contain more than one hazardous material only when--	For entire subsection (c), designer to do and shipper responsibility to ensure. For Type A packagings that are to contain other nonradioactive material, the package must meet both Type A and the required performance requirements.	Shipper responsibility to ensure.
(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;		Shipper responsibility to ensure.
(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;		Shipper responsibility to ensure.
(iii) Corrosive materials (except ORM-D) in bottles are further packed in securely closed inner receptacles before packing in outer packagings; and		Shipper responsibility to ensure.
(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 172.101 Table. The permitted maximum net quantity must be calculated in kilograms if a package contains both a liquid and a solid.		Shipper responsibility to ensure.
(2) A packaging containing inner packagings of Division 6.2 materials may not contain other hazardous materials, except dry ice.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(d) Liquids must not completely fill a	Designer to do and shipper	Shipper responsibility to

receptacle at a temperature of 55 °C (131 °F) or less.

responsibility to ensure.

ensure.

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Table B-7. Miscellaneous Packagings--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). HM-169A (effective April 1, 1996).		
Regulatory requirement: 49 CFR 173.24a	**Action required/by whom**	**Packaging category--miscellaneous**
(a) Packaging design. Except as provided in 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.	Designer to do and shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(5) *Vibration*. Each non-bulk package must be capable of withstanding, without rupture or leakage, the vibration test procedure specified in 178.608 of this subchapter.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure. For specific vibration test data, refer to Appendix G, Table G-7.
(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:	Designer to do and shipper responsibility to ensure that the material being shipped falls within the envelope of acceptable materials based on design and testing. Type A packagings are not required to be marked with specific gravity.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(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;	This is not applicable as a Type A packaging does not incorporate packing groups.	
(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,	This is not applicable as a Type A packaging does not incorporate packing groups.	

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 as a Type A packaging does not incorporate packing groups.	
(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:	Designer to do and shipper responsibility to ensure that the material being shipped falls within the envelope of acceptable materials based on design and testing.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(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.	This not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	

(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.	This is not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	
(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 Type A packagings as Type A packagings do not incorporate packing groups.	
(4) Packagings tested as prescribed in 178.605 of this subchapter and marked with the hydrostatic test pressure as prescribed in 178.503(a)(5) of this subchapter may be used for liquids only when the vapor pressure of the liquid confirms to one of the following:	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(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 (d) of this section and a filling temperature of 15 °C (59 °F)], will not exceed two-thirds of the marked test pressure;	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.

(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	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(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. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(5) No hazardous material may remain on the outside of a package after filling.	This is modified for a Type A packaging (see 49 CFR 173.443). Shipper responsibility to ensure.	Shipper responsibility to ensure.
(c) Mixed contents.		
(1) An outer non-bulk packaging may contain more than one hazardous material only when--	For entire subsection (c), designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
	For Type A packagings that are to contain other nonradioactive material, the package must meet both Type A and the required performance requirements.	
(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;		Shipper responsibility to ensure.
(ii) The package as prepared for shipment meets the performance tests prescribed in part 178 of this		Shipper responsibility to ensure.

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		Shipper responsibility to ensure.
(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 172.101 Table. The permitted maximum net quantity must be calculated in kilograms if a package contains both a liquid and a solid.		Shipper responsibility to ensure. The Stagecoach is not authorized for transport by aircraft. The Modified WRAP 1-Trip, 208-L Drum assemblies are not authorized for transport by aircraft.
(2) A packaging containing inner packagings of Division 6.2 materials may not contain other hazardous materials, except dry ice.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(d) Liquids must not completely fill a receptacle at a temperature of 55 °C (131 °F) or less.	Designer to do and shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.

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Table C-1. Steel Drums--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). HM-169A (effective April 1, 1996).

Regulatory requirement: 49 CFR 173.24b	Action required/by whom	Packaging category--steel drums
(a) *Outage and filling limits.*		
(1) Except as otherwise provided in this subchapter, liquids and liquefied gases must be so loaded that the outage is at least five percent for materials poisonous by inhalation, or at least one percent for all other materials, of the total capacity of a cargo tank, portable tank, tank car (including dome capacity), multi-unit tank car tank, or any compartment thereof, at the following reference temperatures—	Designer to do and shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids or gases. Shipper responsibility to ensure.
(i) 46 °C (115 °F) for a noninsulated tank;		
(ii) 43 °C (110 °F) for a tank car having a thermal protection system, incorporating a metal jacket that provides an overall thermal conductance at 15.5 °C (60 °F) of no more than 10.22 kilojoules per hour per square meter per degree Celsius (0.5 Btu per hour/per square foot/per degree F) temperature differential; or		
(iii) 41 °C (105 °F) for an insulated tank.		
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

provide the required outage.

(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 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-in. test specimen.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure. NOTE: This requirement is not applicable for DOT Specification 7A Type A packagings. 49 CFR 178.350 does not require the use of stainless steel or its equivalent.
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

mixture within the flammability range of the lading in the vapor space of the tank.		
(d) A bulk packaging may not be loaded with a hazardous material that:	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(1) Is at a temperature outside of the packaging's design temperature range; or		
(2) Except as otherwise provided in this subchapter, exceeds the maximum weight of lading marked on the specification plate.		

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Table C-2. Steel Boxes--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). HM-169A (effective April 1, 1996).

Regulatory requirement: 49 CFR 173.24b	Action required/by whom	Packaging category--steel boxes
(a) *Outage and filling limits.*		
(1) Except as otherwise provided in this subchapter, liquids and liquefied gases must be so loaded that the outage is at least five percent for materials poisonous by inhalation, or at least one percent for all other materials, of the total capacity of a cargo tank, portable tank, tank car (including dome capacity), multi-unit tank car tank, or any compartment thereof, at the following reference temperatures—	Designer to do and shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids or gases. Shipper responsibility to ensure.
(i) 46 °C (115 °F) for a noninsulated tank;		
(ii) 43 °C (110 °F) for a tank car having a thermal protection system, incorporating a metal jacket that provides an overall thermal conductance at 15.5 °C (60 °F) of no more than 10.22 kilojoules per hour per square meter per degree Celsius (0.5 Btu per hour/per square foot/per degree F) temperature differential; or		
(iii) 41 °C (105 °F) for an insulated tank.		

(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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 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:	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure. NOTE: This requirement is not applicable for DOT Specification 7A Type A packagings. 49 CFR 178.350 does not require the use of stainless steel or its equivalent.
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-in.		

test specimen.		
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(d) A bulk packaging may not be loaded with a hazardous material that:	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(1) Is at a temperature outside of the packaging's design temperature range; or		
(2) Except as otherwise provided in this subchapter, exceeds the maximum weight of lading marked on the specification plate.		

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Table C-3. Wooden Boxes--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). HM-169A (effective April 1, 1996).

Regulatory requirement: 49 CFR 173.24b	Action required/by whom	Packaging category--wooden boxes
(a) *Outage and filling limits.*		
(1) Except as otherwise provided in this subchapter, liquids and liquefied gases must be so loaded that the outage is at least five percent for materials poisonous by inhalation, or at least one percent for all other materials, of the total capacity of a cargo tank, portable tank, tank car (including dome capacity), multi-unit tank car tank, or any compartment thereof, at the following reference temperatures—	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) 46 °C (115 °F) for a noninsulated tank;		
(ii) 43 °C (110 °F) for a tank car having a thermal protection system, incorporating a metal jacket that provides an overall thermal conductance at 15.5 °C (60 °F) of no more than 10.22 kilojoules per hour per square meter per degree Celsius (0.5 Btu per hour/per square foot/per degree F) temperature differential; or		
(iii) 41 °C (105 °F) for an insulated tank.		
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

space must be left in the shell to provide the required outage.		
(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 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-in. test specimen.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure. NOTE: This requirement is not applicable for DOT Specification 7A Type A packagings. 49 CFR 178.350 does not require the use of stainless steel or its equivalent.
(c) Air pressure in excess of ambient atmospheric pressure may not be used to load or unload any lading	Designer to do and shipper responsibility to	Shipper responsibility to ensure.

which may create an air-enriched mixture within the flammability range of the lading in the vapor space of the tank.	ensure.	
(d) A bulk packaging may not be loaded with a hazardous material that:	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(1) Is at a temperature outside of the packaging's design temperature range; or		
(2) Except as otherwise provided in this subchapter, exceeds the maximum weight of lading marked on the specification plate.		

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Table C-4. Fiberboard Containers--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). HM-169A (effective April 1, 1996).

Regulatory requirement: 49 CFR 173.24b	Action required/by whom	Packaging category--fiberboard containers
(a) *Outage and filling limits.*		
(1) Except as otherwise provided in this subchapter, liquids and liquefied gases must be so loaded that the outage is at least five percent for materials poisonous by inhalation, or at least one percent for all other materials, of the total capacity of a cargo tank, portable tank, tank car (including dome capacity), multi-unit tank car tank, or any compartment thereof, at the following reference temperatures—	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) 46 °C (115 °F) for a noninsulated tank;		
(ii) 43 °C (110 °F) for a tank car having a thermal protection system, incorporating a metal jacket that provides an overall thermal conductance at 15.5 °C (60 °F) of no more than 10.22 kilojoules per hour per square meter per degree Celsius (0.5 Btu per hour/per square foot/per degree F) temperature differential; or		
(iii) 41 °C (105 °F) for an insulated tank.		
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

space must be left in the shell to provide the required outage.		
(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 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-in. test specimen.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure. NOTE: This requirement is not applicable for DOT Specification 7A Type A packagings. 49 CFR 178.350 does not require the use of stainless steel or its equivalent.
(c) Air pressure in excess of ambient atmospheric pressure may not be used to load or unload any lading	Designer to do and shipper responsibility to	Shipper responsibility to ensure.

which may create an air-enriched mixture within the flammability range of the lading in the vapor space of the tank.	ensure.	
(d) A bulk packaging may not be loaded with a hazardous material that:	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(1) Is at a temperature outside of the packaging's design temperature range; or		
(2) Except as otherwise provided in this subchapter, exceeds the maximum weight of lading marked on the specification plate.		

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Table C-5. UF_6 Cylinders--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). HM-169A (effective April 1, 1996).

Regulatory requirement: 49 CFR 173.24b	Action required/by whom	Packaging category--UF_6 Cylinders
(a) *Outage and filling limits.*		
(1) Except as otherwise provided in this subchapter, liquids and liquefied gases must be so loaded that the outage is at least five percent for materials poisonous by inhalation, or at least one percent for all other materials, of the total capacity of a cargo tank, portable tank, tank car (including dome capacity), multi-unit tank car tank, or any compartment thereof, at the following reference temperatures—	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) 46 °C (115 °F) for a noninsulated tank;		
(ii) 43 °C (110 °F) for a tank car having a thermal protection system, incorporating a metal jacket that provides an overall thermal conductance at 15.5 °C (60 °F) of no more than 10.22 kilojoules per hour per square meter per degree Celsius (0.5 Btu per hour/per square foot/per degree F) temperature differential; or		
(iii) 41 °C (105 °F) for an insulated tank.		
(2) Hazardous materials may not be loaded into the dome of a tank car. If the dome of the tank car does not	Designer to do and shipper responsibility to	Shipper responsibility to ensure.

provide sufficient outage, vacant space must be left in the shell to provide the required outage.	ensure.	
(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 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-in. test specimen.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure. NOTE: This requirement is not applicable for DOT Specification 7A Type A packagings. 49 CFR 178.350 does not require the use of stainless steel or its equivalent.
(c) Air pressure in excess of ambient atmospheric pressure may not be	Designer to do and shipper	Shipper responsibility to ensure.

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.	responsibility to ensure.	
(d) A bulk packaging may not be loaded with a hazardous material that:	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(1) Is at a temperature outside of the packaging's design temperature range; or		
(2) Except as otherwise provided in this subchapter, exceeds the maximum weight of lading marked on the specification plate.		

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Table C-6. Liquid and Gas Packagings--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). HM-169A (effective April 1, 1996).

Regulatory requirement: 49 CFR 173.24b	Action required/by whom	Packaging category--liquid and gas packagings
(a) *Outage and filling limits.*		
(1) Except as otherwise provided in this subchapter, liquids and liquefied gases must be so loaded that the outage is at least five percent for materials poisonous by inhalation, or at least one percent for all other materials, of the total capacity of a cargo tank, portable tank, tank car (including dome capacity), multi-unit tank car tank, or any compartment thereof, at the following reference temperatures— (i) 46 °C (115 °F) for a noninsulated tank; (ii) 43 °C (110 °F) for a tank car having a thermal protection system, incorporating a metal jacket that provides an overall thermal conductance at 15.5 °C (60 °F) of no more than 10.22 kilojoules per hour per square meter per degree Celsius (0.5 Btu per hour/per square foot/per degree F) temperature differential; or (iii) 41 °C (105 °F) for an insulated tank.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

required outage.

(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 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-in. test specimen.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure. NOTE: This requirement is not applicable for DOT Specification 7A Type A packagings. 49 CFR 178.350 does not require the use of stainless steel or its equivalent.
(c) Air pressure in excess of ambient atmospheric pressure may not be used	Designer to do and shipper	Shipper responsibility to ensure.

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.	responsibility to ensure.	
(d) A bulk packaging may not be loaded with a hazardous material that:	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(1) Is at a temperature outside of the packaging's design temperature range; or		
(2) Except as otherwise provided in this subchapter, exceeds the maximum weight of lading marked on the specification plate.		

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Table C-7. Miscellaneous Packagings--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). HM-169A (effective April 1, 1996).		
Regulatory requirement: 49 CFR 173.24b	**Action required/by whom**	**Packaging category--miscellaneous packagings**
(a) *Outage and filling limits.*		
(1) Except as otherwise provided in this subchapter, liquids and liquefied gases must be so loaded that the outage is at least five percent for materials poisonous by inhalation, or at least one percent for all other materials, of the total capacity of a cargo tank, portable tank, tank car (including dome capacity), multi-unit tank car tank, or any compartment thereof, at the following reference temperatures—	Designer to do and shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids or gasses. Shipper responsibility to ensure.
(i) 46 °C (115 °F) for a noninsulated tank;		
(ii) 43 °C (110 °F) for a tank car having a thermal protection system, incorporating a metal jacket that provides an overall thermal conductance at 15.5 °C (60 °F) of no more than 10.22 kilojoules per hour per square meter per degree Celsius (0.5 Btu per hour/per square foot/per degree F) temperature differential; or		
(iii) 41 °C (105 °F) for an insulated tank.		
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

space must be left in the shell to provide the required outage.		
(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 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:	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure. NOTE: This requirement is not applicable for DOT Specification 7A Type A packagings. 49 CFR 178.350 does not require the use of stainless steel or its equivalent.
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-in. test specimen.		
(c) Air pressure in excess of ambient atmospheric pressure may not be used to load or unload any lading	Designer to do and shipper responsibility to	Shipper responsibility to ensure.

which may create an air-enriched mixture within the flammability range of the lading in the vapor space of the tank.	ensure.	
(d) A bulk packaging may not be loaded with a hazardous material that:	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(1) Is at a temperature outside of the packaging's design temperature range; or		
(2) Except as otherwise provided in this subchapter, exceeds the maximum weight of lading marked on the specification plate.		

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Table D-1. Steel Drums--Compliance with General Design Requirements (49 CFR 173.410). HM-169A (effective April 1, 1996).

Regulatory requirement	Guidance for application	Packaging category--steel drums
In addition to the requirements of subparts A and B of this part, each package used for the shipment of Class 7 (radioactive) materials must be designed so that--		
(a) The package can be easily handled and properly secured in or on a conveyance during transport.	This does not necessarily mean handles are required. The intent is to maintain a package size and geometry that allow conformance to paragraph (a). For example, a package 1.22 x 1.83 x 1.22 m (4 x 6 x 4 ft) cannot be easily handled by hand. For such a package, other handling methods would be designed. A package with sharp edges or components may not be easily handled manually. Also, package stability is required during transport. A round-shaped package, a top-heavy package, or any similar package that would not maintain its initial orientation and load position under conditions incidental to routine transportation would not meet these requirements. Tie-downs are required for the packagings mentioned in this paragraph, and exclusive use shipments or documented special provisions with the carrier are required. Designer to do and shipper responsibility to ensure.	All the drums evaluated meet the intent of this requirement. In all cases, the shipper should avoid loading a top-heavy package and should be aware of the need for tie-downs for any such package.
(b) Each lifting attachment that is a structural part of the package must be designed with a minimum safety factor of three against yielding when used	A sign saying "Do Not Use As A Lifting Device," "Not A Lifting Device," etc. is not adequate to prevent the use of the unauthorized lifting devices. The	All the drums evaluated meet the intent of this requirement.

to lift the package in the intended manner, and it must be designed so that failure of any lifting attachment under excessive load would not impair the ability of the package to meet other requirements of this subpart. Any other structural part of the package which could be used to lift the package must be capable of being rendered inoperable for lifting the package during transport or must be designed with strength equivalent to that required for lifting attachments.	procedures for use of the packaging should also state the intended use of any attachment points for other purposes (e.g., "For lifting the lid only--not entire packaging"). Designer, and perhaps tester and evaluator, to do and shipper responsibility to ensure.	
(c) The external surface, as far as practicable, will be free from protruding features and will be easily decontaminated.	The intent is to minimize the number of protrusions by consideration during design and/or as a result of any modifications to the packaging. Designer to do and shipper responsibility to ensure.	All evaluated packagings meet this requirement.
(d) The outer layer of packaging will avoid, as far as practicable, pockets or crevices where water might collect.	This is not intended to eliminate 208-L drums as Specification 7A packaging. The intent is for packaging design personnel to consider this aspect. Avoid designing a packaging that provides cavities to collect water, which could spill during transport or handling, or could promote rusting and general deterioration of the packaging, possibly in locations difficult to detect. Designer to do and shipper responsibility to ensure.	All the drums evaluated meet the intent of this requirement. A newly designed package should consider this requirement.
(e) Each feature that is added to the package will not reduce the safety of the package.	As an example, a canvas cover placed over a package for protection against the rain must not adversely affect heat transfer requirements. Shipper responsibility to ensure.	This is a shipper responsibility because the regulation addresses items added to the packaging at the time of transport.
(f) The package will be capable of withstanding the effects of any acceleration, vibration or vibration resonance that may arise under normal conditions of transport without any deterioration in the effectiveness of the closing devices on the	Typically, one uses actual experience as a guide. If experience is not available, one normally uses a comparison to a similar packaging with an experience profile. If this isn't possible, vibration testing can be performed. The purpose of this	The shipper must ensure the application of quality assurance necessary to achieve this requirement. Refer to Appendix G, Table G-1 for specific vibration testing

various receptacles or in the integrity of the package as a whole and without loosening or unintentionally releasing the nuts, bolts, or other securing devices even after repeated use (see 173.24, 173.24a, and 173.24b).	section is to prevent the loosening of nuts, bolts, and containment devices under conditions incident to routine transportation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	information.
(g) The materials of construction of the packaging and any components or structure will be physically and chemically compatible with each other and with the package contents. The behavior of the packaging and the package contents under irradiation will be taken into account.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(h) All valves through which the package contents could escape will be protected against unauthorized operation.	Designer to do and shipper responsibility to ensure.	None of the packagings tested incorporate valves.
(i) For transport by air--	Designer, tester, and evaluator to do and shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(1) The temperature of the accessible surfaces of the package will not exceed 50 °C (122 °F) at an ambient temperature of 38 °C (100 °F) with no account taken for insulation;		
(2) The integrity of containment will not be impaired if the package is exposed to ambient temperatures ranging from -40 °C (-40 °F) to +55 °C (131 °F); and		
(3) Packages containing liquid contents will be capable of withstanding, without leakage, an internal pressure that produces a pressure differential of not less than 95 kPa (13.8 lb/in^2).		

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Table D-2. Steel Boxes--Compliance with General Design Requirements (49 CFR 173.410). HM-169A (effective April 1, 1996).

Regulatory requirement	Guidance for application	Packaging category--steel boxes
In addition to the requirements of subparts A and B of this part, each package used for the shipment of Class 7 (radioactive) materials must be designed so that--		
(a) The package can be easily handled and properly secured in or on a conveyance during transport.	This does not necessarily mean handles are required. The intent is to maintain a package size and geometry that allow conformance to paragraph (a). For example, a package 1.22 x 1.83 x 1.22 m (4 x 6 x 4 ft) cannot be easily handled by hand. For such a package, other handling methods would be designed. A package with sharp edges or components may not be easily handled manually. Also, package stability is required during transport. A round-shaped package, a top-heavy package, or any similar package that would not maintain its initial orientation and load position under conditions incidental to routine transportation would not meet these requirements. Tie-downs are required for the packagings mentioned in this	All the steel boxes evaluated meet the intent of this requirement. In all cases, the shipper should avoid loading a top-heavy package and should be aware of the need for tie-downs for any such package.

	paragraph, and exclusive use shipments or documented special provisions with the carrier are required. Designer to do and shipper responsibility to ensure.	
(b) Each lifting attachment that is a structural part of the package must be designed with a minimum safety factor of three against yielding when used to lift the package in the intended manner, and it must be designed so that failure of any lifting attachment under excessive load would not impair the ability of the package to meet other requirements of this subpart. Any other structural part of the package which could be used to lift the package must be capable of being rendered inoperable for lifting the package during transport or must be designed with strength equivalent to that required for lifting attachments.	A sign saying "Do Not Use As A Lifting Device," "Not A Lifting Device," etc. is not adequate to prevent the use of the unauthorized lifting devices. The procedures for use of the packaging should also state the intended use of any attachment points for other purposes (e.g., "For lifting the lid only--not entire packaging"). Designer, and perhaps tester and evaluator, to do and shipper responsibility to ensure.	All the steel boxes evaluated meet the intent of this requirement.
(c) The external surface, as far as practicable, will be free from protruding features and will be easily decontaminated.	The intent is to minimize the number of protrusions by consideration during design and/or as a result of any modifications to the packaging. Designer to do and shipper responsibility to ensure.	All evaluated packagings meet this requirement.
(d) The outer layer of packaging will avoid, as far as practicable, pockets or crevices where water might collect.	The intent is for packaging design personnel to consider this aspect. Avoid designing a packaging that provides cavities to collect water, which could spill during transport or handling, or could promote rusting and general deterioration of the packaging, possibly in locations difficult to detect. Designer to do and shipper responsibility to ensure.	All the steel boxes evaluated meet the intent of this requirement. A newly designed package should consider this requirement.
(e) Each feature that is added to the package will not reduce the safety of the package.	As an example, a canvas cover placed over a package for protection against the rain must not adversely affect heat transfer requirements. Shipper responsibility to ensure.	This is a shipper responsibility because the regulation addresses items added to the packaging at the time of transport.
(f) The package will be capable of withstanding the effects of any	Typically, one uses actual experience as a guide. If	The shipper must ensure the application of quality assurance

acceleration, vibration or vibration resonance that may arise under normal conditions of transport without any deterioration in the effectiveness of the closing devices on the various receptacles or in the integrity of the package as a whole and without loosening or unintentionally releasing the nuts, bolts, or other securing devices even after repeated use (see 173.24, 173.24a, and 173.24b).	experience is not available, one normally uses a comparison to a similar packaging with an experience profile. If this isn't possible, vibration testing can be performed. The purpose of this section is to prevent the loosening of nuts, bolts, and containment devices under conditions incident to routine transportation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	necessary to achieve this requirement. Refer to Appendix G, Table G-2 for specific vibration testing information.
(g) The materials of construction of the packaging and any components or structure will be physically and chemically compatible with each other and with the package contents. The behavior of the packaging and the package contents under irradiation will be taken into account.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(h) All valves through which the package contents could escape will be protected against unauthorized operation.	Designer to do and shipper responsibility to ensure.	None of the packagings tested incorporate valves.
(i) For transport by air--	Designer, tester, and evaluator to do and shipper responsibility to ensure.	None of the packagings tested are authorized for use in shipping liquids. Shipper responsibility to ensure.
(1) The temperature of the accessible surfaces of the package will not exceed 50 °C (122 °F) at an ambient temperature of 38 °C (100 °F) with no account taken for insulation;		
(2) The integrity of containment will not be impaired if the package is exposed to ambient temperatures ranging from -40 °C (-40 °F) to +55 °C (131 °F); and		
(3) Packages containing liquid contents will be capable of withstanding, without leakage, an internal pressure that produces a pressure differential of not less than 95 kPa (13.8 lb/in^2).		

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Table D-3. Wooden Boxes--Compliance with General Design Requirements (49 CFR 173.410). HM-169A (effective April 1, 1996).

Regulatory requirement	Guidance for application	Packaging category--wooden boxes
In addition to the requirements of subparts A and B of this part, each package used for the shipment of Class 7 (radioactive) materials must be designed so that--		
(a) The package can be easily handled and properly secured in or on a conveyance during transport.	This does not necessarily mean handles are required. The intent is to maintain a package size and geometry that allow conformance to paragraph (a). For example, a package 1.22 x 1.83 x 1.22 m (4 x 6 x 4 ft) cannot be easily handled by hand. For such a package, other handling methods would be designed. A package with sharp edges or components may not be easily handled manually. Also, package stability is required during transport. A round-shaped package, a top-heavy package, or any similar package that would not maintain its initial orientation and load position under conditions incidental to routine transportation would not meet these requirements. Tie-downs are required for the packagings mentioned in this paragraph, and exclusive use shipments or documented special provisions with the carrier are required. Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance will be added for this packaging type upon completion of testing for this packaging type.
(b) Each lifting attachment that is a structural part of the	A sign saying "Do Not Use As A Lifting Device," "Not A Lifting Device," etc. is not adequate to prevent the use of the unauthorized lifting devices. The procedures for use of the packaging should	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this

package must be designed with a minimum safety factor of three against yielding when used to lift the package in the intended manner, and it must be designed so that failure of any lifting attachment under excessive load would not impair the ability of the package to meet other requirements of this subpart. Any other structural part of the package which could be used to lift the package must be capable of being rendered inoperable for lifting the package during transport or must be designed with strength equivalent to that required for lifting attachments.	also state the intended use of any attachment points for other purposes (e.g., "For lifting the lid only--not entire packaging"). Designer, and perhaps tester and evaluator, to do and shipper responsibility to ensure.	packaging type.
(c) The external surface, as far as practicable, will be free from protruding features and will be easily decontaminated.	The intent is to minimize the number of protrusions by consideration during design and/or as a result of any modifications to the packaging. Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(d) The outer layer of	The intent is for packaging design personnel to consider this aspect. Avoid designing a packaging	NOTE: Packaging category compliance information will be

packaging will avoid, as far as practicable, pockets or crevices where water might collect.	that provides cavities to collect water, which could spill during transport or handling, or could promote rusting and general deterioration of the packaging, possibly in locations difficult to detect. Designer to do and shipper responsibility to ensure.	added for this packaging type upon completion of testing for this packaging type.
(e) Each feature that is added to the package will not reduce the safety of the package.	As an example, a canvas cover placed over a package for protection against the rain must not adversely affect heat transfer requirements. Shipper responsibility to ensure.	This is a shipper responsibility because the regulation addresses items added to the packaging that was already evaluated.
(f) The package will be capable of withstanding the effects of any acceleration, vibration or vibration resonance that may arise under normal conditions of transport without any deterioration in the effectiveness of the closing devices on the various receptacles or in the integrity of the package as a whole and without loosening or unintentionally releasing the nuts, bolts, or other securing devices even after repeated use (see 173.24, 173.24a, and 173.24b).	Typically, one uses actual experience as a guide. If experience is not available, one normally uses a comparison to a similar packaging with an experience profile. If this isn't possible, vibration testing can be performed. The purpose of this section is to prevent the loosening of nuts, bolts, and containment devices under conditions incident to routine transportation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	The shipper must ensure the application of quality assurance necessary to achieve this requirement. Refer to Appendix G, Table G-3 for specific vibration testing information.
(g) The materials of construction of the packaging	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

and any components or structure will be physically and chemically compatible with each other and with the package contents. The behavior of the packaging and the package contents under irradiation will be taken into account.		
(h) All valves through which the package contents could escape will be protected against unauthorized operation.	Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(i) For transport by air--	Designer, tester, and evaluator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(1) The temperature of the accessible surfaces of the package will not exceed 50 °C (122 °F) at an ambient temperature of 38 °C (100 °F) with no account taken for insulation;		
(2) The integrity of containment will not be impaired if the package is exposed to ambient temperatures ranging from -		

40 °C (-40 °F) to +55 °C (131 °F); and

(3) Packages containing liquid contents will be capable of withstanding, without leakage, an internal pressure that produces a pressure differential of not less than 95 kPa (13.8 lb/in^2).

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Table D-4. Fiberboard Containers--Compliance with General Design Requirements (49 CFR 173.410).HM-169A (effective April 1, 1996).

Regulatory requirement	Guidance for application	Packaging category--fiberboard containers
In addition to the requirements of subparts A and B of this part, each package used for the shipment of Class 7 (radioactive) materials must be designed so that--		
(a) The package can be easily handled and properly secured in or on a conveyance during transport.	This does not necessarily mean handles are required. The intent is to maintain a package size and geometry that allow conformance to paragraph (a). For example, a package 1.22 x 1.83 x 1.22 m (4 x 6 x 4 ft) cannot be easily handled by hand. For such a package, other handling methods would be designed. A package with sharp edges or components may not be easily handled manually. Also, package stability is required during transport. A round-shaped package, a top-heavy package, or any similar package that would not maintain its initial orientation and load position under conditions incidental to routine transportation would not meet these requirements. Tie-downs are required for the packagings mentioned in this paragraph, and exclusive use shipments or documented special provisions with the carrier are required. Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance will be added for this packaging type upon completion of testing for this packaging type.

(b) Each lifting attachment that is a structural part of the package must be designed with a minimum safety factor of three against yielding when used to lift the package in the intended manner, and it must be designed so that failure of any lifting attachment under excessive load would not impair the ability of the package to meet other requirements of this subpart. Any other structural part of the package which could be used to lift the package must be capable of being rendered inoperable for lifting the package during transport or must be designed with strength equivalent to that required for lifting attachments.	A sign saying "Do Not Use As A Lifting Device," "Not A Lifting Device," etc. is not adequate to prevent the use of the unauthorized lifting devices. The procedures for use of the packaging should also state the intended use of any attachment points for other purposes (e.g., "For lifting the lid only--not entire packaging"). Designer, and perhaps tester and evaluator, to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(c) The external surface, as far as practicable, will be free from protruding features and will be easily	The intent is to minimize the number of protrusions by consideration during design and/or as a result of any modifications to the packaging. Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

decontaminated.		
(d) The outer layer of packaging will avoid, as far as practicable, pockets or crevices where water might collect.	The intent is for packaging design personnel to consider this aspect. Avoid designing a packaging that provides cavities to collect water, which could spill during transport or handling, or could promote rusting and general deterioration of the packaging, possibly in locations difficult to detect. Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(e) Each feature that is added to the package will not reduce the safety of the package.	As an example, a canvas cover placed over a package for protection against the rain must not adversely affect heat transfer requirements. Shipper responsibility to ensure.	This is a shipper responsibility because the regulation addresses items added to the packaging that was already evaluated.
(f) The package will be capable of withstanding the effects of any acceleration, vibration or vibration resonance that may arise under normal conditions of transport without any deterioration in the effectiveness of the closing devices on the various receptacles or in the integrity of the package as a whole and without loosening or unintentionally releasing the nuts, bolts, or other securing devices even after repeated use (see 173.24, 173.24a, and 173.24b).	Typically, one uses actual experience as a guide. If experience is not available, one normally uses a comparison to a similar packaging with an experience profile. If this isn't possible, vibration testing can be performed. The purpose of this section is to prevent the loosening of nuts, bolts, and containment devices under conditions incident to routine transportation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	The shipper must ensure the application of quality assurance necessary to achieve this requirement. Refer to Appendix G, Table G-4 for specific vibration testing information.

(g) The materials of construction of the packaging and any components or structure will be physically and chemically compatible with each other and with the package contents. The behavior of the packaging and the package contents under irradiation will be taken into account.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(h) All valves through which the package contents could escape will be protected against unauthorized operation.	Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(i) For transport by air-- (1) The temperature of the accessible surfaces of the package will not exceed 50 °C (122 °F) at an ambient temperature of 38 °C (100 °F) with no account taken for insulation; (2) The integrity of containment will not be impaired if the package is	Designer, tester, and evaluator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

exposed to ambient temperatures ranging from -40 °C (-40 °F) to +55 °C (131 °F); and

(3) Packages containing liquid contents will be capable of withstanding, without leakage, an internal pressure that produces a pressure differential of not less than 95 kPa (13.8 lb/in^2).

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Table D-5. UF_6 Cylinders--Compliance with General Design Requirements (49 CFR 173.410). HM-169A (effective April 1, 1996).

Regulatory requirement	Guidance for application	Packaging category--UF_6 cylinders
In addition to the requirements of subparts A and B of this part, each package used for the shipment of Class 7 (radioactive) materials must be designed so that--		
(a) The package can be easily handled and properly secured in or on a conveyance during transport.	This does not necessarily mean handles are required. The intent is to maintain a package size and geometry that allow conformance to paragraph (a). For example, a package 1.22 x 1.83 x 1.22 m (4 x 6 x 4 ft) cannot be easily handled by hand. For such a package, other handling methods would be designed. A package with sharp edges or components may not be easily handled manually. Also, package stability is required during transport. A round-shaped package, a top-heavy package, or any similar package that would not maintain its initial orientation and load position under conditions incidental to routine transportation would not meet these requirements. Tie-downs are required for the packagings mentioned in this paragraph, and exclusive use shipments or documented special provisions with the carrier are required. Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance will be added for this packaging type upon completion of testing for this packaging type.
(b) Each lifting attachment that is a structural part of the	A sign saying "Do Not Use As A Lifting Device," "Not A Lifting Device," etc. is not adequate to prevent the use of the unauthorized lifting devices. The procedures for use of the packaging should	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this

package must be designed with a minimum safety factor of three against yielding when used to lift the package in the intended manner, and it must be designed so that failure of any lifting attachment under excessive load would not impair the ability of the package to meet other requirements of this subpart. Any other structural part of the package which could be used to lift the package must be capable of being rendered inoperable for lifting the package during transport or must be designed with strength equivalent to that required for lifting attachments.	also state the intended use of any attachment points for other purposes (e.g., "For lifting the lid only--not entire packaging"). Designer, and perhaps tester and evaluator, to do and shipper responsibility to ensure.	packaging type.
(c) The external surface, as far as practicable, will be free from protruding features and will be easily decontaminated.	The intent is to minimize the number of protrusions by consideration during design and/or as a result of any modifications to the packaging. Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(d) The outer layer of	The intent is for packaging design personnel to consider this aspect. Avoid designing a packaging	NOTE: Packaging category compliance information will be

packaging will avoid, as far as practicable, pockets or crevices where water might collect.	that provides cavities to collect water, which could spill during transport or handling, or could promote rusting and general deterioration of the packaging, possibly in locations difficult to detect. Designer to do and shipper responsibility to ensure.	added for this packaging type upon completion of testing for this packaging type.
(e) Each feature that is added to the package will not reduce the safety of the package.	As an example, a canvas cover placed over a package for protection against the rain must not adversely affect heat transfer requirements. Shipper responsibility to ensure.	This is a shipper responsibility because the regulation addresses items added to the packaging that was already evaluated.
(f) The package will be capable of withstanding the effects of any acceleration, vibration or vibration resonance that may arise under normal conditions of transport without any deterioration in the effectiveness of the closing devices on the various receptacles or in the integrity of the package as a whole and without loosening or unintentionally releasing the nuts, bolts, or other securing devices even after repeated use (see 173.24, 173.24a, and 173.24b).	Typically, one uses actual experience as a guide. If experience is not available, one normally uses a comparison to a similar packaging with an experience profile. If this isn't possible, vibration testing can be performed. The purpose of this section is to prevent the loosening of nuts, bolts, and containment devices under conditions incident to routine transportation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	The shipper must ensure the application of quality assurance necessary to achieve this requirement. Refer to Appendix G, Table G-5 for specific vibration testing information.
(g) The materials of construction of the packaging	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

and any components or structure will be physically and chemically compatible with each other and with the package contents. The behavior of the packaging and the package contents under irradiation will be taken into account.		
(h) All valves through which the package contents could escape will be protected against unauthorized operation.	Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(i) For transport by air--	Designer, tester, and evaluator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(1) The temperature of the accessible surfaces of the package will not exceed 50 °C (122 °F) at an ambient temperature of 38 °C (100 °F) with no account taken for insulation;		
(2) The integrity of containment will not be impaired if the package is exposed to ambient temperatures ranging from -		

40 °C (-40 °F) to +55 °C (131 °F); and

(3) Packages containing liquid contents will be capable of withstanding, without leakage, an internal pressure that produces a pressure differential of not less than 95 kPa (13.8 lb/in^2).

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Table D-6. Liquid and Gas Packagings--Compliance with General Design Requirements (49 CFR 173.410). HM-169A (effective April 1, 1996).

Regulatory requirement	Guidance for application	Packaging category--liquid and gas
In addition to the requirements of subparts A and B of this part, each package used for the shipment of Class 7 (radioactive) materials must be designed so that--		
(a) The package can be easily handled and properly secured in or on a conveyance during transport.	This does not necessarily mean handles are required. The intent is to maintain a package size and geometry that allow conformance to paragraph (a). For example, a package 1.22 x 1.83 x 1.22 m (4 x 6 x 4 ft) cannot be easily handled by hand. For such a package, other handling methods would be designed. A package with sharp edges or components may not be easily handled manually. Also, package stability is required during transport. A round-shaped package, a top-heavy package, or any similar package that would not maintain its initial orientation and load position under conditions incidental to routine transportation would not meet these requirements. Tie-downs are required for the packagings mentioned in this paragraph, and exclusive use shipments or documented special provisions with the carrier are required. Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance will be added for this packaging type upon completion of testing for this packaging type.
(b) Each lifting attachment that is a structural part of the	A sign saying "Do Not Use As A Lifting Device," "Not A Lifting Device," etc. is not adequate to prevent the use of the unauthorized lifting devices. The procedures for use of the packaging should	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this

package must be designed with a minimum safety factor of three against yielding when used to lift the package in the intended manner, and it must be designed so that failure of any lifting attachment under excessive load would not impair the ability of the package to meet other requirements of this subpart. Any other structural part of the package which could be used to lift the package must be capable of being rendered inoperable for lifting the package during transport or must be designed with strength equivalent to that required for lifting attachments.	also state the intended use of any attachment points for other purposes (e.g., "For lifting the lid only--not entire packaging"). Designer, and perhaps tester and evaluator, to do and shipper responsibility to ensure.	packaging type.
(c) The external surface, as far as practicable, will be free from protruding features and will be easily decontaminated.	The intent is to minimize the number of protrusions by consideration during design and/or as a result of any modifications to the packaging. Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(d) The outer layer of	The intent is for packaging design personnel to consider this aspect. Avoid designing a packaging	NOTE: Packaging category compliance information will be

packaging will avoid, as far as practicable, pockets or crevices where water might collect.	that provides cavities to collect water, which could spill during transport or handling, or could promote rusting and general deterioration of the packaging, possibly in locations difficult to detect. Designer to do and shipper responsibility to ensure.	added for this packaging type upon completion of testing for this packaging type.
(e) Each feature that is added to the package will not reduce the safety of the package.	As an example, a canvas cover placed over a package for protection against the rain must not adversely affect heat transfer requirements. Shipper responsibility to ensure.	This is a shipper responsibility because the regulation addresses items added to the packaging that was already evaluated.
(f) The package will be capable of withstanding the effects of any acceleration, vibration or vibration resonance that may arise under normal conditions of transport without any deterioration in the effectiveness of the closing devices on the various receptacles or in the integrity of the package as a whole and without loosening or unintentionally releasing the nuts, bolts, or other securing devices even after repeated use (see 173.24, 173.24a, and 173.24b).	Typically, one uses actual experience as a guide. If experience is not available, one normally uses a comparison to a similar packaging with an experience profile. If this isn't possible, vibration testing can be performed. The purpose of this section is to prevent the loosening of nuts, bolts, and containment devices under conditions incident to routine transportation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	The shipper must ensure the application of quality assurance necessary to achieve this requirement. Refer to Appendix G, Table G-6 for specific vibration testing information.
(g) The materials of construction of the packaging	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

and any components or structure will be physically and chemically compatible with each other and with the package contents. The behavior of the packaging and the package contents under irradiation will be taken into account.		
(h) All valves through which the package contents could escape will be protected against unauthorized operation.	Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(i) For transport by air--	Designer, tester, and evaluator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(1) The temperature of the accessible surfaces of the package will not exceed 50 °C (122 °F) at an ambient temperature of 38 °C (100 °F) with no account taken for insulation;		
(2) The integrity of containment will not be impaired if the package is exposed to ambient temperatures ranging from -		

40 °C (-40 °F) to +55 °C (131 °F); and

(3) Packages containing liquid contents will be capable of withstanding, without leakage, an internal pressure that produces a pressure differential of not less than 95 kPa (13.8 lb/in^2).

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Table D-7. Miscellaneous--Compliance with General Design Requirements (49 CFR 173.410). HM-169A (effective April 1, 1996).		
Regulatory requirement	**Guidance for application**	**Packaging category--miscellaneous**
In addition to the requirements of subparts A and B of this part, each package used for the shipment of Class 7 (radioactive) materials must be designed so that--		
(a) The package can be easily handled and properly secured in or on a conveyance during transport.	This does not necessarily mean handles are required. The intent is to maintain a package size and geometry that allow conformance to paragraph (a). For example, a package 1.22 x 1.83 x 1.22 m (4 x 6 x 4 ft) cannot be easily handled by hand. For such a package, other handling methods would be designed. A package with sharp edges or components may not be easily handled manually. Also, package stability is required during transport. A round-shaped package, a top-heavy package, or any similar package that would not maintain its initial orientation and load position under conditions incidental to routine transportation would not meet these requirements. Tie-downs are required for the packagings mentioned in this paragraph, and exclusive use shipments or documented special provisions with the carrier are required. Designer to do and shipper responsibility to ensure.	All the packagings tested and evaluated meet the intent of this requirement. The Stagecoach packaging design may be banded onto a suitable pallet for use in transport. Four metal bands are recommended due to the flexibility of the container.
(b) Each lifting attachment that is a structural part of the package	A sign saying "Do Not Use As A Lifting Device," "Not A Lifting	All the packagings evaluated meet the intent of this

must be designed with a minimum safety factor of three against yielding when used to lift the package in the intended manner, and it must be designed so that failure of any lifting attachment under excessive load would not impair the ability of the package to meet other requirements of this subpart. Any other structural part of the package which could be used to lift the package must be capable of being rendered inoperable for lifting the package during transport or must be designed with strength equivalent to that required for lifting attachments.	Device," etc. is not adequate to prevent the use of the unauthorized lifting devices. The procedures for use of the packaging should also state the intended use of any attachment points for other purposes (e.g., "For lifting the lid only--not entire packaging"). Designer, and perhaps tester and evaluator, to do and shipper responsibility to ensure.	requirement.
(c) The external surface, as far as practicable, will be free from protruding features and will be easily decontaminated.	The intent is to minimize the number of protrusions by consideration during design and/or as a result of any modifications to the packaging. Designer to do and shipper responsibility to ensure.	All the packagings evaluated meet the intent of this requirement.
(d) The outer layer of packaging will avoid, as far as practicable, pockets or crevices where water might collect.	The intent is for packaging design personnel to consider this aspect. Avoid designing a packaging that provides cavities to collect water, which could spill during transport or handling, or could promote rusting and general deterioration of the packaging, possibly in locations difficult to detect. Designer to do and shipper responsibility to ensure.	All the packagings evaluated meet the intent of this requirement. A newly designed package should consider this requirement.
(e) Each feature that is added to the package will not reduce the safety of the package.	As an example, a canvas cover placed over a package for protection against the rain must not adversely affect heat transfer requirements. Shipper responsibility to ensure.	This is a shipper responsibility because the regulation addresses items added to the packaging that was already evaluated. The Stagecoach packaging was tested with and without a pallet banded into place. The pallet is a feature that may be added to the package. Three different pallet styles were tested, and had no interference with the packaging. Four metal bands are recommended due to the flexibility of the container.

(f) The package will be capable of withstanding the effects of any acceleration, vibration or vibration resonance that may arise under normal conditions of transport without any deterioration in the effectiveness of the closing devices on the various receptacles or in the integrity of the package as a whole and without loosening or unintentionally releasing the nuts, bolts, or other securing devices even after repeated use (see 173.24, 173.24a, and 173.24b).	Typically, one uses actual experience as a guide. If experience is not available, one normally uses a comparison to a similar packaging with an experience profile. If this isn't possible, vibration testing can be performed. The purpose of this section is to prevent the loosening of nuts, bolts, and containment devices under conditions incident to routine transportation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	The shipper must ensure the application of quality assurance necessary to achieve this requirement. Refer to Appendix G, Table G-7 for specific vibration testing information.
(g) The materials of construction of the packaging and any components or structure will be physically and chemically compatible with each other and with the package contents. The behavior of the packaging and the package contents under irradiation will be taken into account.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(h) All valves through which the package contents could escape will be protected against unauthorized operation.	Designer to do and shipper responsibility to ensure.	None of the packagings tested incorporate valves.
(i) For transport by air--	Designer, tester, and evaluator to do and shipper responsibility to ensure.	Shipper responsibility to ensure. The Stagecoach packaging is not evaluated nor recommended for air shipments. In addition, the Stagecoach is not authorized for use with liquid contents. The Modified WRAP 1-Trip, 208-L Drum assemblies are not authorized for air shipment, nor may this packaging transport liquid contents.
(1) The temperature of the accessible surfaces of the package will not exceed 50 °C (122 °F) at an ambient temperature of 38 °C (100 °F) with no account taken		

for insulation;		
(2) The integrity of containment will not be impaired if the package is exposed to ambient temperatures ranging from -40 °C (-40 °F) to +55 °C (131 °F); and		
(3) Packages containing liquid contents will be capable of withstanding, without leakage, an internal pressure that produces a pressure differential of not less than 95 kPa (13.8 lb/in^2).		

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Table E-1. Steel Drums--Compliance with Additional Design Requirements for Type A Packages (49 CFR 173.412). HM-169A (effective April 1, 1996).

Regulatory requirement	Action required/by whom	Packaging category--steel drums
In addition to meeting the general design requirements prescribed in 173.410, each Type A packaging shall be designed so that--		
(a) 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 closed transport vehicles in exclusive use, the cargo compartment, instead of the individual packages, may be sealed.	For this requirement, the package designer may need to be skilled and creative. This is especially true for packages such as fiberboard cartons and wooden boxes. A padlock is not effective as a security seal. It is not possible with most types of padlocks to ascertain if they have been illicitly opened. One acceptable approach toward meeting this requirement is serially numbered lead-wire seals, or, in the case of fiberboard packages, a tape of sufficient adhesive strength to damage the fiberboard upon removal. Designer to do and shipper responsibility to ensure.	There are acceptable approaches to compliance for all evaluated packagings. It is the shipper's responsibility to ensure compliance with this requirement.
(b) The smallest external dimension of the package is not less than 10 centimeters (4 inches).	Designer to do and shipper responsibility to ensure.	As shown in the figures and as given in the packaging descriptions in Section 2.0, all packagings meet this requirement.
(c) Containment and shielding is maintained during transportation and storage in a	This does not mean any of the tests must necessarily be performed at the temperature extremes. Note that the regulations [49 CFR	Metals used in these drums will not become excessively brittle at -40 °C and all

temperature range of -40 °C (-40 °F) to 70 °C (158 °F). Special attention shall be given to liquid contents and to the potential degradation of the packaging materials within the temperature range.	173.461(b)] allow the assumption that the packaging is in equilibrium at 38 °C (100 ° F prior to testing. One must evaluate the packaging components with respect to behavior at the temperature extremes under conditions incidental to transportation (i.e., the jiggles, bounces, and bumps normally encountered in transportation). Gaskets and packaging components need to be evaluated to determine if they will become excessively brittle at -40 °C. This may be accomplished by actual testing, referring to property of material tables, obtaining data from manufacturers, etc. Theshipper must consider such things as freezing of liquid contents and evaluate the effect to ensure continued containment integrity. The shipper must also consider the buildup of pressure at elevated temperatures and ensure continued containment. Designer, tester, and evaluator to do and shipper responsibility to ensure.	gaskets used also meet this requirement. None of these packagings are authorized for liquids, so freezing of contents is not a concern. Temperatures of +70 °C will not result in any significant decrease in containment integrity.
(d) The packaging must include 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 Class 7 (radioactive) material, as demonstrated in accordance with 173.469, may be considered as a component of the containment system. If the containment system forms a separate unit of the package, it must be securely closed by a positive fastening device that is independent of any other part of the package.	Screw-type closures can qualify. Friction fit normally does not qualify. Security clips on cans could be acceptable. However, one cannot depend on friction alone. Designer, tester, and evaluator to do and shipper responsibility to ensure.	All packagings evaluated meet this requirement, as shown on the figures or in the packaging descriptions in Section 2.0.
(e) 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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(f) The containment system will retain its radioactive contents under the reduction of ambient pressure to 25 kPa (3.6 pounds per square inch).	The containment system is defined as the components intended to retain the radioactive contents during transportation. Thus, one starts by identifying the containment system. The radioactive	This analysis requires a more detailed description to provide adequate information. See **Table E-2.**

	contents must be completely retained in the containment system if the package is subjected to reduced pressure. A filtered packaging is possible as long as it can be demonstrated that the filtered package will retain the contents and that the filter is not susceptible to damage from any other tests. Caution should be exercised to ensure that the contents and internal packaging components (e.g., plastic boxes, etc.) will not effectively seal the filter during normal use. In cases where a pressure differential will not build up because of the free-flow through a filter, the requirement of demonstrating the retention of contents must still be met. For a package that breathes (does not hold 11.3 psi), such as a wooden box, one must demonstrate that, even with breathing, the contents will be retained. Otherwise, a separate inner containment capable of meeting the reduced pressure requirement is required. Designer, tester, and evaluator to do and shipper responsibility to ensure.	
(g) Each valve other than a pressure relief device, is provided with an enclosure to retain any leakage.	Designer to do and shipper responsibility to ensure.	None of these packagings has valves.
(h) 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 shield shall be securely closed or, by way of packaging design, ensure against escape of a containment component. One example is a package with Celotex* on top of a lead shield with a press-fit lid in which closure of the Celotex holds the lid in place. The shipper must make sure that under the tests prescribed in 49 CFR 173.465, there will be no rearrangement of the original containment/shield orientation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	None of these packagings has shielding as described.
(i) Failure of any tie-down attachment that is a structural part of the packaging, under both normal and accident conditions, must not impair the ability of the package to meet other requirements of this subpart.	Designer, tester, and evaluator to do and shipper responsibility to ensure.	None of these packagings has tie-down attachments as described.
(j) When evaluated against the performance requirements of this section and the tests specified in 173.465 or using		

any of the methods authorized by 173.461(a), the packaging will prevent--		
(1) Loss or dispersal of the radioactive contents; and	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) A significant increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test.	Consideration of the internal load and shifting of contents needs to be taken into account during transport. Designer, tester, and evaluator to do; shipper responsibility to ensure.	It is the shipper's responsibility to ensure that the amount of radiation 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 or because of shifting of the load [IAEA 1996, para. 646(b)].
(k) Each packaging designed for liquids will--		
(1) Be designed to provide for ullage to accommodate variations in temperature of the contents, dynamic effects and filling dynamics;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	None of these packagings are authorized for use in shipping liquids. Shipper responsibility to ensure.
(2) Meet the conditions prescribed in paragraph (j) of this section when subjected to the tests specified in 173.466 or evaluated against these tests by any of the methods authorized by 173.461(a); and	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(3) Either--		
(i) Have sufficient suitable absorbent material to absorb twice the volume of the liquid contents. The absorbent material must be compatible with the package contents and suitably positioned to contact the liquid in the event of leakage; or	Designer, tester, and evaluator to do; shipper responsibility to ensure.	None of these packagings are authorized for use in shipping liquids. Shipper responsibility to ensure.
(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 component in the event that the primary	Designer, tester, and evaluator to do; shipper responsibility to ensure.	None of these packagings are authorized for use in shipping liquids. Shipper responsibility to ensure.

inner component leaks.		
(l) Each package designed for gases, other than tritium not exceeding 40 TBq (1000 Ci) or nobel gases not exceeding the A_2 value appropriate for the noble gas, will be able to prevent loss or dispersal 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 173.461(a).	Designer, tester, and evaluator to do; shipper responsibility to ensure.	None of these packagings are authorized for use in shipping gases. Shipper responsibility to ensure.
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Table E-2. Steel Drums--"Reduced Pressure" Tests Summary.			
Steel drums in order of presentation in Section 2.0	Test analysis	Results	Comments
Myers Model G5501	None tested. Evaluation based on testing/analysis of DOT-17C and DOT-17H configurations by Mound Laboratory and Westinghouse Hanford Company. Refer to **DOE/RL 1996, Vol 1.**, Rev. 0.		
Myers Model 5526	None tested. Evaluation based on testing/analysis of DOT-17C and DOT-17H configurations by Mound Laboratory and Westinghouse Hanford Company. Refer to **DOE/RL 1996, Vol 1.**, Rev. 0.		

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Table E-3. Steel Boxes--Compliance with Additional Design Requirements for Type A Packages (49 CFR 173.412). HM-169A (effective April 1, 1996).

Regulatory requirement	Action required/by whom	Packaging category--steel boxes
In addition to meeting the general design requirements prescribed in 173.410, each Type A packaging shall be designed so that--		
(a) 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 closed transport vehicles in exclusive use, the cargo compartment, instead of the individual packages, may be sealed.	For this requirement, the package designer may need to be skilled and creative. This is especially true for packages such as fiberboard cartons and wooden boxes. A padlock is not effective as a security seal. It is not possible with most types of padlocks to ascertain if they have been illicitly opened. One acceptable approach toward meeting this requirement is serially numbered lead-wire seals, or, in the case of fiberboard packages, a tape of sufficient adhesive strength to damage the fiberboard upon removal. Designer to do and shipper responsibility to ensure.	There are acceptable approaches to compliance for all evaluated packagings. It is the shipper's responsibility to ensure compliance with this requirement.
(b) The smallest external dimension of the package is not less than 10 centimeters (4 inches).	Designer to do and shipper responsibility to ensure.	As shown in the figures and as given in the packaging descriptions in Section 3.0, all packagings meet this requirement.
(c) Containment and shielding is	This does not mean any of the tests	Metals used in these boxes

maintained during transportation and storage in a temperature range of -40 °C (-40 °F) to 70 °C (158 °F). Special attention shall be given to liquid contents and to the potential degradation of the packaging materials within the temperature range.	must necessarily be performed at the temperature extremes. Note that the regulations [49 CFR 173.461(b)] allow the assumption that the packaging is in equilibrium at 38 °C prior to testing. One must evaluate the packaging components with respect to behavior at the temperature extremes under conditions incidental to transportation (i.e., the jiggles, bounces, and bumps normally encountered in transportation). Gaskets and packaging components need to be evaluated to determine if they will become excessively brittle at -40 °F. This may be accomplished by actual testing, referring to property of material tables, obtaining data from manufacturers, etc. The shipper must consider such things as freezing of liquid contents and evaluate the effect to ensure continued containment integrity. The shipper must also consider the buildup of pressure at elevated temperatures and ensure continued containment. Designer, tester, and evaluator to do and shipper responsibility to ensure.	will not become excessively brittle at -40 °C and all gaskets used also meet this requirement. None of these packagings are authorized for liquids, so freezing of contents is not a concern. Temperatures of +70 °C will not result in any significant decrease in containment integrity.
(d) The packaging must include 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 Class 7 (radioactive) material, as demonstrated in accordance with 173.469, may be considered as a component of the containment system. If the containment system forms a separate unit of the package, it must be securely closed by a positive fastening device that is independent of any other part of the package.	Screw-type closures can qualify. Friction fit normally does not qualify. Security clips on cans could be acceptable. However, one cannot depend on friction alone. Designer, tester, and evaluator to do and shipper responsibility to ensure.	All packagings evaluated met this requirement, as shown on the figures or in the packaging descriptions in Section 3.0.
(e) 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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

radiolysis.		
(f) The containment system will retain its radioactive contents under the reduction of ambient pressure to 25 kPa (3.6 pounds per square inch).	The containment system is defined as the components intended to retain the radioactive contents during transportation. Thus, one starts by identifying the containment system. The radioactive contents must be completely retained in the containment system if the package is subjected to reduced pressure. A filtered packaging is possible as long as it can be demonstrated that the filtered package will retain the contents and that the filter is not susceptible to damage from any other tests. Caution should be exercised to ensure that the contents and internal packaging components (e.g., plastic boxes, etc.) will not effectively seal the filter during normal use. In cases where a pressure differential will not build up because of the free-flow through a filter, the requirement of demonstrating the retention of contents must still be met. For a package that breathes (does not hold 11.3 psi), such as a wooden box, one must demonstrate that, even with breathing, the contents will be retained. Otherwise, a separate inner containment capable of meeting the reduced pressure requirement is required. Designer, tester, and evaluator to do and shipper responsibility to ensure.	This analysis requires a more detailed description to provide adequate information. See Table E-4.
(g) Each valve other than a pressure relief device, is provided with an enclosure to retain any leakage.	Designer to do and shipper responsibility to ensure.	None of these packagings has valves.
(h) 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 shield shall be securely closed or, by way of packaging design, ensure against escape of a containment component. One example is a package with Celotex* on top of a lead shield with a press-fit lid in which closure of the Celotex holds the lid in place. The shipper must make sure that under the tests prescribed in 49 CFR 173.465, there will be no rearrangement of the original containment/shield orientation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	None of these packagings has shielding as described.
(i) Failure of any tie-down	Designer, tester, and evaluator to do	None of these packagings has

attachment that is a structural part of the packaging, under both normal and accident conditions, must not impair the ability of the package to meet other requirements of this subpart.	and shipper responsibility to ensure.	tie-down attachments as described.
(j) When evaluated against the performance requirements of this section and the tests specified in 173.465 or using any of the methods authorized by 173.461(a), the packaging will prevent--		
(1) Loss or dispersal of the radioactive contents; and	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) A significant increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test.	Consideration of the internal load and shifting of contents needs to be taken into account during transport. Designer, tester, and evaluator to do; shipper responsibility to ensure.	It is the shipper's responsibility to ensure that the amount of radiation 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 or because of shifting of the load [IAEA 1996, para. 646(b)].
(k) Each packaging designed for liquids will--		
(1) Be designed to provide for ullage to accommodate variations in temperature of the contents, dynamic effects and filling dynamics;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	None of these packagings are authorized for use in shipping liquids. Shipper responsibility to ensure.
(2) Meet the conditions prescribed in paragraph (j) of this section when subjected to the tests specified in 173.466 or evaluated against these tests by any of the methods authorized by 173.461(a); and	Designer, tester, and evaluator to do; shipper responsibility to ensure.	None of these packagings are authorized for use in shipping liquids. Shipper responsibility to ensure.
(3) Either--		
(i) Have sufficient suitable absorbent material to absorb twice the volume of the liquid contents. The absorbent material must be compatible with the package contents and suitably positioned to contact the liquid	Designer, tester, and evaluator to do; shipper responsibility to ensure.	None of these packagings are authorized for use in shipping liquids. Shipper responsibility to ensure.

in the event of leakage; 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 component in the event that the primary inner component leaks.	Designer, tester, and evaluator to do; shipper responsibility to ensure.	None of these packagings are authorized for use in shipping liquids. Shipper responsibility to ensure.
(l) Each package designed for gases, other than tritium not exceeding 40 TBq (1000 Ci) or nobel gases not exceeding the A_2 value appropriate for the noble gas, will be able to prevent loss or dispersal 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 173.461(a).	Designer, tester, and evaluator to do; shipper responsibility to ensure.	None of these packagings are authorized for use in shipping gases. Shipper responsibility to ensure.
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Table E-4. Steel Boxes--"Reduced Pressure" Tests Summary.			
Steel boxes in order of presentation in Section 3.0	**Test analysis**	**Results**	**Comments**
M-100 Container (M-101/7A/12/90)	**None tested. Because this is a filtered packaging, a pressure differential of this magnitude should not be achieved under conditions normal to transportation.**		
TRUPACT-II SWB	**None tested. The SWB requires a minimum of 2 filters or a maximum of 4 filters. The shipper is to ensure that the number of filters installed is adequate to prevent the build up of a pressure differential for the contents being shipped. Because this is a filtered packaging, a pressure differential of this magnitude should not be achieved under conditions normal to transportation.**		

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Table E-5. Wooden Boxes--Compliance with Additional Design Requirements for Type A Packages (49 CFR 173.412). HM-169A (effective April 1, 1996).

Regulatory requirement	Action required/by whom	Packaging category--wooden boxes
In addition to meeting the general design requirements prescribed in 173.410, each Type A packaging shall be designed so that--		
(a) 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 closed transport vehicles in exclusive use, the cargo compartment, instead of the individual packages, may	For this requirement, the package designer may need to be skilled and creative. This is especially true for packages such as fiberboard cartons and wooden boxes. A padlock is not effective as a security seal. It is not possible with most types of padlocks to ascertain if they have been illicitly opened. One acceptable approach toward meeting this requirement is serially numbered lead-wire seals, or, in the case of fiberboard packages, a tape of sufficient adhesive strength to damage the fiberboard upon removal. Designer to do and shipper responsibility to ensure.	There are acceptable approaches to compliance for all evaluated packagings. It is the shipper's responsibility to ensure compliance with this requirement.

be sealed.		
(b) The smallest external dimension of the package is not less than 10 centimeters (4 inches).	Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(c) Containment and shielding is maintained during transportation and storage in a temperature range of -40 °C (-40 °F) to 70 °C (158 °F). Special attention shall be given to liquid contents and to the potential degradation of the packaging materials within the temperature range.	This does not mean any of the tests must necessarily be performed at the temperature extremes. Note that the regulations [49 CFR 173.461(b)] allow the assumption that the packaging is in equilibrium at 38 °C prior to testing. One must evaluate the packaging components with respect to behavior at the temperature extremes under conditions incidental to transportation (i.e., the jiggles, bounces, and bumps normally encountered in transportation). Gaskets and packaging components need to be evaluated to determine if they will become excessively brittle at -40 °F. This may be accomplished by actual testing, referring to property of material tables, obtaining data from manufacturers, etc. The shipper must consider such things as freezing of liquid contents and evaluate the effect to ensure continued containment integrity. The shipper must also consider the buildup of pressure at elevated temperatures and ensure continued containment. Designer, tester, and evaluator to do and shipper responsibility to ensure.	The materials (wood, caulking, metal strips, nails, gaskets, etc.) would not become excessively brittle at -40 °C and all gaskets used also meet this requirement. None of these packagings are authorized for liquids, so freezing of contents is not a concern. Temperatures of +70 °C will not result in any significant decrease in containment integrity, as shown in property of materials tables.
(d) The packaging must include 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.	Screw-type closures can qualify. Friction fit normally does not qualify. Security clips on cans could be acceptable. However, one cannot depend on friction alone. Designer, tester, and evaluator to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

Special form Class 7 (radioactive) material, as demonstrated in accordance with 173.469, may be considered as a component of the containment system. If the containment system forms a separate unit of the package, it must be securely closed by a positive fastening device that is independent of any other part of the package.		
(e) 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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(f) The containment system will retain its radioactive contents under the reduction	The containment system is defined as the components intended to retain the radioactive contents during transportation. Thus, one starts by identifying the containment system. The radioactive contents must be completely retained in the containment system if the package is subjected to reduced pressure.	This analysis requires a more detailed description to provide adequate information. See Table E-6.

of ambient pressure to 25 kPa (3.6 pounds per square inch).	A filtered packaging is possible as long as it can be demonstrated that the filtered package will retain the contents and that the filter is not susceptible to damage from any other tests. Caution should be exercised to ensure that the contents and internal packaging components (e.g., plastic boxes, etc.) will not effectively seal the filter during normal use. In cases where a pressure differential will not build up because of the free-flow through a filter, the requirement of demonstrating the retention of contents must still be met. For a package that breathes (does not hold 11.3 psi), such as a wooden box, one must demonstrate that, even with breathing, the contents will be retained. Otherwise, a separate inner containment capable of meeting the reduced pressure requirement is required. Designer, tester, and evaluator to do and shipper responsibility to ensure.	
(g) Each valve other than a pressure relief device, is provided with an enclosure to retain any leakage.	Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(h) 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 shield shall be securely closed or, by way of packaging design, ensure against escape of a containment component. One example is a package with Celotex* on top of a lead shield with a press-fit lid in which closure of the Celotex holds the lid in place. The shipper must make sure that under the tests prescribed in 49 CFR 173.465, there will be no rearrangement of the original containment/shield orientation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(i) Failure of any tie-down attachment that is a structural part of the packaging, under both	Designer, tester, and evaluator to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

normal and accident conditions, must not impair the ability of the package to meet other requirements of this subpart.		
(j) When evaluated against the performance requirements of this section and the tests specified in 173.465 or using any of the methods authorized by 173.461(a), the packaging will prevent--		
(1) Loss or dispersal of the radioactive contents; and	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) A significant increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test.	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(k) Each packaging designed for liquids will--		
(1) Be designed to provide for ullage to accommodate	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

variations in temperature of the contents, dynamic effects and filling dynamics;		
(2) Meet the conditions prescribed in paragraph (j) of this section when subjected to the tests specified in 173.466 or evaluated against these tests by any of the methods authorized by 173.461(a); and	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(3) Either--		
(i) Have sufficient suitable absorbent material to absorb twice the volume of the liquid contents. The absorbent material must be compatible with the package contents and suitably positioned to contact the liquid in the event of leakage; or	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) Have a containment system composed of primary inner	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

and secondary outer containment components designed to assure retention of the liquid contents within the secondary outer component in the event that the primary inner component leaks.		
(l) Each package designed for gases, other than tritium not exceeding 40 TBq (1000 Ci) or nobel gases not exceeding the A_2 value appropriate for the noble gas, will be able to prevent loss or dispersal 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 173.461(a).	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table E-6. Wooden Boxes--"Reduced Pressure" Tests Summary.

Wooden boxes in order of presentation in Section 4.0	Model/size	Test analysis	Results	Comments

NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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Table E-7. Fiberboard Containers--Compliance with Additional Design Requirements for Type A Packages (49 CFR 173.412). HM-169A (effective April 1, 1996)

Regulatory requirement	Action required/by whom	Packaging category--fiberboard containers
In addition to meeting the general design requirements prescribed in 173.410, each Type A packaging shall be designed so that--		
(a) 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 closed transport vehicles in exclusive use, the cargo compartment, instead of the individual packages, may	For this requirement, the package designer may need to be skilled and creative. This is especially true for packages such as fiberboard cartons and wooden boxes. A padlock is not effective as a security seal. It is not possible with most types of padlocks to ascertain if they have been illicitly opened. One acceptable approach toward meeting this requirement is serially numbered lead-wire seals, or, in the case of fiberboard packages, a tape of sufficient adhesive strength to damage the fiberboard upon removal. Designer to do and shipper responsibility to ensure.	There are acceptable approaches to compliance for all evaluated packagings. It is the shipper's responsibility to ensure compliance with this requirement.

be sealed.		
(b) The smallest external dimension of the package is not less than 10 centimeters (4 inches).	Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(c) Containment and shielding is maintained during transportation and storage in a temperature range of -40 °C (-40 °F) to 70 °C (158 °F). Special attention shall be given to liquid contents and to the potential degradation of the packaging materials within the temperature range.	This does not mean any of the tests must necessarily be performed at the temperature extremes. Note that the regulations [49 CFR 173.461(b)] allow the assumption that the packaging is in equilibrium at 38 °C prior to testing. One must evaluate the packaging components with respect to behavior at the temperature extremes under conditions incidental to transportation (i.e., the jiggles, bounces, and bumps normally encountered in transportation). Gaskets and packaging components need to be evaluated to determine if they will become excessively brittle at -40 °F. This may be accomplished by actual testing, referring to property of material tables, obtaining data from manufacturers, etc. The shipper must consider such things as freezing of liquid contents and evaluate the effect to ensure continued containment integrity. The shipper must also consider the buildup of pressure at elevated temperatures and ensure continued containment. Designer, tester, and evaluator to do and shipper responsibility to ensure.	The materials (fiberboard, metal strips, nails, gaskets, etc.) will not become excessively brittle at -40 °C and all gaskets used also meet this requirement. None of these packagings are authorized for liquids, so freezing of contents is not a concern. Temperatures of +70 °C will not result in any significant decrease in containment integrity, as shown in property of materials tables.
(d) The packaging must include 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.	Screw-type closures can qualify. Friction fit normally does not qualify. Security clips on cans could be acceptable. However, one cannot depend on friction alone. Designer, tester, and evaluator to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

Special form Class 7 (radioactive) material, as demonstrated in accordance with 173.469, may be considered as a component of the containment system. If the containment system forms a separate unit of the package, it must be securely closed by a positive fastening device that is independent of any other part of the package.		
(e) 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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(f) The containment system will retain its radioactive contents under the reduction	The containment system is defined as the components intended to retain the radioactive contents during transportation. Thus, one starts by identifying the containment system. The radioactive contents must be completely retained in the containment system if the package is subjected to reduced pressure. A	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

of ambient pressure to 25 kPa (3.6 pounds per square inch).	filtered packaging is possible as long as it can be demonstrated that the filtered package will retain the contents and that the filter is not susceptible to damage from any other tests. Caution should be exercised to ensure that the contents and internal packaging components (e.g., plastic boxes, etc.) will not effectively seal the filter during normal use. In cases where a pressure differential will not build up because of the free-flow through a filter, the requirement of demonstrating the retention of contents must still be met. For a package that breathes (does not hold 11.3 psi), such as a wooden box, one must demonstrate that, even with breathing, the contents will be retained. Otherwise, a separate inner containment capable of meeting the reduced pressure requirement is required. Designer, tester, and evaluator to do and shipper responsibility to ensure.	
(g) Each valve other than a pressure relief device, is provided with an enclosure to retain any leakage.	Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(h) 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 shield shall be securely closed or, by way of packaging design, ensure against escape of a containment component. One example is a package with Celotex* on top of a lead shield with a press-fit lid in which closure of the Celotex holds the lid in place. The shipper must make sure that under the tests prescribed in 49 CFR 173.465, there will be no rearrangement of the original containment/shield orientation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(i) Failure of any tie-down attachment that is a structural part of the packaging, under both	Designer, tester, and evaluator to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

normal and accident conditions, must not impair the ability of the package to meet other requirements of this subpart.		
(j) When evaluated against the performance requirements of this section and the tests specified in 173.465 or using any of the methods authorized by 173.461(a), the packaging will prevent--		
(1) Loss or dispersal of the radioactive contents; and	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) A significant increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test.	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(k) Each packaging designed for liquids will--		
(1) Be designed to provide for ullage to accommodate	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

variations in temperature of the contents, dynamic effects and filling dynamics;		
(2) Meet the conditions prescribed in paragraph (j) of this section when subjected to the tests specified in 173.466 or evaluated against these tests by any of the methods authorized by 173.461(a); and	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(3) Either--		
(i) Have sufficient suitable absorbent material to absorb twice the volume of the liquid contents. The absorbent material must be compatible with the package contents and suitably positioned to contact the liquid in the event of leakage; or	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) Have a containment system composed of primary inner	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

and secondary outer containment components designed to assure retention of the liquid contents within the secondary outer component in the event that the primary inner component leaks.		
(l) Each package designed for gases, other than tritium not exceeding 40 TBq (1000 Ci) or nobel gases not exceeding the A_2 value appropriate for the noble gas, will be able to prevent loss or dispersal 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 173.461(a).	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table E-8. UF_6 Cylinders--Compliance with Additional Design Requirements for Type A Packages (49 CFR 173.412). HM-169A (effective April 1, 1996).

Regulatory requirement	Action required/by whom	Packaging category--UF_6 Cylinders
In addition to meeting the general design requirements prescribed in 173.410, each Type A packaging shall be designed so that--		
(a) 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 closed transport vehicles in exclusive use, the cargo compartment, instead of the individual	For this requirement, the package designer may need to be skilled and creative. This is especially true for packages such as fiberboard cartons and wooden boxes. A padlock is not effective as a security seal. It is not possible with most types of padlocks to ascertain if they have been illicitly opened. One acceptable approach toward meeting this requirement is serially numbered lead-wire seals, or, in the case of fiberboard packages, a tape of sufficient adhesive strength to damage the fiberboard upon removal. Designer to do and shipper responsibility to ensure.	There are acceptable approaches to compliance for all evaluated packagings. It is the shipper's responsibility to ensure compliance with this requirement.

packages, may be sealed.		
(b) The smallest external dimension of the package is not less than 10 centimeters (4 inches).	Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(c) Containment and shielding is maintained during transportation and storage in a temperature range of -40 °C (-40 °F) to 70 °C (158 °F). Special attention shall be given to liquid contents and to the potential degradation of the packaging materials within the temperature range.	This does not mean any of the tests must necessarily be performed at the temperature extremes. Note that the regulations [49 CFR 173.461(b)] allow the assumption that the packaging is in equilibrium at 38 °C prior to testing. One must evaluate the packaging components with respect to behavior at the temperature extremes under conditions incidental to transportation (i.e., the jiggles, bounces, and bumps normally encountered in transportation). Gaskets and packaging components need to be evaluated to determine if they will become excessively brittle at -40 °F. This may be accomplished by actual testing, referring to property of material tables, obtaining data from manufacturers, etc. The shipper must consider such things as freezing of liquid contents and evaluate the effect to ensure continued containment integrity. The shipper must also consider the buildup of pressure at elevated temperatures and ensure continued containment. Designer, tester, and evaluator to do and shipper responsibility to ensure.	Metals used in these cylinders will not become excessively brittle at -40 °C and all gaskets used also meet this requirement. None of these packagings are authorized for liquids, so freezing of contents is not a concern. Temperatures of +70 °C will not result in any significant decrease in containment integrity, as shown in property of materials tables.
(d) The packaging must include 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	Screw-type closures can qualify. Friction fit normally does not qualify. Security clips on cans could be acceptable. However, one cannot depend on friction alone. Designer, tester, and evaluator to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

transport. Special form Class 7 (radioactive) material, as demonstrated in accordance with 173.469, may be considered as a component of the containment system. If the containment system forms a separate unit of the package, it must be securely closed by a positive fastening device that is independent of any other part of the package.		
(e) 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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(f) The containment system will retain its radioactive contents under	The containment system is defined as the components intended to retain the radioactive contents during transportation. Thus, one starts by identifying the containment system. The radioactive contents must be completely retained in the containment system if the	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

the reduction of ambient pressure to 25 kPa (3.6 pounds per square inch).	package is subjected to reduced pressure. A filtered packaging is possible as long as it can be demonstrated that the filtered package will retain the contents and that the filter is not susceptible to damage from any other tests. Caution should be exercised to ensure that the contents and internal packaging components (e.g., plastic boxes, etc.) will not effectively seal the filter during normal use. In cases where a pressure differential will not build up because of the free-flow through a filter, the requirement of demonstrating the retention of contents must still be met. For a package that breathes (does not hold 11.3 psi), such as a wooden box, one must demonstrate that, even with breathing, the contents will be retained. Otherwise, a separate inner containment capable of meeting the reduced pressure requirement is required. Designer, tester, and evaluator to do and shipper responsibility to ensure.	
(g) Each valve other than a pressure relief device, is provided with an enclosure to retain any leakage.	Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(h) 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 shield shall be securely closed or, by way of packaging design, ensure against escape of a containment component. One example is a package with Celotex* on top of a lead shield with a press-fit lid in which closure of the Celotex holds the lid in place. The shipper must make sure that under the tests prescribed in 49 CFR 173.465, there will be no rearrangement of the original containment/shield orientation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(i) Failure of any tie-down attachment that is a structural part of the packaging,	Designer, tester, and evaluator to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

under both normal and accident conditions, must not impair the ability of the package to meet other requirements of this subpart.		
(j) When evaluated against the performance requirements of this section and the tests specified in 173.465 or using any of the methods authorized by 173.461(a), the packaging will prevent--		
(1) Loss or dispersal of the radioactive contents; and	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) A significant increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test.	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(k) Each packaging designed for liquids will--		
(1) Be designed to provide for ullage to	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

accommodate variations in temperature of the contents, dynamic effects and filling dynamics;		
(2) Meet the conditions prescribed in paragraph (j) of this section when subjected to the tests specified in 173.466 or evaluated against these tests by any of the methods authorized by 173.461(a); and	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(3) Either--		
(i) Have sufficient suitable absorbent material to absorb twice the volume of the liquid contents. The absorbent material must be compatible with the package contents and suitably positioned to contact the liquid in the event of leakage; or	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) Have a containment system composed of	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

primary inner and secondary outer containment components designed to assure retention of the liquid contents within the secondary outer component in the event that the primary inner component leaks.		
(l) Each package designed for gases, other than tritium not exceeding 40 TBq (1000 Ci) or nobel gases not exceeding the A_2 value appropriate for the noble gas, will be able to prevent loss or dispersal 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 173.461(a).	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table E-9. Calculated Safety Factor for UF_6 Cylinders.

Cylinder	Weight (lb)	Calculated Safety Factor	Result
NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.			

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Table E-10. Liquid and Gas Packages--Compliance with Additional Design Requirements for Type A Packages (49 CFR 173.412). HM-169A (effective April 1, 1996).

Regulatory requirement	Action required/by whom	Packaging category--liquid and gas packagings
In addition to meeting the general design requirements prescribed in 173.410, each Type A packaging shall be designed so that--		
(a) 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 closed transport vehicles in exclusive use, the cargo compartment, instead of the individual packages, may	For this requirement, the package designer may need to be skilled and creative. This is especially true for packages such as fiberboard cartons and wooden boxes. A padlock is not effective as a security seal. It is not possible with most types of padlocks to ascertain if they have been illicitly opened. One acceptable approach toward meeting this requirement is serially numbered lead-wire seals, or, in the case of fiberboard packages, a tape of sufficient adhesive strength to damage the fiberboard upon removal. Designer to do and shipper responsibility to ensure.	There are acceptable approaches to compliance for all evaluated packagings. It is the shipper's responsibility to ensure compliance with this requirement.

be sealed.		
(b) The smallest external dimension of the package is not less than 10 centimeters (4 inches).	Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(c) Containment and shielding is maintained during transportation and storage in a temperature range of -40 °C (-40 °F) to 70 °C (158 °F). Special attention shall be given to liquid contents and to the potential degradation of the packaging materials within the temperature range.	This does not mean any of the tests must necessarily be performed at the temperature extremes. Note that the regulations [49 CFR 173.461(b)] allow the assumption that the packaging is in equilibrium at 38 °C prior to testing. One must evaluate the packaging components with respect to behavior at the temperature extremes under conditions incidental to transportation (i.e., the jiggles, bounces, and bumps normally encountered in transportation). Gaskets and packaging components need to be evaluated to determine if they will become excessively brittle at -40 °F. This may be accomplished by actual testing, referring to property of material tables, obtaining data from manufacturers, etc. The shipper must consider such things as freezing of liquid contents and evaluate the effect to ensure continued containment integrity. The shipper must also consider the buildup of pressure at elevated temperatures and ensure continued containment. Designer, tester, and evaluator to do and shipper responsibility to ensure.	The materials (wood, caulking, metal strips, nails, gaskets, etc.) will not become excessively brittle at -40 °C. Temperatures of +70 °C will not result in any significant decrease in containment integrity, as shown in property of materials table. The shipper must ensure that, if the contents freeze, no rupture of the container will occur. In addition, the shipper must evaluate the potential for pressure buildup at elevated temperatures.
(d) The packaging must include 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.	Screw-type closures can qualify. Friction fit normally does not qualify. Security clips on cans could be acceptable. However, one cannot depend on friction alone. Designer, tester, and evaluator to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

Special form Class 7 (radioactive) material, as demonstrated in accordance with 173.469, may be considered as a component of the containment system. If the containment system forms a separate unit of the package, it must be securely closed by a positive fastening device that is independent of any other part of the package.		
(e) 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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(f) The containment system will retain its radioactive contents under the reduction	The containment system is defined as the components intended to retain the radioactive contents during transportation. Thus, one starts by identifying the containment system. The radioactive contents must be completely retained in the containment system if the package is subjected to reduced pressure. A	This analysis requires a more detailed description to provide adequate information. See Table E-11.

of ambient pressure to 25 kPa (3.6 pounds per square inch).	filtered packaging is possible as long as it can be demonstrated that the filtered package will retain the contents and that the filter is not susceptible to damage from any other tests. Caution should be exercised to ensure that the contents and internal packaging components (e.g., plastic boxes, etc.) will not effectively seal the filter during normal use. In cases where a pressure differential will not build up because of the free-flow through a filter, the requirement of demonstrating the retention of contents must still be met. For a package that breathes (does not hold 11.3 psi), such as a wooden box, one must demonstrate that, even with breathing, the contents will be retained. Otherwise, a separate inner containment capable of meeting the reduced pressure requirement is required. Designer, tester, and evaluator to do and shipper responsibility to ensure.	
(g) Each valve other than a pressure relief device, is provided with an enclosure to retain any leakage.	Designer to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(h) 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 shield shall be securely closed or, by way of packaging design, ensure against escape of a containment component. One example is a package with Celotex* on top of a lead shield with a press-fit lid in which closure of the Celotex holds the lid in place. The shipper must make sure that under the tests prescribed in 49 CFR 173.465, there will be no rearrangement of the original containment/shield orientation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	The packagings meeting this criterion are discussed in Table E-12.
(i) Failure of any tie-down attachment that is a structural part of the packaging, under both	Designer, tester, and evaluator to do and shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

normal and accident conditions, must not impair the ability of the package to meet other requirements of this subpart.		
(j) When evaluated against the performance requirements of this section and the tests specified in 173.465 or using any of the methods authorized by 173.461(a), the packaging will prevent--		
(1) Loss or dispersal of the radioactive contents; and	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) A significant increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test.	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(k) Each packaging designed for liquids will--		
(1) Be designed to provide for ullage to accommodate	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

variations in temperature of the contents, dynamic effects and filling dynamics;		
(2) Meet the conditions prescribed in paragraph (j) of this section when subjected to the tests specified in 173.466 or evaluated against these tests by any of the methods authorized by 173.461(a); and	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(3) Either--		
(i) Have sufficient suitable absorbent material to absorb twice the volume of the liquid contents. The absorbent material must be compatible with the package contents and suitably positioned to contact the liquid in the event of leakage; or	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) Have a containment system composed of primary inner	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

and secondary outer containment components designed to assure retention of the liquid contents within the secondary outer component in the event that the primary inner component leaks.		
(l) Each package designed for gases, other than tritium not exceeding 40 TBq (1000 Ci) or nobel gases not exceeding the A_2 value appropriate for the noble gas, will be able to prevent loss or dispersal 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 173.461(a).	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table E-11. Liquid and Gas Packagings--"Reduced Pressure" Tests Summary.

Liquid and gas packaging in order of presentation in Section 7.0	Model/Size	Containment System	Test/Analysis	Results

NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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Table E-12. Packages Meeting 49 CFR 173.412(k) Criterion.

Liquid and gas packaging in order of presentation in Section 7.0	Containment System	Analysis	Results

NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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Table E-13. Miscellaneous Packagings--Compliance with Additional Design Requirements for Type A Packages (49 CFR 173.412). HM-169A (effective April 1, 1996).		
Regulatory requirement	**Action required/by whom**	**Packaging category--miscellaneous packagings**
In addition to meeting the general design requirements prescribed in 173.410, each Type A packaging shall be designed so that--		
(a) 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 closed transport vehicles in exclusive use, the cargo compartment, instead of the individual packages, may be sealed.	For this requirement, the package designer may need to be skilled and creative. This is especially true for packages such as fiberboard cartons and wooden boxes. A padlock is not effective as a security seal. It is not possible with most types of padlocks to ascertain if they have been illicitly opened. One acceptable approach toward meeting this requirement is serially numbered lead-wire seals, or, in the case of fiberboard packages, a tape of sufficient adhesive strength to damage the fiberboard upon removal. Designer to do and shipper responsibility to ensure.	There are acceptable approaches to compliance for all evaluated packagings. It is the shipper's responsibility to ensure compliance with this requirement.
(b) The smallest external dimension of the package is not less than 10 centimeters (4 inches).	Designer to do and shipper responsibility to ensure.	As shown in the figures and as given in the packaging descriptions in Section 8.0, all packagings meet this requirement.
(c) Containment and shielding is maintained during transportation and storage in a temperature range of -40 °C (-40 °F) to 70 °C (158 °F). Special attention shall be given to liquid contents and to the potential degradation of the	This does not mean any of the tests must necessarily be performed at the temperature extremes. Note that the regulations [49 CFR 173.461(b)] allow the assumption that the packaging is in equilibrium at 38	The materials of construction for the packagings identified in Section 8.0 will not become excessively brittle at -40 °C. None of these packagings are authorized for liquids, so freezing of contents is not a concern.

packaging materials within the temperature range.	°C prior to testing. One must evaluate the packaging components with respect to behavior at the temperature extremes under conditions incidental to transportation (i.e., the jiggles, bounces, and bumps normally encountered in transportation). Gaskets and packaging components need to be evaluated to determine if they will become excessively brittle at -40 °F. This may be accomplished by actual testing, referring to property of material tables, obtaining data from manufacturers, etc. Theshipper must consider such things as freezing of liquid contents and evaluate the effect to ensure continued containment integrity. The shipper must also consider the buildup of pressure at elevated temperatures and ensure continued containment. Designer, tester, and evaluator to do and shipper responsibility to ensure.	Temperatures of +70 °C will not result in any significant decrease in containment integrity.
(d) The packaging must include 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 Class 7 (radioactive) material, as demonstrated in accordance with 173.469, may be considered as a component of the containment system. If the containment system forms a separate unit of the package, it must be securely closed by a positive fastening device that is independent of any other part of the package.	Screw-type closures can qualify. Friction fit normally does not qualify. Security clips on cans could be acceptable. However, one cannot depend on friction alone. Designer, tester, and evaluator to do and shipper responsibility to ensure.	All packagings evaluated meet this requirement, as shown in the figures or in the packaging descriptions in Section 8.0.
(e) 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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

(f) The containment system will retain its radioactive contents under the reduction of ambient pressure to 25 kPa (3.6 pounds per square inch).	The containment system is defined as the components intended to retain the radioactive contents during transportation. Thus, one starts by identifying the containment system. The radioactive contents must be completely retained in the containment system if the package is subjected to reduced pressure. A filtered packaging is possible as long as it can be demonstrated that the filtered package will retain the contents and that the filter is not susceptible to damage from any other tests. Caution should be exercised to ensure that the contents and internal packaging components (e.g., plastic boxes, etc.) will not effectively seal the filter during normal use. In cases where a pressure differential will not build up because of the free-flow through a filter, the requirement of demonstrating the retention of contents must still be met. For a package that breathes (does not hold 11.3 psi), such as a wooden box, one must demonstrate that, even with breathing, the contents will be retained. Otherwise, a separate inner containment capable of meeting the reduced pressure requirement is required. Designer, tester, and evaluator to do and shipper responsibility to ensure.	This analysis requires a more detailed description to provide adequate information. See Table E-14.
(g) Each valve other than a pressure relief device, is provided with an enclosure to retain any leakage.	Designer to do and shipper responsibility to ensure.	None of these packagings has valves.
(h) 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 shield shall be securely closed or, by way of packaging design, ensure against escape of a containment component. One example is a package with Celotex* on top of a lead shield with a press-fit lid in which closure of the Celotex holds the lid in place. The shipper must make sure that under the tests	None of these packagings has shielding as described.

	prescribed in 49 CFR 173.465, there will be no rearrangement of the original containment/shield orientation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	
(i) Failure of any tie-down attachment that is a structural part of the packaging, under both normal and accident conditions, must not impair the ability of the package to meet other requirements of this subpart.	Designer, tester, and evaluator to do and shipper responsibility to ensure.	None of these packagings has tie-down attachments as described.
(j) When evaluated against the performance requirements of this section and the tests specified in 173.465 or using any of the methods authorized by 173.461(a), the packaging will prevent--		
(1) Loss or dispersal of the radioactive contents; and	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) A significant increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test.	Designer, tester, and evaluator to do; shipper responsibility to ensure.	It is the shipper's responsibility to ensure that the amount of radiation, 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 or because of shifting of the load [TS-R-1 (ST-1, Revised), para. 646(b)].
(k) Each packaging designed for liquids will--		
(1) Be designed to provide for ullage to accommodate variations in temperature of the contents, dynamic effects and filling dynamics;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	None of these packagings are authorized for use in shipping liquids. Shipper responsibility to ensure.
(2) Meet the conditions prescribed in paragraph (j) of this section when subjected to the tests specified in 173.466 or evaluated against these tests by any of the methods authorized by 173.461(a); and	Designer, tester, and evaluator to do; shipper responsibility to ensure.	None of these packagings are authorized for use in shipping liquids. Shipper responsibility to ensure.
(3) Either--		

(i) Have sufficient suitable absorbent material to absorb twice the volume of the liquid contents. The absorbent material must be compatible with the package contents and suitably positioned to contact the liquid in the event of leakage; or	Designer, tester, and evaluator to do; shipper responsibility to ensure.	None of these packagings are authorized for use in shipping liquids. Shipper responsibility to ensure.
(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 component in the event that the primary inner component leaks.	Designer, tester, and evaluator to do; shipper responsibility to ensure.	None of these packagings are authorized for use in shipping liquids. Shipper responsibility to ensure.
(l) Each package designed for gases, other than tritium not exceeding 40 TBq (1000 Ci) or nobel gases not exceeding the A_2 value appropriate for the noble gas, will be able to prevent loss or dispersal 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 173.461(a).	Designer, tester, and evaluator to do; shipper responsibility to ensure.	None of these packagings are authorized for use in shipping liquids. Shipper responsibility to ensure.
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Table E-14. Miscellaneous Packagings Containment System Analysis.			
Miscellaneous packagings in order of presentation in Section 8.0	**Test Analysis**	**Results**	**Comments**
Stagecoach Model 320162, V1.1	None tested. The Stagecoach, as closed in the assembly instructions, is not hermetically sealed. The design features a containment system with tamperproof seal. The containment system consists of (1) An inner 6-mil liner bag that contains the contents and is closed by two plastic ties; (2) An inner duffel closure design that includes a sewn-on tie; and (3) The body of the container which is made from corrugated fiberboard that is encapsulated in a woven polypropylene fabric. Two layers of polypropylene fabric make up the external sidewall and cover surface of the container, and one layer of polypropylene fabric makes up the internal sidewall and cover surface of the container. The base of the Stagecoach consists of two layers of polypropylene fabric. There is no corrugated fiberboard in the base. The cover of the container is stitched on one side. The cover overhangs three of the side walls by approximately 15.24 cm (6 in.) and contains grommets for securing to the package. Two wire ties and one plastic tamper-proof tie are provided which are inserted through the grommets in the cover and corresponding grommets in tabs that are stitched to the front body of the packaging. All seams of the Stagecoach are chain stitched. There are three rows of stitching. Although the Stagecoach cover is stitched along one side, and secured in place by ties, the cover should not be relied on to provide containment. It is reasonable to believe, based on common sense engineering evaluations, that if atmospheric pressure drops rapidly and/or substantially, the inner 6-mil polyethylene liner would experience a rupture or fissure. However, this type of pressure change would not result from normal atmospheric changes; it is the type of pressure change that could occur in air transportation. Air transport of the Stagecoach is not authorized. Additionally, the solid matter would be retained because of the inner duffel closure design. The multiple layers of fabric, including fiberboard, would also assist in providing containment for solid materials. It is the shipper's responsibility to ensure that the contents will not allow the escape of radioactive materials due to an equalization of pressure.		
Modified WRAP 1-Trip, 208-L	None conducted. Due to the incorporation of the filter into the external		

Drum	and internal lids, the packaging design will not hold pressure. The containment system for the Modified WRAP 1-Trip Drum, Assembly -010 consists of the drum, drumhead gasket, inner Neoprene gasket sheet, closure ring, nut, bolt, and NucFil*-013 filter. The containment system for Assembly -020 is the same. The addition of a 10-mil nylon-reinforced polyethylene bag enhances the design of the drum.
*NucFil is a registered trademark of Nuclear Filter Technology, Inc.	

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Table F-1. Water Spray Test Results for Steel Drums.

Specific packaging	Test/Analysis/Results
Myers Model G5501	None tested. Due to the materials of construction and design of the packaging, by comparison with performance of drums in **DOE/RL 1996, Vol. 1**, Rev. 0, this drum would meet this requirement.
Myers Model 5526	None tested. Due to the materials of construction and design of the packaging, by comparison with performance of drums in **DOE/RL 1996, Vol. 1**, Rev. 0, this drum would meet this requirement.

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Table F-2. Water Spray Test Results for Steel Boxes.

Specific packaging	Test/Analysis Results
M-100 Container (M-101/7A/12/90)	None tested. By evaluation and comparison with performance of steel boxes in DOE/RL 1996, Vol. 1, Rev. 0, this steel box is evaluated to meet this requirement.
TRUPACT-II SWB	The water spray test was conducted on the SWB prior to each of the Type A tests performed by Mound. In all cases the packagings passed the performance requirements. In addition, the box was tested empty to evaluate the potential inleakage of water. Test Unit No. 1 was tested and then opened and inspected for the presence of water. None was found. Pass.

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Table F-3. Water Spray Test Results for Wooden Boxes.

Specific packaging	Test/Analysis Results
NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.	

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Table F-4. Water Spray Test Results for Fiberboard Containers.

Specific packaging	Test/Analysis results
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Table F-5. Water Spray Test Results for UF_6 Cylinders.

Specific packaging	Test/Analysis results
NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.	

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Table F-6. Water Spray Test Results for Liquid and Gas Packagings.

Specific packaging	Test/Analysis results

NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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Table F-7. Water Spray Test Results for Miscellaneous Packagings.	
Specific packaging	**Test/Analysis results**
Stagecoach Model 320162, V1.1	The water spray test was applied simultaneously to four sides of test units 7A-49-TU-01 and 7A-49-TU-02 for one hour, at a rate of 5 cm (2 in.) of water per hour. Prior to conducting this test, each test unit was filled with simulated contents. The gross weight of 7A-49-TU-01 was 1404.3 kg (3,096 lb) (without pallet). The gross weight of 7A-49-TU-02 was 1405.2 kg (3,098 lb) (with pallet). Water rolled off of the fabric, and the cardboard retained its rigidity. It was determined that the water spray had no detrimental effect on the ability of the packaging to perform and resulted in no loss of material or in-leakage of water. No further water spray tests were performed on packagings prior to testing.
Modified WRAP 1-Trip, 208-L Drum	The water spray test was not conducted. Due to the materials of construction, filtered design, and extensive testing on steel drums that has been performed as documented in DOE/RL-96-57, Vol. 1, the assemblies were evaluated to pass this test requirement. (Refer to prior testing performed on DOT-17C, DOT-17H, and the WHC WRAP-1 Drum design tested in 1994 under Docket 94-35-7A.)

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Table F-9. Free Drop Test Results for Steel Boxes.		
Specific packaging	Weight kg (lb)	Test Unit/Orientation/Results/Comments
M-100 Container (M-101/7A/12/90)	***NOTE: Drop testing conducted onto the top of the M-100 Container in June 1997 demonstrated the integrity of the design for the top portion of the container. The bottom design of the container failed during testing in June 1997 and April 1998. The bottom design was successfully demonstrated during testing performed in September 1998. The approved, as-tested design is represented by Model M-101/7A/12/90, Issue #4, Revision 6.***	
M-100 Container (M-101/7A/12/90)	4,236.55 (9,340)	**43-TU-02 - June 1997 - Pass**. Dropped onto the top corner of the container at the lifting ring, center of gravity over the impact point. For testing purposes, this test unit contained a plug instead of a filter. Upon impact, the lift lug was completely mashed into the lid. Slight lifting occurred between several of the closure screws located at the area of impact. This lifting ranged from 0.317 to 1.27 cm (0.125 to 0.50 in.). The bottom of the container pushed inward approximately 5.08 cm (2 in.) and outward approximately 5.08 cm (2 in.), 20.32 cm (8 in.) from the lengthwise edge and 60.96 cm (24 in.) from the short side edge. There was no release of contents.
	4,145.83 (9,140)	**43-TU-04 - June 1997 - Pass**. Dropped onto the top of the container lid along the short edge of the package, center of gravity over the impact point. For testing purposes, this test unit contained a plug instead of a filter. Upon impact a screw sheared off at the head, and the lid shifted approximately 0.635 cm (0.25 in.) at the impact point. The top of the lid bowed outwards slightly. The lid flange lifted upward about 0.317 cm (0.125 in.) between all of the screws at the area of impact. Slight cracking along the lid flange at the welds occurred. The sidewall and bottom of the container bowed outward between the support channels, approximately 5.08

		cm (2 in.). There was no release of contents.
	4,327.27 (9,540)	**43-TU-06 - June 1997 - Pass.** Dropped flat onto the end with the NucFil filter. This was a filtered test unit. The riser at the end of impact broke off. There was no further damage to the packaging. There was no release of contents.
	4,127.69 (9,100)	**43-TU-11 - Sept. 1998 - Pass.** Dropped onto the bottom long edge of the package, center of gravity over the impact point. Removable riser design. For testing purposes, this test unit contained a plug instead of a filter. Upon impact, the clips that hold the removable risers into place all released at the impact edge, and all three risers flew off the package. There was slight crushing of the container body along the edge of impact. The riser subplate along one side of the container lifted outward approximately 0.635 cm (0.25 in.) for a distance of 49.53 cm (19.5 in.). A 2.54 cm (1 in.) tear occurred in the outer layer of the container body (material overlaps) where the removable clip is welded onto the bottom edge of the. There was no release of contents.
	4,127.69 (9,100)	**43-TU-12 - Sept. 1998 - Drop #1 - Pass.** Dropped onto the bottom short edge of the package, center of gravity over the impact point. Fixed riser design. For testing purposes, this test unit contained a plug instead of a filter. The riser along the edge of impact pushed inward and flattened slightly. The riser on the opposite end (slap-down end) squashed slightly. The sides and bottom of the container showed slight bulging. There was no release of contents.
	4,127.69 (9,100)	**43-TU-12 - Sept. 1998 - Drop #2 - Pass.** Dropped onto bottom corner of the package, center of gravity over the impact point. Fixed riser design. For testing purposes, this test unit contained a plug instead of a filter. The riser at the area of impact ripped out of the weld and tore approximately 0.125 cm (1/8 in.) wide and 3.18 cm (1.25 in.) in length. This tear occurred in the outer layer of the container body (material overlaps) where the edge of the fixed riser is welded onto the bottom of the container. The corner of impact showed crushing effects across an area measuring approximately 32.02 cm (13 in.). This area indented a distance of 6.35 to 7.62 cm (2.5 to 3 in.). The center riser and one end riser pulled away from the container. A slight tear occurred in the outer layer of the container body (material overlaps) where this end riser was welded onto the bottom of the container. The end riser crushed across a distance of approximately 22.86 cm (9 in.) at the area of impact. At this area, crushing occurred approximately 12.70 to 15.24 cm (5 to 6 in.) onto the container body. The sides and bottom of the container had slight bulging. There was no release of contents.
	4,127.69 (9,100)	**43-TU-13 - Sept. 1998 - Drop #1 -Pass.** Dropped onto the bottom long edge of the package, center of gravity over the impact point. Fixed riser design. For testing purposes, this

		test unit contained a plug instead of a filter. All three risers crushed/flattened along the impact edge. The center riser and the riser located at the end on the opposite side of the initial impact pulled out from the welded area. The center riser tore a small hole at the weld located on the subplate. The end riser pulled away from the body of the container and there was no weld penetration at this location. The only noted damage was slight and occurred to the riser at the initial impact location. There was no release of contents.
	NOTE: The second drop test using 43-TU-13 was performed to ensure design integrity due to the poor workmanship of the slotted holes in the container lids on test units received in September 1998.	
	4,127.69 (9,100)	**43-TU-13 - Sept. 1998 - Drop #2 - Pass.** Dropped onto top long edge of the package, center of gravity over the impact point. Fixed riser design. For testing purposes, this test unit contained a plug instead of a filter. Slight cracking of the welds along the lid flange occurred at all welded areas. Slight bulging occurred at the top and sides of the container. There was no release of contents.
TRUPACT-II SWB	**1832.513 (4,040)**	**TU-1A – Tested by Mound – Pass.** Contents included flour, fluorescein, and sand (Forms 1 & 2). Dropped onto a top corner. The only result was a minor dent at the point of impact.
	1859.729 (4,100)	**TU-1B –Tested by Mound – Pass.** Contents included flour, fluorescein, and sand (Forms 1 & 2). This test unit was dropped twice onto a bottom corner. Resulting damage was a dent measuring 10.16-cm (4-in.) at the point of impact.
	1856.1 (4,092)	**TU-2 – Tested by Mound – Pass.** Contents included flour, fluorescein, and debris (i.e. motors, pipes, steel plates, concrete blocks) (Forms 1, 3, & 4). This test unit was dropped flat on an end. The only results were minor dents on the end surface.
	1859.729 (4,100)	**TU-3B – Tested by Mound – Pass.** Contents included flour, fluorescein, and four loaded steel drums (Forms 1 & 5). This test unit was dropped onto a top corner. The only results were minor dents at the point of impact due to the inner drums.
	1859.729 (4,100)	**TU-3B (1B) – Tested by Mound – Pass.** Test Unit 1B was emptied and refilled with flour, fluorescein, and four loaded steel drums (Forms 1 & 5). This test unit was dropped onto a top corner. The resulting damage included minor dents at the point of impact due to the inner drums.

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Table F-10. Free Drop Test Results for Wooden Boxes.

Specific packaging	Weight (lb)	Contents	Results	Comments
NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.				

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Table F-11. Corner Free Drop Test Results for Wooden Boxes.

Specific packaging	Weight (lb)	Contents	No. tested	Results	Comments

NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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Table F-12. Free Drop Test Results for Fiberboard Boxes.

Specific packaging	Weight (lb)	Contents	No. tested	Results	Comments

NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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Table F-13. Corner Free Drop Test Results for Fiberboard Boxes.

Specific packaging	Weight(lb)	Contents	No. tested	Results	Comments

NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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Table F-14. Free Drop Test Results for Fiberboard Drums.

Specific packaging	Weight (lb)	Contents	No. tested	Results	Comments

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Table F-15. Corner Free Drop Test Results for Fiberboard Drums.

Specific packaging	Weight(lb)	Contents	No. tested	Results	Comments

NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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Table F-16. Free Drop Test Results for UF_6 Cylinders.

Specific packaging	Weight kg (lb)	Orientation	Comments
NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.			

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Table F-17. Additional Drop Test Results for Liquid and Gas Packagings.

Specific Packaging	Weight kg (lb)	Contents		Results/Comments
	Number of drops	Orientation	Results	Comments

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Table F-18. Free Drop Test Results for Liquid and Gas Packagings.

Specific Packaging	Weight kg (lb)	Contents		Results/Comments	
	Number of drops	Orientation	Results	Comments	

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Table F-20. Stacking Test Results for Steel Drums.

Specific packaging	Authorized gross weight kg (lb)	Stack test weight kg (lb)	Test Unit/Results/Comments
Myers Model G5501	None tested. Due to the materials of construction and design of the packaging, by comparison with performance of drums in **DOE/RL 1996, Vol. 1**, Rev. 0, this drum would meet this requirement.		
Myers Model 5526	None tested. Due to the materials of construction and design of the packaging, by comparison with performance of drums in **DOE/RL 1996, Vol. 1**, Rev. 0, this drum would meet this requirement.		

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Table F-21. Stacking Test Results for Steel Boxes.			
Specific packaging	**Authorized gross weight kg (lb)**	**Stack Test weight kg (lb)**	**Test Unit/Results/Comments**
M-100 Container (M-101/7A/12/90)	4082.33 (9,000)	20,983.18 (46,260)	The stack test was conducted in June 1997 on test unit 43-TU-07. This was an empty packaging that incorporated the original fixed riser design (which is not approved for use). Although the approved, as-tested design differs from the June 1997 design used for this test, the changes made for testing conducted in Sept. 1998 actually improved the integrity of the container. The compressive load applied was five times the estimated gross weight of the package. There was no deformation to the container. Pass.
TRUPACT-II SWB	1814,369 (4,000)	9573.067 (21,105)	This test was conducted by Mound. A compressive load was applied for over a 24-hour period to TU-2. The test had no detectable effect, and there was no loss of contents as evidenced by an inspection for fluorescein using UV light. Pass.

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Table F-22. Stacking Test Results for Wooden Boxes.

Specific packaging	Authorized gross weight (lb)	Compression test weight (lb)	Test duration (hr)	Test/analysis data and results: No. tested	Test/analysis data and results: Results	Comments

NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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Table F-23. Stacking Test Results for Fiberboard Containers.

Specific packaging	Authorized gross weight (lb)	Compression test weight (lb)	Test duration (hr)	Test/analysis data and results		
				No. tested	Results	Comments

NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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Table F-24. Stacking Test Results for UF_6 Cylinders.

Packaging	Calculated no. of packages required for stress leading to failure	Results	Comments

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Table F-25. Stacking Test Results for Liquid and Gas Packagings.

Specific packaging	Authorized gross weight kg (lb)	Compression test weight kg (lb)	Test duration (hr)	Test/analysis data and results		
				No. tested	Results	Comments

NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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Table F-27. Penetration Test Results for Steel Drums.

Specific packaging	Test Unit/Location/Results/Comments
Myers Model G5501	None tested. Due to the materials of construction and design of the packaging, by comparison with performance of drums in **DOE/RL 1996, Vol. 1, Rev. 0**, this drum would meet this requirement.
Myers Model 5526	None tested. Due to the materials of construction and design of the packaging, by comparison with performance of drums in **DOE/RL 1996, Vol. 1, Rev. 0**, this drum would meet this requirement.

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Table F-28. Penetration Test Results for Steel Boxes.	
Specific packaging	**Test Unit/Location/Results/Comments**
M-100 Container (M-101/7A/12/90)	None tested. By evaluation and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, filter, and materials of construction) with the performance of the metal boxes previously tested and evaluated in DOE/RL 1996, Vol. 1, Rev. 0, this packaging is evaluated to meet this requirement.
TRUPACT-II SWB	Two penetration tests were conducted by Mound on TU-1. The first penetration bar drop was onto the center of the container lid. There was no effect, not even a minor dent. The second penetration bar drop was onto the filter housing. The filter housing was scuffed/scraped at the point of impact, but that was the only visible effect. An inspection with UV light provided no indication of fluorescein. Pass.

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Table F-29. Penetration Test Results for Wooden Boxes.

Specific packaging	No. tested	Test/analysis results: Location	Results	Comments

NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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Table F-30. Penetration Test Results for Fiberboard Containers.

		Test/analysis results		
Specific packaging	**No. tested**	**Location**	**Results**	**Comments**

NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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Table F-31. Penetration Test Results for UF_6 Cylinders.

Specific packaging	Test/analysis results

NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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Table F-32. Penetration Test Results for Liquid and Gas Packagings.

Specific packaging	No. tested	Test/analysis results: Location	Results	Comments

NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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Table F-33. Penetration Test Results for Miscellaneous Packagings.	
Specific packaging	**Test Unit/Results/Comments**
Stagecoach Model 320162, V1.1	The penetration test was applied to test unit 7A-49-TU-01. Prior to conducting this test, this test unit was filled with simulated contents to a gross weight of 1404.3 kg (3,096 lb.) (without pallet). The water spray test was conducted on this test unit prior to conducting the penetration test. The penetration bar was lifted above the center of the top cover of the packaging. The damage to the test unit consisted of the cardboard indenting approximately 1.25 cm (0.50 in.) and 3.2 cm (1.25 in.) diameter of the penetration bar. There was no indicated damage to the fabric. There was no release of contents. There was no damage to the penetration bar.
Modified WRAP 1-Trip, 208-L Drum	Pass. The penetration test was conducted on test unit 7A-48-TU-01. The penetration bar was lifted above the center of the external drum lid. The damage to the test unit was minimal, and resulted in an indent of 0.64 cm (0.25 in.) at the area of impact. There was no release of contents. There was no damage to the penetration bar.

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Table G-1. Steel Drums--Compliance With Vibration Standard (49 CFR 178.608).

Specific packaging	Weight kg (lb)	Test Unit/Results/Comments
Myers Model G5501		None tested. Due to the materials of construction, design, and weight of the packaging tested under this docket, by comparison with DOT-17C drum testing conducted under Docket 94-37-7A (**DOE/RL 1996, Vol. 1, Rev. 0**), this drum would meet this requirement.
Myers Model 5526		None tested. Due to the materials of construction, design, and weight of the packaging tested under this docket, by comparison with DOT-17C drum testing conducted under Docket 94-37-7A (**DOE/RL 1996, Vol. 1, Rev. 0**), this drum would meet this requirement.

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Table G-2. Steel Boxes--Compliance With Vibration Standard (49 CFR 178.608).		
Specific packaging	**Weight kg (lb)**	**Test Unit/Results/Comments**
M-100 Container (M-101/7A/12/90)	**4,179.40 (9,214)**	43-TU-10 - Sept. 1998 - Pass. This test unit was the removable riser style. No loosening of bolts or loss of contents. Only damage was that the two end risers completely came loose during the test, and the center riser came loose from one side. By comparison, the fixed riser design is also judged to pass.
TRUPACT-II SWB		None tested. Based upon the materials of construction and design, by evaluation, the SWB should not experience any negative impact because of the effects of temperature and vibration normally incident to transportation.

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Table G-3. Wooden Boxes--Compliance With Vibration Standard (49 CFR 178.608).

Specific packaging	No. tested	Weight (lb)	Contents	Results	Comments

NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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Table G-4. Fiberboard Containers--Compliance With Vibration Standard (49 CFR 178.608).

Specific packaging	No. tested	Weight (lb)	Contents	Results	Comments

NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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Table G-5. UF_6 Cylinders--Compliance With Vibration Standard (49 CFR 178.608).

Specific packaging	No. tested	Weight (lb)	Contents	Results	Comments

NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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Table G-6. Liquid and Gas Packagings--Compliance With Vibration Standard (49 CFR 178.608).

Specific packaging	No. tested	Weight kg (lb)	Contents	Results	Comments

NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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Table 1-1. New Packaging Configurations.		
Docket(s)	**Configurations**	**Description**
94-35	1	WHC WRAP-1, 208-L Waste Drum
95-40	1	INEL ARROW-PAK Packaging
95-41	1	WHC 1-L Liquid Shipper

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APPENDIX I
U.S. DEPARTMENT OF TRANSPORTATION LETTER OF CONCURRENCE

Figure I-1. U.S. Department of Transportation Letter of Concurrence.

US Department
of Transportation

**Research and
Special Programs
Administration**

400 Seventh Street S.W.
Washington, D.C. 20590

APR 21 1992

Michael E. Wangler, Director
Transportation and Packaging Safety Division
EH-33.3
U.S. Department of Energy
Washington, DC 20585

Dear Mr. Wangler:

This letter refers to your request for our review of the revision to your document entitled "Test and Evaluation Document for DOT Specification 7A Type A Packagings" DOE/DP/00052-H1. This document is intended to assist shippers in satisfying some of the requirements for documenting the results of testing of DOT Specification 7A packaging.

We have reviewed the subject document and concur with its purpose and contents. The document will provide DOE contractors and other radioactive materials shippers with information about the types of packaging components that can be used with various DOT specification packagings, the results of tests performed on the various packaging configurations, and quality control requirements for using the packagings. This information is essential for a program that offers a broad range of Type A packages for radioactive materials transported by a number of shippers.

We continue to concur with the restrictions that you place on using the document. Historically, some shippers have assumed that this type of document, as extracted or by itself, provides the complete documentation required by 49 CFR 173.415 for offering a Type A package for transportation. You emphasize that in addition to having this report, the shipper must also maintain documentation on other aspects of the shipment. These aspects include a comparison of the physical properties of the actual content of the package to those surrogate materials used for testing, and the implementation of a quality control program to ensure that package use complies with the applicable DOE and DOT requirements. This documentation is required for shippers to meet DOT requirements.

Thank you for the opportunity to review your document.

Sincerely,

Alan I. Roberts
Associate Administrator for
Hazardous Materials Safety

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Table 2.1-1. Dimensions.		
Drum	**Height (in.)**	**Diameter (in.)**
5-gallon interior	12.50	11.25
5-gallon exterior	13.50	12.25
10-gallon interior	15.75	14.00
10-gallon exterior	17.25	15.00

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Table 2.1-2. Materials/Method of Construction.

5 gallon		**10 gallon**	
Body and head sheet	22 gauge	Body and head sheet	20 gauge
Ring	20 gauge	Ring	16 gauge
Bolt	0.218 in.	Bolt	0.312 in.
Gasket required		Gasket required	

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Table 2.1-3. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-1.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-1.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-1.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted on nine different types of steel drums and a total of 26 packages. In all cases, there was no detectable effect on the ability of the packaging to meet the subsequent Type A tests. Also, in all cases, there was no inleakage of water as a result of this test. See Appendix D, Table D-1.a.
Free drop	Pass. 4-ft drop test conducted on: Top - approximately 45° on bolt Bottom - approximately 45° Side - flat on bolt. See Appendix D, Table D-10.a.
Corner drop	Not required.
Compression	Pass. This test was conducted at greater than five times the gross weight for 24 hr. No detectable effect on the packaging was observed. See Appendix D, Table D-24.
Penetration	Pass. This test was conducted on the center of the lid, on the center of side body, and on the lid close to the closure ring. See Appendix D, Table D-31.
49 CFR 178.99, Specification 6C: steel barrels and drums	See Appendix J, Table J-5.

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Table 2.1-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface sealing surface	Vendor qualifications and experience	Functional: • Ease of lid/closure ring application • Bolt closure ring--bolt size • Gasket, adhesive, as specified • Geometry, as specified Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces
Gasket		• Dimensions, as specified
Weld areas		• Continuous welds, no sharp edges
Body and chime	Metal thickness	Lot tests by shipper, as appropriate.
Air leak tests	Bolt size	Vendor Data and/or Certification: • Marking • Test data • Type A document provided as appropriate • Air leak tests
	Protective coating application	Visual: • Surface/coating as specified • Lack of imperfections in application • Lack of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 2.2-1. Dimensions.

5-gallon drum	Height (in.)	Diameter (in.)
Interior	12.5	11.25
Exterior (with ring)	13.0	12.00

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Table 2.2-2. Materials/Method of Construction.	
5 gallon	
Body and head sheet	24 gauge
Ring	18 gauge
Bolt	0.25 in.
Gasket required	

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Table 2.2-3. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-1.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-1.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-1.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Tests were conducted on all three styles of drums and demonstrated no inleakage of water. Further, the water spray test preceded each of the remaining Type A tests. In no case was there any effect on the ability of the packagings to meet the required tests. See Appendix D, Table D-1.a.
Free drop	Pass. Sixty-nine separate drop tests were conducted (22 on Styles 1A and B, 26 on Style 2, and 21 on Style 3). Drops were conducted on edges, top corners, bottom corners, and the ends. In all cases, there was no loss of contents or major distortion of the packagings. See Appendix D, Table D-10.a.
Corner drop	Not required.
Compression	Pass. The test was conducted on all three styles at greater than five times the gross weight for greater than 24 hr. There was no visible distortion of the packagings or loss of contents. See Appendix D, Table D-24.
Penetration	Pass. The test was conducted at several points on all three styles of the packagings with no significant effect. The tests on the bungs left no discernable mark. The impact on the centers of the covers resulted in a maximum dent of 0.25 in. The tests on the closure rings left no visible effect. See Appendix D, Table D-31.
49 CFR 178.115, Specification 17C: steel drums	See Appendix J, Table J-6.

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Table 2.2-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface sealing surface	Vendor qualifications and experience	Functional: • Ease of lid/closure ring application • Bolt closure ring--bolt size • Gasket, adhesive, as specified • Geometry, as specified Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces
Gasket		• Dimensions, as specified
Weld areas		• Continuous welds, no sharp edges
Body and chime	Metal thickness	Lot tests by shipper, as appropriate.
Air leak tests	Bolt size	Vendor Data and/or Certification: • Marking • Test data • Type A document provided as appropriate • Air leak tests
	Protective coating application	Visual: • Surface/coating as specified • Lack of imperfections in application • Lack of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 2.3-1. Dimensions.		
30-gallon drum	**Height (in.)**	**Diameter (in.)**
Interior	28.0	18.0
Exterior	29.5	20.0

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Table 2.3-2. Materials/Method of Construction.	
30 gallon	
Body and head sheet	18 gauge
Ring	12 gauge
Bolt	0.625 in.
Gasket required	

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Table 2.3-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-1.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-1.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-1.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted on nine different types of steel drums and a total of 26 packages. In all cases, there was no detectable effect on the ability of the packaging to meet the subsequent Type A tests. Also, in all cases, there was no inleakage of water as a result of this test. See Appendix D, Table D-1.a.
Free drop	Pass. 4-ft drop test conducted on:
	Top - approximately 45° on bolt
	Bottom - approximately 45°
	Side - flat on bolt.
	See Appendix D, Table D-10.a.
Corner drop	Not required.
Compression	Pass. This test was conducted at greater than five times the gross weight for 24 hr. No detectable effect on the packaging was observed. See Appendix D, Table D-24.
Penetration	Pass. This test was conducted on the center of the lid, on the center of the side body, and on the lid close to the closure ring. See Appendix D, Table D-31.
49 CFR 178.115, Specification 17C: steel drums	See Appendix J, Table J-6.

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Table 2.3-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface sealing surface	Vendor qualifications and experience	Functional: • Ease of lid/closure ring application • Bolt closure ring--bolt size • Gasket, adhesive, as specified • Geometry, as specified Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces
Gasket		• Dimensions, as specified
Weld areas		• Continuous welds, no sharp edges
Body and chime	Metal thickness	Lot tests by shipper, as appropriate.
Air leak tests	Bolt size	Vendor Data and/or Certification: • Marking • Test data • Type A document provided as appropriate • Air leak tests
	Protective coating application	Visual: • Surface/coating as specified • Lack of imperfections in application • Lack of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 2.4-1. Dimensions.		
35-gallon drum	**Height (in.)**	**Diameter (in.)**
Interior	33.50	18.00
Exterior	34.75	20.50

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Table 2.4-2. Materials/Method of Construction.	
35 gallon	
Body and head sheet	16 gauge
Ring	12 gauge
Bolt	0.625 in.
Gasket required	

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Table 2.4-3. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-1.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-1.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-1.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted on a total of six packagings. In all cases, there was no detectable effect on the ability of the packaging to meet the subsequent Type A test. Also, there was no inleakage of water as a result of this test. See Appendix D, Table D-1.a.
Free drop	Pass. 4-ft drop test conducted on: Top - approximately 45° on bolt Bottom - approximately 45° Side - flat on bolt. See Appendix D, Table D-10.d.
Corner drop	Not required.
Compression	Pass. This test was conducted at greater than five times the gross weight for 24 hr. No detectable effect on the packaging was observed. See Appendix D, Table D-24.
Penetration	Pass. This test was conducted on the center of the lid, on the center of side body, and on the lid close to the closure ring. Only minor dents occurred. See Appendix D, Table D-31.
49 CFR 178.115, Specification 17C: steel drums	See Appendix J, Table J-6.

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Table 2.4-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface sealing surface	Vendor qualifications and experience	Functional: • Ease of lid/closure ring application • Bolt closure ring--bolt size • Gasket, adhesive, as specified • Geometry, as specified Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces
Gasket		• Dimensions, as specified
Weld areas		• Continuous welds, no sharp edges
Body and chime	Metal thickness	Lot tests by shipper, as appropriate.
Air leak tests	Bolt size	Vendor Data and/or Certification: • Marking • Test data • Type A document provided as appropriate • Air leak tests
	Protective coating application	Visual: • Surface/coating as specified • Lack of imperfections in application • Lack of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 2.5-1. Authorized Configurations. (2 pages)	
HF-1	Drum with vent clip, liner, bag and catalyst: a DOT-17C drum with a vent clip, with a 90-mil HDPE liner (vented or nonvented), that encloses a 4-mil polyethylene bag, that encloses the contents.
HF-2	Drum with liner: a DOT-17C (filtered or nonfiltered) drum with an HDPE liner (90-mil body, 110-mil head, vented or nonvented), that encloses the contents.
LL-1	Drum with liner: a DOT-17C (filtered or nonfiltered) drum with an HDPE liner (90-mil body, 110-mil head, vented or nonvented), that encloses the contents.
MD-1	Drum with liner: a DOT-17C (filtered or nonfiltered) drum with an HDPE liner (90-mil body, 110-mil head, vented or nonvented), that encloses the contents.
RF-1	Drum with polyethylene bag: a DOT-17C nonfiltered drum with an optional 4-mil polyethylene bag, that encloses the contents. For Form No. 1 materials, either the bag or sealing the lid gasket to the body seal interface with RTV adhesive is required.
RF-2	Filtered drum, liner with bag: a DOT-17C filtered (NucFil-014*) drum with a 90-mil HDPE liner, that encloses a 4-mil polyethylene bag, that encloses the contents.
RF-3	Drum with liner: a DOT-17C nonfiltered drum with an HDPE liner (90-mil body, 110-mil head, vented or nonvented), that encloses the contents.
RF-4	Filtered drum with vented liner and bag: a DOT-17C filtered (NucFil-014) drum with a vented HDPE 90-mil liner, that encloses a 10-mil plastic bag, that encloses the contents.
RF-5	Filtered drum, closed Type IV liner: a DOT-17C filtered (NucFil-014) drum with a Type IV HDPE 110-mil liner, that encloses a 10-mil plastic bag, that encloses the contents.
RF-6	Filtered drum, PVC bag with Type V liner: a DOT-17C filtered (NucFil-014) drum with a 10-mil plastic drum liner (polyethylene bag), that encloses a PVC glovebox bag, that encloses a Type V HDPE 110-mil liner, that encloses the contents.
RF-7	Filtered drum, vented liner with bag: a DOT-17C filtered (NucFil-014) drum with a vented Type IV HDPE 110-mil liner, that encloses a 10-mil plastic bag, that encloses the contents.
RF-8	Filtered drum, PVC bag with Type V liner: a DOT-17C filtered (NucFil-014) drum with a 10-mil plastic drum liner (polyethelene bag), that encloses a PVC glovebox bag, that encloses a vented Type V HDPE 110-mil liner, that encloses the contents.
G-1	Filtered drum: a DOT-17C drum with catalyst packet and NucFil filter or vent clip--single packaging. Authorized only for use with Form No. 2 and 3 contents,

	see Section 2.5.2.1.
G-2	Drum (nonfiltered): a DOT-17C drum (nonfiltered)--single packaging. Authorized only for use with Form No. 2 and 3 contents, see Section 2.5.2.1.
LL-2	Filtered drum, open Type IV liner: a DOT-17C (or UN1A2 built to be equivalent to the DOT-17C) filtered (NucFil-013) drum with a Type IV HDPE 110-mil liner, that encloses a 3.5-mil plastic bag that encloses the contents. Note: Any contents that are heavy, sharp objects should be enclosed by a plastic bag (e.g., glovebox bag) that has been enclosed by a secondary plastic bag, prior to placing into the 3.5-mil plastic bag.
*NucFil is a trademark of Nuclear Filter Technology, Incorporated.	
HDPE = high-density polyethylene.	
PVC = polyvinyl chloride.	
RTV = room temperature vulcanizing.	

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Table 2.5-2. Dimensions.				
208-Liter (55-gallon) drum	**Height**		**Diameter**	
	cm	**in.**	**cm**	**in.**
Interior	84.46	33.25	56.51	22.50
Exterior	88.90	35.00	61.24	24.10

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Table 2.5-3. Materials/Method of Construction. (2 pages)	
Drums	DOT-17C (or UN1A2 built to be equivalent to the DOT-17C), steel or galvanized steel
Drum lid	Steel with 1.9-cm (0.750-in.) Rieke Bung fitting welded on (required on filtered configurations only)
Drum gasket	Closed cell Neoprene[a] meeting ASTM D1056 grade SCE-45, 30-40 durometer, shore-A
	Tubular styrene-butadiene
	Butadiene foam
Pressure relief devices	
Vent Clip	Stainless steel, 304, per Rockwell Hanford drawing H-2-28798
Filter	Nuclear Filter Technology, Incorporated Model NucFil-014[b] or Model NucFil-013
Liners	
HF-1, HF-2, MD-1	Per RHO-MA-222, Rev. 4 (RHO 1987)
	Open-head molded polyethylene liner with carbon black
	Snap-lock closure; use of adhesive bonding optional, but not required
	Vent hole (if used) is at the center of the head with approximately 1.9-cm (0.750-in.) diameter
LL-1	Open-head molded polyethylene liner without carbon black
	Vent hole (if used) is at the center of the head with approximately 1.9-cm (0.750-in.) diameter
RF-2, RF-3, RF-4	Per Rocky Flats Plant Standard No. SX-202
	Open-head molded polyethylene liner with carbon black
	Bolted closure ring with gasket
	Vent hole (if used) is at the center of the head with approximately 1.9-cm (0.750-in.) diameter
RF-5, RF-6, RF-7, RF-8	Open-head, molded, polyethylene (density is 0.946 to 0.953 per ASTM-D-792 [ASTM 1986]) liner with 2.5% black (Type IV) or brown color (Type V) added, minimum 110-mil thick
	Vent hole (if used) is at the center with approximately 2.54-cm (1-in.) diameter
LL-2	Open-head, molded, polyethylene (density is 0.946 to 0.953 per ASTM-D-792 [ASTM 1986]) liner with 2.5% black (Type IV) added, minimum 110-mil thick.
	Vent hole is unplugged, and is at the center with approximately 2.54-cm (1-in.) diameter.
[a]Neoprene is a trademark of E. I. duPont de Nemours & Company.	
[b]NucFil is a trademark of Nuclear Filter Technology, Incorporated.	
ASTM = American Society for Testing and Materials.	

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Table 2.5-4. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-1.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-1.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-1.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted and there was no inleakage of water. See Appendix D, Table D-1.a.
Free drop	Pass. Multiple 4-ft drop tests have been conducted on a number of test units with successful results. The impact orientations included: Top - CG over corner on bolt Top - flat on top Bottom - CG over corner Bottom - flat on bottom Side - flat on bolt. See Appendix D, Tables D-10.a and D-10.b.
Corner drop	Not required.
Compression	Pass. This test was conducted on a number of test units with successful results. See Appendix D, Table D-24.
Penetration	Pass. Penetration bar was dropped on a number of test units impacting all potentially vulnerable features with no adverse effects on the packaging. The features impacted included the lid, the filter, the side, and the bottom center. See Appendix D, Table D-31.
49 CFR 178.608, Vibration standards [Applied to demonstrate compliance with 49 CFR 173.412 (e)]	Meets applicable requirements. See Appendix E, Table E-1.
49 CFR 178.115, Specification 17C: steel drums	See Appendix J, Table J-6.

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Table 2.5-5. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface sealing surface	Vendor qualifications and experience	Functional: • Ease of lid/closure ring application • Bolt closure ring--bolt size • Gasket, adhesive, as specified • Geometry, as specified Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces
Gasket		• Dimensions, as specified
Weld areas		• Continuous welds, no sharp edges
Body and chime	Metal thickness	Lot tests by shipper, as appropriate.
Air leak tests	Bolt size	Vendor Data and/or Certification: • Marking • Test data • Type A document provided as appropriate • Air leak tests
	Protective coating application	Visual: • Surface/coating as specified • Lack of imperfections in application • Lack of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 2.6-1. Authorized Configurations.

AW-1	Filtered drum with bag: a DOT-17H filtered (NucFil-031*) drum with a 20-mil polyethylene filtered (NucFil-030) bag, which encloses an HDPE 100-mil vented liner, which encloses the contents. <See Note below>
FM-1	Filtered drum with bag: a DOT-17H filtered (NucFil-031) drum with a 20-mil polyethylene filtered (NucFil-030) bag, which encloses the contents. <See Note below>
OR-1	Drum (nonfiltered): a DOT-17H drum (nonfiltered)--single packaging. An RTV sealant must be applied to the seal for Material Form No. 1 contents, see Section 2.6.2.

*NucFil is a trademark of Nuclear Filter Technology, Inc. (NFTI).

HDPE = high-density polyethylene.

Note: A NucFil-031 does not exist for use in drums. This is a possible typo.

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Table 2.6-2. Dimensions.		
17H 30-gallon drum	**Height (in.)**	**Diameter (in.)**
Interior	28.0	18.0
Exterior	29.5	20.0

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Table 2.6-3. Materials/Method of Construction.

Drum	Steel, DOT-17H, 49 CFR 178.118
Body and lid	18 gauge
Ring	12 gauge
Ring bolt	0.625 in.
Gasket	Tubular, styrene--butadiene
Plastic bag	Polyethylene, 20-mil
Filter	
- drum	NFTI Model NucFil-031* <See note below>
- bag	NFTI Model NucFil-030
Rigid liner	Polyethylene (high density), 100-mil
Liner lid	Polyethylene (high density), .062 in.
Fiberboard liner	90-mil, single wall, 26 gal

*NucFil is a trademark of Nuclear Filter Technology, Inc.

Note: A NucFil-031 does not exist for use in drums. This is a possible typo.

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Table 2.6-4. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-1.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-1.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-1.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted on a number of test units with no inleakage of water. See Appendix D, Table D-1.a.
Free drop	Pass. Multiple drop tests at varying impact angles on a number of test units with successful results. The orientations included: Top - CG over corner on bolt Top - flat on top Bottom - CG over corner Bottom - flat on bottom. See Appendix D, Table D-10.c.
Corner drop	Not required.
Compression	Pass. This test was conducted on several test units at more than five times the maximum gross weight with successful results. See Appendix D, Table D-24.
Penetration	Pass. All potentially vulnerable package features were subjected to the penetration impact with no adverse affects. See Appendix D, Table D-31.
49 CFR 178.118, Specification 17H: steel drums	See Appendix J, Table J-7.

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Table 2.6-5. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface sealing surface	Vendor qualifications and experience	Functional: • Ease of lid/closure ring application • Bolt closure ring--bolt size • Gasket, adhesive, as specified • Geometry, as specified Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces
Gasket		• Dimensions, as specified
Weld areas		• Continuous welds, no sharp edges
Body and chime	Metal thickness	Lot tests by shipper, as appropriate.
Air leak tests	Bolt size	Vendor Data and/or Certification: • Marking • Test data • Type A document provided as appropriate • Air leak tests
	Protective coating application	Visual: • Surface/coating as specified • Lack of imperfections in application • Lack of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 2.7-1. Dimensions.		
55-gallon drum	**Height (in.)**	**Diameter (in.)**
Interior	33.25	22.25
Exterior	35.00	24.00

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Table 2.7-2. Materials/Method of Construction.	
55 gallon	
Body	18 gauge
Head	14 or 16 gauge
Ring	12 gauge
Bolt	0.625 in.
Gasket required	

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Table 2.7-3. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-1.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-1.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-1.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Tests were conducted on a total of 26 test units of 9 different types of steel drums. In all cases, there was no detectable effect on the ability of the packaging to meet the subsequent Type A tests. In all cases, there was no inleakage of water. See Appendix D, Table D-1.a.
Free drop	Pass. 4-ft drop test conducted on: Top - approximately 45° on bolt Bottom - approximately 45° Side - flat on bolt. See Appendix D, Table D-10.c.
Corner drop	Not required.
Compression	Pass. The test was conducted at five times the gross weight for 24 hr. No detectable effect on the packaging was observed. See Appendix D, Table D-24.
Penetration	Pass. The test was not conducted. Conclusion based on successful testing of comparable DOT-17H drum. See Appendix D, Table D-31.
49 CFR 178.118, Specification 17H: steel drums	See Appendix J, Table J-7.

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Table 2.7-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface sealing surface	Vendor qualifications and experience	Functional: • Ease of lid/closure ring application • Bolt closure ring--bolt size • Gasket, adhesive, as specified • Geometry, as specified Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces
Gasket		• Dimensions, as specified
Weld areas		• Continuous welds, no sharp edges
Body and chime	Metal thickness	Lot tests by shipper, as appropriate.
Air leak tests	Bolt size	Vendor Data and/or Certification: • Marking • Test data • Type A document provided as appropriate • Air leak tests
	Protective coating application	Visual: • Surface/coating as specified • Lack of imperfections in application • Lack of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 2.8-1. Dimensions and Weights.

Drum number	Volume (gal)	Inside height (in.)	Inside diameter (in.)	Gross weight (lb)
MS-24347-21[a]	0.25	4.25	5.00	10
MS-24347-27	1.25	7.25	8.50	35
MS-27684-11	3.00	8.08	10.50	60
MS-27684-12	4.00	12.86	10.50	110
MS-27684-13	6.00	16.74	10.50	80
MS-27684-16	8.00	21.48	10.50	80
MS-27684-18	12.00	19.68	13.81	200
MS-27683-36	30.00	26.99	18.25	400
MS-27683-42	45.00	26.11	22.50	500
MS-27683-50	85.00	36.00[b]	26.00	800

[a]This number refers to the body number of the drum on the drawing.

[b]Normal height for this drum is 34.43 in. Be sure to specify the additional height when ordering.

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Table 2.8-2. Restrictions/Specifications.

Drum number	Volume (gal)	RTV required		Liner required[b]		Maximum distance reduction to package center (in.)
		Form No. 1	Form No. 2	Form No. 1	Form No. 2	
MS-24347-21[a]	0.25	No	No	Yes	No	1.625 side
MS-24347-27	1.25	No	No	Yes	No	1.250 side
MS-27684-11	3.00	No	No	Yes	No	1.0 side
MS-27684-12	4.00	No	No	Yes	No	1.0 lid
MS-27684-13	6.00	No	No	Yes	No	1.0 lid
MS-27684-16	8.00	No	No	Yes	No	1.0 lid
MS-27684-18	12.00	No	No	Yes	No	1.0 lid
MS-27683-36	30.00	No	No	Yes	No	1.0 lid
MS-27683-42	45.00	No	No	Yes	No	0.375 side
MS-27683-50	85.00	Yes	No	No	No	0.375 side

[a]This number refers to the body number of the drum on the drawing.

[b]The liner shall be high density polyethylene, 4-mil thickness minimum.

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Table 2.8-3. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-1.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-1.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-1.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Tests were conducted on a total of 26 test units of nine different types of steel drums. In all cases, there was no detectable effect on the ability of the packaging to meet the subsequent Type A tests. In all cases, there was no inleakage of water. See Appendix D, Table D-1.a.
Free drop	Pass. 4-ft drop test conducted on: Top - approximately 45° on bolt Bottom - approximately 45° Side - flat on bolt. See Appendix D, Table D-10.c.
Corner drop	Not required
Compression	Pass. The test was conducted at five times the gross weight for 24 hr. No detectable effect on the packaging was observed. See Appendix D, Table D-24.
Penetration	Pass. Significant dents occurred in the smaller packages. The reduction in distance to the package center is shown in Table 2.8-2. Each shipper must ensure that the radiation level at the surface of the package will not increase more than 20% as a result of such a deformation. See Appendix D, Table D-31.

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Table 2.8-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface sealing surface	Vendor qualifications and experience	Functional: • Ease of lid/closure ring application • Bolt closure ring--bolt size • Gasket, adhesive, as specified • Geometry, as specified Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces
Gasket		• Dimensions, as specified
Weld areas		• Continuous welds, no sharp edges
Body and chime	Metal thickness	Lot tests by shipper, as appropriate.
Air leak tests	Bolt size	Vendor Data and/or Certification: • Marking • Test data • Type A document provided as appropriate • Air leak tests
	Protective coating application	Visual: • Surface/coating as specified • Lack of imperfections in application • Lack of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 2.9-1. Dimensions.

71-gallon drum	Height (in.)			Width (in.)[a]		
	Style 1A & 1B	Style 2	Style 3	Style 1A & 1B	Style 2	Style 3
External	34.75	34.75	34.88	23.50	23.50	23.50
Internal	33.25	33.25	33.25	22.25	22.25	22.25

[a]Each equal side, including rolling hoop.

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Table 2.9-2. Materials/Methods of Construction. (2 pages)	
Style 1A & 1B[a]	
Body, head sheet	16 gauge steel
Cover (6 in.)	20 gauge steel
Gasket	Neoprene[b] foam, ASTM-D-1056-85
Threaded plug	2-in. MTP[c] Tri-sure,[d]
	2-in. pressed steel plug
	Neoprene gasket
Style 2	
Body, head sheet, and cover (18.250-in. diameter)	16 gauge steel
Bolted closure ring	12 gauge steel with 0.500-in. matched steel lugs and 0.500-in. bolt
Cover gasket	Neoprene, half-round tubular Mil-R-6855, Class 2, Grade 60 MS-27683-81
Threaded plug	Same as Style 1
Style 3	
Body and head (removable)	16 gauge steel
Cover gasket	Neoprene, half-round tubular
Bolted closure	12 gauge steel with 0.625-in. bolts (4)
Threaded plug	Same as Styles 1 and 2
NOTE: Drawings; Packaging Specialties: Style 1A-PN.225035WV71GC, Style 1B-PN.225035WVTST1, Style 2-PN.225035EGTST1 and Style 3-PN.225035OHTST1.	
[a]Style 1A has a welded collar and Style 1B has a rolled (one piece) collar against which the cover is crimped.	
[b]Neoprene is a trademark of E. I. duPont de Nemours.	
[c]MTP is a trademark of Moll Plasticrafters Limited Partnership.	
[d]Tri-Sure is a trademark of American Flange & Manufacturing Company, Inc.	

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Table 2.9-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-1.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-1.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-1.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Tests were conducted on all 3 styles of drums and demonstrated no inleakage of water. Further, the water spray test preceded each of the remaining Type A tests. In no case was there any effect on the ability of the packagings to meet the required tests. See Appendix D, Table D-1.b.
Free drop	Pass. Sixty-nine separate drop tests were conducted (22 on Styles 1A and 1B, 26 on Style 2, and 21 on Style 3). Drops were conducted on edges, top corners, bottom corners, and the ends. In all cases there was no loss of contents or major distortion of the packagings. See Appendix D, Table D-10.e.
Corner drop	Not Required.
Compression	Pass. The test was conducted on all three styles with greater than five times the gross weight for greater than 24 hr. There was no visible distortion of the packagings or loss of contents. See Appendix D, Table D-24.
Penetration	Pass. The test was conducted at several points on all three styles of the packagings with no significant effect. The tests on the bungs left no discernable mark. The impact on the centers of the covers resulted in a maximum dent of 0.25 in. The tests on the closure rings left no visible effect. See Appendix D, Table D-31.

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Table 2.9-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface sealing surface	Vendor qualifications and experience	Functional: • Ease of lid/closure ring application • Bolt closure ring--bolt size
Gasket		• Geometry, as specified • Size, material, geometry as specified Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces • Dimensions, as specified • Gasket size, materials, geometry
Welds		• Continuous, no sharp edges
Body and chime	Metal thickness	Lot tests by shipper, as appropriate. • Metal type, thickness, and quality as specified • Bolt number, locations, and materials as specified with appropriate vendor/shipper data/certification: - Marking - Test Data - Type A document provided as appropriate • Air leak as appropriate
	Protective coating application	Visual: • Surface/coating as specified • Lack of imperfections • Lack of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 3.1-1. Dimensions and Weights.						
Model		**Height (in.)**	**Width (in.)**	**Length (in.)**	**Authorized gross weight (lb)**	**Engineering drawing number**
S-0510-0823	Interior	51.00	48.375	82.375	7,000	S-0483-0510-0823-0104, sheets 1 and 2
	Exterior	54.00	54.000	88.000		
V-0510-0823	Interior	51.00	42.375	82.375	7,000	S-0483-0510-0823-0104, sheets 1 and 2
	Exterior	54.00	54.000	88.000		
S-0450-0846	Interior	45.00	39.625	84.625	5,240	S-0396-0450-0846-0104, sheets 1 and 6
	Exterior	48.00	45.000	90.000		
S-0730-0846	Interior	73.00	48.625	84.625	8,700	S-0486-0730-0846-0134, sheets 1 and 6
	Exterior	76.00	54.000	90.000		
S-0240-0906	Interior	24.00	48.375	90.625	3,672	S-0486-0240-0906-0104, sheets 1 and 6
	Exterior	27.00	54.000	96.000		
S-0480-0906	Interior	48.00	48.000	90.625	6,120	S-0486-0480-0906-0104, sheets 1 and 6
	Exterior	51.00	54.000	96.000		
S-0730-1006	Interior	73.00	48.625	100.625	10,400	S-0486-0730-1006-0134, sheets 1 and 6
	Exterior	76.00	54.000	106.000		
S-0480-1376	Interior	48.00	48.625	137.625	9,295	S-0486-0480-1376-0134, sheets 1 and 6
	Exterior	51.00	54.000	143.000		
S-0840-1440	Interior	84.00	72.000	144.000	22,700	S-0720-0840-1440-0187, sheets 1 and 6
	Exterior	86.75	77.375	149.375		

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Table 3.1-2. Materials/Method of Construction.

Model	Part	Description
V-0510-0823	Sides, top, ends, and bottom	12 gauge steel
S-0510-0823	Sides, top, and ends	12 gauge steel
S-0480-0906	Bottom	10 gauge steel
S-0240-0906		
S-0450-0844		
S-0730-1006	Sides, top, ends, and bottom	10 gauge steel
S-0730-0846		
S-0480-1376		
S-0840-1440	Sides, top, ends, and bottom	0.187-in. steel plate
	Continuous welds	0.187-in. structural members
	Bolt closure depends on box size	0.5 - 13 x 1.5 in.
		0.5 - 13 x 1.25 in.
		0.5 - 13 x 1 in.
	Gasket	2 in. x 0.25 in. Neoprene[a]
		30 durometer or high-density closed cell
	Filter	NucFil[b]
	Skids	

[a]Neoprene is a trademark of E. I. duPont de Nemours and Company.

[b]NucFil is a trademark of Nuclear Filter Technology, Inc.

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Table 3.1-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-2.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-2.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-3.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Test not conducted; however, this test would not adversely affect the ability of this packaging to meet the Type A test requirements and there would not be an inleakage of water. See Appendix D, Table D-2.
Free drop	Pass. This test was conducted on a top, lid corner (S-0518-0823, V-0510-0823, S-0840-1440 and S-0730-1006). There was no loss of contents or significant distortion of package geometry. The remaining packagings were evaluated by analysis based on the tested packages. See Appendix D, Table D-11.a.
Corner drop	Not required.
Compression	Pass. Tests were conducted with greater than five times the gross weight for 24 hr. There was no loss of contents or significant package distortion. These data were then used for analysis of similar packages. See Appendix D, Table D-25.
Penetration	Pass. Steel box--This test was successfully conducted on the top (middle) with only a minor dent.
	Filter--Tests were conducted with impacts directly on the filter top. Only a minor dent resulted, and there was no loss of contents or containment in either the filter or the filter housing. See Appendix D, Table D-32.

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Table 3.1-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid application • Flange--flat surface; no foreign matter • Geometry, as specified Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces • Dimensions, as specified
Gasket		• Gasket size, materials, geometry
Weld areas		• Continuous welds, no sharp edges
Body	Metal thickness Bolt size and spacing	Lot tests by shipper, as appropriate, and/or vendor certification.
Air leak tests	Protective coating	Visual: • Surface/coating as specified • Lack of imperfections in application • Lack of rust, dents, nicks
Filter Type Efficiency, flow characteristics	Filter location and installation	Acceptable Conditions: • Filter free-flowing • Filter securely installed

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 3.2-1. Dimensions and Weights.

Model		Height (in.)	Width (in.)	Length (in.)	Authorized gross weight (lb)	Engineering drawing number
B-96-5-S/L-FD	Exterior	52.000	48.625	93.375	6,050	01-2101-1-00, Revision 0
	Interior	44.000	43.000	88.000		
B-96-5-S/L-RA	Exterior	52.000	48.625	93.625	6,800	01-1901-1-00, Revision 0
	Interior	44.000	43.000	88.000		
B-96-5-RA-B	Exterior	51.254	47.250	92.250	6,500	01-2201-1-01, Revision 0
	Interior	44.000	43.000	88.000		
B-96-5-FD-B	Exterior	51.250	47.250	92.250	6,500	01-2301-1-01, Revision 0
	Interior	44.000	43.000	88.000		
467-C-S/L FD TRU waste container	Exterior	38.500	54.000	68.000	4,000	01-3700-1-00, Revision C
	Interior	33.500	52.000	66.000		
B-12-44-4-S/L FD	Exterior	28.250	51.625	77.625	4,625	01-3100-1-00, Revision B
	Interior	23.000	46.000	72.000		
B-25-4-S/L FD	Exterior	52.187	48.625	75.625	4,820	01-2800-1-00, Revision C
	Interior	47.000	43.000	70.000		
B-52-4-S/L FD	Exterior	43.187	54.625	54.625	4,775	04-1000-1-00, Revision F
	Interior	38.000	49.000	49.000		
B-82-6-S/L FD	Exterior	52.187	47.187	74.187	6,775	01-2300-1-00, Revision 0
	Interior	47.000	43.000	70.000		
B-87-6-S/L FD	Exterior	43.187	57.625	81.625	6,970	04-1300-1-00, Revision B
	Interior	38.000	52.000	76.000		
B-96-6-S/L FD	Exterior	48.1876	48.567	93.567	7,000	04-1200-1-00, Revision 0
	Interior	44.000	43.000	88.000		
B-96-8-S/L FD	Exterior	48.187	48.567	93.567	9,100	04-1200-2-0, Revision 0
	Interior	44.000	43.000	88.000		

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Table 3.2-2. Materials/Method of Construction.	
Sides, top, ends, and bottom	12 gauge steel, ASTM A569 low-carbon hot rolled steel
Closure	Seal-loc[a] or bolt depending on box style
Gasket	Closed cell Neoprene[b] (Mil R-6130-B)
Sealant	Scotch No. 776 (Mil D-17951-B)
Filter	NucFil[c]
[a]Seal-loc is a trademark of Container Products Corporation.	
[b]Neoprene is a trademark of E. I. duPont de Nemours and Company.	
[c]NucFil is a trademark of Nuclear Filter Technology, Inc.	
ASTM = American Society for Testing and Materials.	

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Table 3.2-3. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-2.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-2.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-3.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Test not conducted; however, this test would not adversely affect the ability of this packaging to meet the Type A test requirements and there would be no inleakage of water. See Appendix D, Table D-2.
Free drop	Pass. This test was conducted on a top, lid corner (four individual boxes). There was no loss of contents or significant distortion of package geometry. The remaining packages were evaluated by analysis based on the tested packages. See Appendix D, Table D-11.a.
Corner drop	Not required.
Compression	Pass. Tests were conducted with greater than five times the gross weight for 24 hr. There was no significant effect. There was no loss of contents or significant package distortion. These data were then used for analysis of similar packages. See Appendix D, Table D-25.
Penetration	Pass. Steel box--Tests were successfully conducted on the box itself with only minor dents resulting.
	Filter--Tests were conducted with impacts on the filter top. Only a minor dent resulted, and there was no loss of contents or containment in either the filter or the filter housing. See Appendix D, Table D-32.

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Table 3.2-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid application • Flange--flat surface; no foreign matter • Geometry, as specified Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces • Dimensions, as specified
Gasket		• Gasket size, materials, geometry
Weld areas		• Continuous welds, no sharp edges
Body	Metal thickness Bolt size and spacing	Lot tests by shipper, as appropriate, and/or vendor data/verification: • Marking • Test data • Type A Certification Document as appropriate Visual: • Surface/coating as specified • Lack of imperfections in application
Air leak tests	Protective coating	• Lack of rust, dents, nicks
Filter Type Efficiency, flow characteristics	Filter location and installation	Acceptable Conditions: • Filter free-flowing • Filter securely installed

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 3.3-1. Dimensions and Weights.						
Model		**Height (in.)**	**Width (in.)**	**Length (in.)**	**Authorized gross weight (lb)**	**Engineering drawing number**
R-1	Interior	38.5	38.5	68.0	7,750	RENS - 031, Revision 0
	Exterior	42.5	41.5	71.0		
R-2	Interior	38.5	54.0	68.0	7,820	RENS - 032, Revision 0
	Exterior	52.5	57.0	71.0		
R-3	Interior	54.0	54.0	88.0	7,920	RENS - 034, Revision 2
	Exterior	58.0	57.0	91.0		
R-4	Interior	48.0	48.0	84.0	7,920	RENS - 036, Revision 0
	Exterior	52.0	51.0	87.0		

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Table 3.3-2. Materials/Method of Construction.	
Sides, top, ends, and bottom	14 gauge steel
Skids	14 gauge steel
Bolt closure	0.5-in. diameter x 5 in. long - 28 required
Gasket	0.25 in. x 1.75 in. Neoprene[a]
All seams welded except closure	
Filter	NucFil[b]
[a]Neoprene is a trademark of E. I. duPont de Nemours and Company.	
[b]NucFil is a trademark of Nuclear Filter Technology, Inc.	

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Table 3.3-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-2.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-2.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-3.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Test not conducted; however, this test would not adversely affect the ability of this packaging to meet the Type A test requirements, and there would be no inleakage of water. See Appendix D, Table D-2.
Free drop	Pass. This test was conducted on a top, lid corner. There was no loss of contents or significant deformation of package geometry. See Appendix D, Table D-11.a.
Corner drop	Not required.
Compression	Pass. Tests were conducted with greater than five times the gross weight for 24 hr with no distortion of the package geometry. See Appendix D, Table D-25.
Penetration	Pass. Steel box--This test was successfully conducted on the top (middle) with only a minor dent.
	Filter--Tests were conducted with impacts on the filter top. Only a minor dent resulted, and there was no loss of contents or containment in either the filter or the filter housing. See Appendix D, Table D-32.

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Table 3.3-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid application • Flange--flat surface; no foreign matter • Geometry, as specified Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces
Gasket		• Dimensions, as specified • Gasket size, materials, geometry
Weld areas		• Continuous welds, no sharp edges
Body	Metal thickness Bolt size and spacing	Lot tests by shipper, as appropriate, and/or vendor data/verification: • Marking • Test data • Type A Certification Document provided as appropriate
Air leak tests	Protective coating application	Visual: • Surface/coating as specified • Lack of imperfections in application • Lack of rust, dents, nicks
Filter Type Efficiency, flow characteristics	Filter location and installation	Acceptable Conditions: • Filter free-flowing • Filter securely installed

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 3.4-1. Dimensions and Weights.				
Model	**Height (in.)**	**Width (in.)**	**Length (in.)**	**Authorized gross weight (lb)**
Style 1	54.00	54.00	88.00	7,000
Style 2	48.00	48.00	84.00	6,000
Style 3	38.50	50.50	74.50	6,000
Style 4	38.50	54.00	68.00	6,000

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Table 3.4-2. Materials/Method of Construction.	
Sides, top, ends, and bottom	14 gauge mild steel
Lifting loops	0.25-in. low-carbon steel
Pipe coupling and plugs	Carbon steel
All seams continuous welds	--
Closure is welded	--
Filter (if used, not required)	NucFil*
*NucFil is a trademark of Nuclear Filter Technology, Inc.	

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Table 3.4-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-2.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-2.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-3.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Test not conducted; however, this test would not adversely affect the ability of this packaging to meet the Type A test requirements, and there would be no inleakage of water. See Appendix D, Table D-2.
Free drop	Pass. Tests on each box size were performed with varying drop angles and impact points. There was no loss of contents or significant deformation of package geometry. See Appendix D, Table D-11.a.
Corner drop	Not required.
Compression	Pass. Both static and dynamic compression tests were conducted at up to 36,700 lb for 24 hr. See Appendix D, Table D-25.
Penetration	Pass. The test was performed on the center of the top of each container with a resulting dent of 0.125 in., which had no effect on container integrity.
	NOTE: For Nuclear Filter Technology filters, if used, the penetration test has routinely been done. See Appendix D, Table D-32.

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Table 3.4-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid application • Flange--flat surface; no foreign matter • Geometry, as specified Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces
Gasket		• Dimensions, as specified • Gasket size, materials, geometry
Weld areas		• Continuous welds, no sharp edges
Body	Metal thickness Bolt size and spacing	Lot tests by shipper, as appropriate, and/or vendor data/verification: • Marking • Test data • Type A certification document provided as appropriate
Air leak tests	Protective coating	Visual: • Surface/coating as specified • Lack of imperfections in application • Lack of rust, dents, nicks
Filter Type Efficiency, flow characteristics	Filter location and installation	Acceptable Conditions: • Filter free-flowing • Filter securely installed

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Table 3.5-1. Dimensions.			
Model	**Height (in.)**	**Width (in.)**	**Length (in.)**
ANL M-4	72.375	58.375	50.375

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Table 3.5-2. Materials/Method of Construction.	
Body	18 gauge
Cover	9 gauge
Bolts	0.312-in. hex head screws (34 required)
Neoprene* gasket	0.187 in. x 1.75 in.
Welded seams (except cover)	--
*Neoprene is a trademark of E. I. duPont de Nemours and Company.	

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Table 3.5-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-2.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-2.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-3.
	NOTE: This packaging failed the reduced pressure test without the RTV or equivalent.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was not conducted; however, this test would not adversely affect the ability of this packaging to meet the Type A test requirements and there would be no inleakage of water. See Appendix D, Table D-2.
Free drop	Pass. Tests conducted. There was no loss of contents or significant deformation of package geometry. See Appendix D, Table D-11.a.
Corner drop	Not required.
Compression	Pass. By reference to tests conducted on M-3 steel bin. See Appendix D, Table D-25.
Penetration	Pass. Test conducted with only minor dents resulting. See Appendix D, Table D-32.
RTV = room temperature vulcanizing.	

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Table 3.5-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/ inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid application • Flange--flat surface; no foreign matter • Geometry, as specified Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces • Dimensions, as specified
Gasket		• Gasket size, materials, geometry
Weld areas		• Continuous welds, no sharp edges
Body	Metal thickness Bolt size and spacing	Lot tests by shipper, as appropriate, and/or vendor certification: • Marking • Test data • Type A Certification Document provided as appropriate • Air leak test
Air leak tests	Protective coating application	Visual: • Surface/coating as specified • Lack of imperfections in application • Lack of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 3.6-1. Dimensions.				
Model		**Height (in.)**	**Width (in.)**	**Length (in.)**
ANL-W steel box	Interior	9.000	13	19
	Exterior	11.375	16	22

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Table 3.6-2. Materials/Method of Construction.	
Body and lid	0.187-in. steel
All joints (except closure)	Continuous fillet welds
Bolts	0.312-in. diameter on approximately 3.5-in. spacings
Gaskets	Not required
NOTE: Drawing No. A 1000-0037-DD-00.	

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Table 3.6-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-2.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-2.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-3.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was not conducted; however, this test would not adversely affect the ability of this packaging to meet the Type A test requirements. See Section 3.6.3, Restrictions/Specifications, and Appendix D, Table D-2.
Free drop	Pass. This test was conducted and there was no loss of contents and no detectable change in package geometry. The contents were pieces of lead. See Appendix D, Table D-11.a.
Corner drop	Not required.
Compression	Pass. This test was conducted with 4,800 lb for 24 hr with no detectable effect on the packaging. See Appendix D, Table D-25.
Penetration	Pass. This test was conducted and had no significant effect. See Appendix D, Table D-32.

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Table 3.6-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/ inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid application • Flange--flat surface; no foreign matter • Geometry, as specified Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces • Dimensions, as specified
Weld areas		• Continuous welds, no sharp edges
Body	Metal thickness Bolt size and spacing	Lot tests by shipper, as appropriate, and/or vendor certification: • Marking • Test data • Type A Certification Document provided as appropriate • Air leak test
	Protective coating	Visual: • Surface/coating as specified • Lack of imperfections in application • Lack of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 3.7-1. Dimensions and Weights.					
Model		**Height (in.)**	**Width (in.)**	**Length (in.)**	**Empty package weight (lb)**
TRUPACT-II standard waste box	External	37.0	54.5	71.0	640
	Internal	36.7	52.0	68.7	640

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Table 3.7-2. Materials/Method of Construction.

Sides, top, ends and bottom	10-gauge, ASTM A569 low carbon hot rolled steel
Steel flat bar	ASTM A-36 commercial quality structural grade
Rectangular tubing	ASTM A-500 or ASTM A-513 commercial quality structural grade carbon steel
Closure	Bolted, 1/2-in. flat head cap screws MS 24667
Gasket	EPDM material, 1/2 in. thick, 1 1/2 in. wide, ASTM-D-1056-67
Filter	NFTI Model NucFil*-013

NOTE: Information for the Standard Waste Box designs discussed in this section are applicable for revisions up to and including Revision E (Westinghouse Electric Drawing No. 165-F-001-W). For current design, test, and evaluation information, see DOE/RL-96-57, Vol. 2, Section 3.2.

*NucFil is a trademark of Nuclear Filter Technology, Inc. (NFTI)

ASTM = American Society for Testing and Materials.

EPDM = ethylenepropylenediene-monomer.

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Table 3.7-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-2.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-2.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-3.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Tests were conducted which demonstrated no inleakage of water. The water spray test preceded each of the remaining tests. In no case was there any effect on the ability of the packaging to meet the remaining tests. See Appendix D, Table D-2.
Free drop	Pass. Four separate drop tests were conducted on top and bottom corners and on the ends. In all cases there was no loss of contents or significant distortion of the packagings. See Appendix D, Table D-11.b.
Corner drop	Not required.
Compression	Pass. The test was conducted with greater than five times the gross weight for more than 24 hr. There was no significant distortion of the packaging or loss of contents. See Appendix D, Table D-25.
Penetration	Pass. The test was conducted on the top center of the packaging with no significant effect. The test was also done with the bar hitting the filter housing. Again there was no significant effect. The test on the top of the cover left no discernable mark and the impact on the filter housing left only a scuff mark. An ultraviolet inspection indicated no leakage of contents. See Appendix D, Table D-32.

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Table 3.7-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/ inspection criteria*
Lid/body interface Sealing surface	Vendor qualification and experience	Functional: • Ease of lid application • Flange--flat surface; no foreign matter
Gasket		• Geometry as specified • Size, material, geometry as specified Acceptable conditions: • Lack of dents, no deformation of sealing surfaces • Dimensions as specified
Welds		• Continuous, no sharp edges
Body		• Metal type, thickness, and quality as specified • Bolt number, locations, and materials as specified Lot test by shipper as appropriate and/or vendor data/certification: • Marking • Test data • Type A certification document provided as appropriate
	Protective coating	Visual: • Surface coating as specified • Lack of imperfections • Lack of rust, dents, nicks

Filter	Acceptable: • Type, location, and installation as specified

*These criteria apply to first-time and to reuse as a DOT-7A Type A packaging.

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Table 3.8-1. Dimensions and Weights.					
Model	**Height (in.)**	**Width (in.)**	**Length (in.)**	**Packaging empty weight (lb)**	
External	50.25	46.00	72.00	Vented	1,150
Internal	47.00	45.75	71.75	Nonvented	1,230

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Table 3.8-2. Materials/Method of Construction.		
Major components	**Material**	**Thickness**
Sides, ends, bottom	ASTM A569 Steel	11 gauge
Top	ASTM A36 Steel	0.250 in.
Bracing	ASTM A36 Steel	Varies
Square tubing	ASTM A501 or A500B	0.500 in. x 0.500 in. x 0.250 in.
Gasket	Nitrile BUNA-N MIL R-3065	0.500 in. x 0.500 in. x 19.333 ft.
Lid bolts	Grade 5 Steel A449	0.375-16 UNC x 1 in. 0.500-13 UNC x 1 in.
NOTES: Container is continuously welded construction with a bolted lid. Filter: NFTI NucFil-013 carbon composite filter (vented container only). Drawings: Martin Marietta Energy Systems, Inc., DPME-13053-B755, Rev. A, Vented Container and DPME-13053-B756, Rev. A, Nonvented Container.		
ASTM = American Society for Testing and Materials.		

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Table 3.8-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-2.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-2.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-3.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Drop test was conducted and there was no inleakage of water and no features on the package that would retain free-standing water. See Appendix D, Table D-2.
Free drop	Pass. Drop tests from a height of 4 ft were conducted as follows: • Flat on top lid • Flat on end containing filter • Center of gravity over struck corner with top end facing down • Center of gravity over struck corner with bottom end facing down. See Appendix D, Table D-11.a.
Corner drop	Not required.
Compression	Pass. A compressive load of 42,475 lb was applied to the package for 24 hr. See Appendix D, Table D-25.
Penetration	Pass. The 1.25-in.-diameter, 13.2-lb penetration bar was dropped from a height of 40 in. on the top of the container. See Appendix D, Table D-32.

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Table 3.8-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualification and experience	Functional: • Ease of lid application • Flange--flat surface; no foreign matter
Gasket		• Geometry as specified • Size, material, geometry as specified Acceptable conditions • Lack of dents, no deformation of sealing surfaces • Dimensions as specified
Welds		• Continuous, no sharp edges
Body		• Metal type, thickness, and quality as specified • Bolt number, locations, and materials as specified • Lot test by shipper as appropriate and/or vendor data/certification: - Marking - Test data - Type a certification document provided as appropriate
	Protective coating	Visual • Surface coating as specified • Lack of imperfections • Lack of rust, dents, nicks.
Filter		Acceptable • Type, location, and installation as specified.

*These criteria apply to first-time and to reuse as a DOT-7A Type A packaging.

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Table 4.1-1. Dimensions and Weights.				
Model	**Height (in.)**	**Width (in.)**	**Length (in.)**	**Authorized gross weight (lb)**
ANL-7A-217[a]	10.75	14.5	22	217
ANL-7A-375[b]	10.00	32.0	60	375
ANL-7A-670[c]	38.00	33.0	33	670
ANL-7A-880[d]	18.00[g]	19.0	136	880
ANL-7A-995[e]	18.00[g]	19.0	166	995
ANL-7A-1315[f]	21.00[h]	20.0	38	1,315
[a]See ANL-W container design SPM-AP-1.				
[b]See ANL-W container design SPM-PS-5.				
[c]See ANL-W container design SPM-PS-8.				
[d]See ANL-W container design SPM-HFEF-1.				
[e]See ANL-W W0093-0812-EE-01.				
[f]See ANL-W container design SPM-PS-9.				
[g]Height does not include skids.				
[h]Height includes skids.				

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Table 4.1-2. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-3.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-3.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-5.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Tests conducted on representative packagings demonstrated that this test did not affect the ability of the packaging to meet other Type A test requirements. With the actions required in Section 4.1.3, Restrictions/Specifications, these packagings also satisfy this test requirement with respect to potential inleakage of water. See Appendix D, Table D-3.
Free drop	Pass. This drop was made on the top corner with the boxes inverted. There was no loss of contents and no significant change in packaging geometry. See Appendix D, Table D-12.
Corner drop	Not required.
Compression	Pass. The tests were conducted with greater than five times the gross weight for 24 hr, shown in Table 4.1-1. There was no detectable effect. See Appendix D, Table D-26.
Penetration	Pass. This test was conducted on each package with no significant effect. See Appendix D, Table D-33.

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Table 4.1-3. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid application • Mating surfaces flat and smooth, no foreign matter • Geometry, as specified Acceptable conditions:
	Joints/seams	• Dimensions, as specified • Glued
	Closure	• As specified, nail or screw • Caulking on lid • Steel banding of proper size and location
	Vendor qualification and experience	Vendor data as appropriate. Lot tests/inspections as appropriate by shipper.

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 4.2-1. Dimensions.		
Height (in.)	**Width (in.)**	**Length (in.)**
48*	48	84
*Does not include lid or skids.		

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Table 4.2-2. Materials/Method of Construction.	
Interior frame	2-in. x 4-in. pine
Sub-flooring	2-in. x 8-in. pine planks (Grade A)
Sides, top, lid	0.75-in. A/B plywood
Inner flooring	0.5-in. A/B plywood
Staples	1.75-in. 15-gauge with 6-in. spacing
Joints/seams	All except floor planks glued
Steel band	3 steel bands (1.25 in. wide) around sides and ends
	4 steel bands (0.75 in. wide) around top, sides, and bottom

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Table 4.2-3. Regulatory Compliance Assessment.

Regulatory Requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-3.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-3.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-5.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Tests conducted on representative packagings demonstrated that this test did not affect the ability of the packaging to meet other Type A test requirements. With the actions required in Section 4.2.3, Restrictions/Specifications, these packagings also satisfy this test requirement with respect to potential inleakage of water. See Appendix D, Table D-3.
Free drop	Pass. This drop was made on the top corner with the box inverted and held at a 45° angle. There was no loss of contents and no significant change in packaging geometry. See Appendix D, Table D-12.
Corner drop	Not required.
Compression	Pass. This test was conducted with greater than five times the gross weight shown in Section 4.2.2.1.2 for 24 hr. There was no detectable effect. See Appendix D, Table D-26.
Penetration	Pass. This test was conducted on each package with no significant effect. See Appendix D, Table D-33.

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Table 4.2-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid application • Mating surfaces flat and smooth, no foreign matter • Geometry, as specified Acceptable Conditions:
	Joints/seams	• Dimensions, as specified • Glued
	Closure	• As specified, nail or screw • Caulking on lid • Steel banding of proper size and location • Nail-type and spacing
	Vendor qualifications and experience	Vendor data as appropriate. Lot tests/inspections as appropriate by shipper.

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 4.3-1. Dimensions and Weights.				
Model	**Height (in.)**	**Width (in.)**	**Length (in.)**	**Authorized gross weight (lb)**
MA-1	8	8	8	40
MA-2	8	8	36	100
MA-3	12	12	12	100
MA-4	12	12	36	100

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Table 4.3-2. Materials/Method of Construction.	
Sides, ends, top, and bottom	0.75-in. exterior grade plywood
Interior frame	Corner posts, 2-in. x 2-in. pine
	Braces, 2-in. x 0.75-in. pine
Nailed construction	Nails, 1.5, 2, and 3 in., depending on thickness of material
	Nail spacing approximately 2 in.
All seams/joints glued	
Steel banding (0.5 in.)	2 bands around sides and ends
	2 bands around top, ends, and bottom
	x band, as appropriate, to provide bands (top to bottom) at least every 18 in. around package
Closure (optional)	May be nail or screw closure
	Nails (see above)
	Screws, 2-in. and 3-in. No. 10 screws depending on thickness of material

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Table 4.3-3. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-3.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-3.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-5.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Tests conducted on representative packagings demonstrated that this test did not affect the ability of the packaging to meet other Type A test requirements. With the actions required in Section 4.4.3, Restrictions/Specifications, these packagings also satisfy this test requirement with respect to potential inleakage of water. See Appendix D, Table D-4.
Free drop	Pass. This drop was made on the top corner with the boxes inverted and held at a 45° angle. There was no loss of contents and no significant change in packaging geometry. See Appendix D, Table D-13.a.
Corner drop	The corner drop was conducted on all four packagings. This allows their potential use at less than 110 lb. See Appendix D, Table D-21.
Compression	Pass. The tests were conducted with greater than five times the gross weight for 24 hr, shown in Table 4.3-1. There was no detectable effect. See Appendix D, Table D-26.
Penetration	Pass. This test was conducted on each package with no significant effect. See Appendix D, Table D-33.

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Table 4.3-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid application • Mating surfaces flat and smooth, no foreign matter • Geometry, as specified Acceptable conditions:
	Joints/seams	• Dimensions, as specified • Glued
	Closure	• As specified, nail or screw • Caulking on lid • Steel banding of proper size and location • Nail-type and spacing
	Vendor qualifications and experience	Vendor data as appropriate. Lot tests/inspections as appropriate by shipper.

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 4.4-1. Dimensions and Weights.				
Model	**Height (in.)**	**Width (in.)**	**Length (in.)**	**Authorized gross weight (lb)**
MA-1	12	12	12	150
MA-2	16	16	16	150
MA-3	24	24	24	200
MA-4	12	12	36	150
MA-5	16	16	36	150
MA-6	24	24	36	200

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Table 4.4-2. Materials/Method of Construction.	
Sides, ends, top, and bottom	0.75-in. exterior grade plywood
Interior frame	2-in. x 4-in. pine
Nailed construction	Nails, 1.5, 2, and 3 in., depending on thickness of material
	Nail spacing approximately 2 in.
All seams/joints glued	
Steel banding (0.5 in.)	2 bands around sides and ends
	2 bands around top, ends, and bottom
	x band, as appropriate, to provide bands (top to bottom) at least every 18 in. around package
Closure (optional)	May be nail or screw closure
	Nails (see above)
	Screws, 2-in and 3-in. No. 10 screws, depending on thickness of material

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Table 4.4-3. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-3.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-3.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-5.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Tests conducted on representative packagings demonstrated that this test did not affect the ability of the packaging to meet other Type A test requirements. With the actions required in Section 4.4.3, Restrictions/Specifications, these packagings also satisfy this test requirement with respect to potential inleakage of water. See Appendix D, Table D-4.
Free drop	Pass. This drop was made on the top corner with the box inverted and held at a 45° angle. There was no loss of contents and no significant change in packaging geometry. See Appendix D, Table D-13.a.
Corner drop	Corner drop was conducted on all six packagings. This allows their potential use at less than 110 lb. See Appendix D, Table D-21.
Compression	Pass. The tests were conducted with greater than five times the gross weight for 24 hr, shown in Table 4.4-1. There was no detectable effect. See Appendix D, Table D-26.
Penetration	Pass. This test was conducted on each package with no significant effect. See Appendix D, Table D-33.

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Table 4.4-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid application • Mating surfaces flat and smooth, no foreign matter • Geometry, as specified
	Joints/seams	Acceptable conditions: • Dimensions, as specified • Glued
	Closure	• As specified, nail or screw • Caulking on lid • Steel banding of proper size and location • Nail-type and spacing
	Vendor qualifications and experience	Vendor data as appropriate. Lot tests/inspections as appropriate by shipper.

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 4.5-1. Dimensions and Weights.				
Model	**Height (in.)**	**Width (in.)**	**Length (in.)**	**Authorized gross weight (lb)**
MC-1	12	12	12	150
MC-2	24	24	24	300
MC-3	14	14	22	250
MC-4	6	6	24	100
MC-5	12	12	36	150

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Table 4.5-2. Materials/Method of Construction.	
Sides, ends, top, and bottom	0.75-in. exterior grade plywood
Interior frame	2-in. x 4-in. pine
Nailed construction	Nails, 1.5, 2, and 3 in., depending on thickness of material
	Nail spacing approximately 2 in.
All seams/joints glued	
Steel banding (0.5 in.)	2 bands around sides and ends
	2 bands around top, ends, and bottom
	x band, as appropriate, to provide bands (top to bottom) at least every 18 in. around package
Closure (optional)	May be nail or screw closure
	Nails (see above)
	Screws, 2-in and 3-in. No. 10 screws, depending on thickness of material

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Table 4.5-3. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-3.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-3.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-5.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Tests conducted on representative packagings demonstrated that this test did not affect the ability of the packaging to meet other Type A test requirements. With the actions required in Section 4.5.3, Restrictions/Specifications, these packagings also satisfy this test requirement with respect to potential inleakage of water. See Appendix D, Table D-4.
Free drop	Pass. This drop was made on the top corner with the boxes inverted and held at a 45° angle. There was no loss of contents and no significant change in packaging geometry. See Appendix D, Table D-13.a.
Corner drop	The corner drop was conducted on all five packagings. This allows their potential use at less than 110 lb. See Appendix D, Table D-21.
Compression	Pass. The tests were conducted with greater than five times the gross weight for 24 hr, shown in Table 4.5-1. There was no detectable effect. See Appendix D, Table D-26.
Penetration	Pass. This test was conducted on each package with no significant effect. See Appendix D, Table D-33.

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Table 4.5-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid application • Mating surfaces flat and smooth, no foreign matter • Geometry, as specified Acceptable conditions:
	Joints/seams	• Dimensions, as specified • Glued
	Closure	• As specified, nail or screw • Caulking on lid • Steel banding of proper size and location • Nail-type and spacing
	Vendor qualification and experience	Vendor data as appropriate. Lot tests/inspections as appropriate by shipper.

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 4.6-1. Dimensions and Weights.				
Model	**Height (in.)**	**Width (in.)**	**Length (in.)**	**Authorized gross weight (lb)**
MD-1	14	17.5	14	200
MD-2	24	27.5	24	300
MD-3	12	15.5	48	250
MD-4	12	15.5	60	250
MD-5	8	11.5	32	200
MD-6	12	15.5	28	200

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Table 4.6-2. Materials/Method of Construction.	
Sides, ends, top, and bottom	0.75-in. exterior grade plywood
Interior frame	2-in. x 4-in. pine
Nailed construction	Nails, 1.5, 2, and 3 in., depending on thickness of material
	Nail spacing approximately 2 in.
All seams/joints glued	
Steel banding (0.5 in.)	2 bands around sides and ends
	2 bands around top, ends, and bottom
	x band, as appropriate, to provide bands (top to bottom) at least every 18 in. around package
Closure (optional)	May be nail or screw closure
	Nails (see above)
	Screws, 2-in. and 3-in. No. 10 screws, depending on thickness of material

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Table 4.6-3. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-3.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-3.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-5.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Tests conducted on representative packagings demonstrated that this test did not affect the ability of the packaging to meet other Type A test requirements. With the actions required in Section 4.6.3, Restrictions/Specifications, these packagings also satisfy this test requirement with respect to potential inleakage of water. See Appendix D, Table D-4.
Free drop	Pass. This drop was made on the top corner with the boxes inverted and held at a 45° angle. There was no loss of contents and no significant change in packaging geometry. See Appendix D, Table D-13.a.
Corner drop	The corner drop was conducted on all six packagings. This allows their potential use at less than 110 lb. See Appendix D, Table D-21.
Compression	Pass. The tests were conducted with greater than five times the gross weight for 24 hr, shown in Table 4.6-1. There was no detectable effect. See Appendix D, Table D-26.
Penetration	Pass. This test was conducted on each package with no significant effect. See Appendix D, Table D-33.

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Table 4.6-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid application • Mating surfaces flat and smooth, no foreign matter • Geometry, as specified Acceptable conditions:
	Joints/seams	• Dimensions, as specified • Glued
	Closure	• As specified, nail or screw • Caulking on lid • Steel banding of proper size and location • Nail-type and spacing
	Vendor qualification and experience	Vendor data as appropriate. Lot tests/inspections as appropriate by shipper.

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 4.7-1. Dimensions.			
Model	**Height (in.)**	**Width (in.)**	**Length (in.)**
ME-1	17	15	18.5
ME-2	13	17	20.5
ME-3	21	21	22.5

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Table 4.7-2. Materials/Method of Construction.	
Sides, ends, top, and bottom	0.75-in. exterior grade plywood
Cleats	0.75-in. x 0.5-in. pine
Interior frame	2-in. x 4-in. pine
Nailed construction	Nails, 1.5, 2, and 3 in. depending on thickness of material
	Nail spacing approximately 2 in.
All seams/joints glued	
Steel banding (0.5 in.)	2 bands around sides and ends
	2 bands around top, ends, and bottom
	x band, as appropriate, to provide bands (top to bottom) at least every 18 in. around package
Closure (optional)	May be nail or screw closure
	Nails (see above)
	Screws, 2-in. and 3-in. No. 10 screws depending on thickness of material

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Table 4.7-3. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-3.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-3.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-5.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Tests conducted on representative packagings demonstrated that this test did not affect the ability of the packaging to meet other Type A test requirements. With the actions required in Section 4.7.3, Restrictions/Specifications, these packagings also satisfy this test requirement with respect to potential inleakage of water. See Appendix D, Table D-4.
Free drop	Pass. This drop was made on the top corner with the boxes inverted and held at a 45° angle. There was no loss of contents and no significant change in packaging geometry. See Appendix D, Table D-13.a.
Corner drop	The corner drop was conducted on two of the packagings. This allows their potential use at less than 110 lb. See Appendix D, Table D-21.
Compression	Pass. The tests were conducted with greater than five times the gross weight given in Section 4.7.2.1.2 for 24 hr. There was no detectable effect. See Appendix D, Table D-26.
Penetration	Pass. This test was conducted on each package with no significant effect. See Appendix D, Table D-33.

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Table 4.7-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid application • Mating surfaces flat and smooth, no foreign matter • Geometry, as specified Acceptable conditions:
	Joints/seams	• Dimensions, as specified • Glued
	Closure	• As specified, nail or screw • Caulking on lid • Steel banding of proper size and location • Nail-type and spacing
	Vendor qualification and experience	Vendor data as appropriate. Lot tests/inspections as appropriate by shipper.

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 4.8-1. Dimensions and Weights.

Model	External dimension				Internal dimension			Empty weight (lb)	Authorized gross weight (lb)
	Width (in.)	Length (in.)	Height (in.)	Skid (in.)	Width (in.)	Length (in.)	Height (in.)		
G-4214	16.375	34.50	10.500	4.000	14.125	30.00	8.372	55	1,805
G-4245	12.250	18.50	10.000	3.250	10.000	14.00	8.500	25	250
G-4255	25.625	35.00	9.750	3.250	24.125	30.75	8.000	120	1,500
G-4273	27.000	41.25	13.750	3.250	25.500	37.00	12.000	140	3,250
G-4292	16.375	34.50	18.125	3.625	14.125	30.00	16.125	80	852

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Table 4.8-2. Materials/Method of Construction.	
Drawing No. NLO-G-4214 and G-4292	
Sides and ends	1.125-in. thick white pine
Bottom	1-in. hardwood
Lids	2, 0.5-in. plywood
Banding	See drawing, 1.25-in. steel
Skids	3 wooden, 3.625 in. or 4 in.
Drawing No. NLO-G-4245	
Lid	1, 0.5-in. plywood
Banding	2 vertical and 2 horizontal
Skids	3.25 in.
Drawing No. NLO-G-4255 and G-4273	
All construction	0.75-in. exterior grade plywood
Skids	3 wooden, 3.625 in. or 4 in.

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Table 4.8-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-3.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-3.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-5.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Tests conducted on representative packagings demonstrated that this test did not affect the ability of the packaging to meet other Type A test requirements. With the actions required in Section 4.8.3, Restrictions/Specifications, these packagings also satisfy this test requirement with respect to potential inleakage of water. See Appendix D, Table D-5.
Free drop	Pass. By analysis and comparison to tests conducted on G-4214 loaded with 1,750 lb and dropped 30 ft. No significant distortion of package geometry or loss of contents would result. See Appendix D, Table D-14.
Corner drop	Not required.
Compression	Pass. By analysis and comparison to test conducted at 9,050 lb. No distortion or loss of contents would result. See Appendix D, Table D-26.
Penetration	Pass. This test was conducted on each package with no significant effect. See Appendix D, Table D-33.

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Table 4.8-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid application • Mating surfaces flat and smooth, no foreign matter • Geometry, as specified Acceptable conditions:
	Joints/seams	• Dimensions, as specified • Glued
	Closure	• As specified, nail or screw • Caulking on lid • Steel banding of proper size and location • Nail-type and spacing
	Vendor qualification and experience	Vendor data as appropriate. Lot tests/inspections as appropriate by shipper.

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 4.9-1. Dimensions.				
Model		**Height (in.)**	**Width (in.)**	**Length (in.)**
B-1	Interior	26.000	18.0	18.0
	Exterior	27.875	19.5	19.5
B-2	Interior	26.000	20.0	20.0
	Exterior	27.875	21.5	21.5
B-3	Interior	18.000	24.0	24.0
	Exterior	19.875	25.5	25.5
B-4	Interior	30.000	26.0	26.0
	Exterior	31.750	27.5	27.5
B-5	Interior	36.000	30.0	30.0
	Exterior	37.750	31.5	31.5
B-6	Interior	12.000	20.0	20.0
	Exterior	13.750	21.5	21.5
B-7	Interior	36.000	24.0	24.0
	Exterior	37.875	25.5	25.5
B-8	Interior	26.000	24.0	24.0
	Exterior	27.750	25.5	25.5

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Table 4.9-2. Materials/Methods of Construction.	
Sides, ends, top, and bottom	0.75-in. exterior grade plywood
All joints nailed and glued	
Nails	Cement coated
Steel banding	0.75 in., 6 required
Corner angles	2 in. x 2 in. x 0.125 in.
Ethafoam*	0.25 in.
Corner braces (inside and triangular)	1 in each corner, 4 in. x 4 in.
NOTE: See Martin Marietta Energy Systems (MMES) Drawing No. T2E-123911.	
*Ethafoam is a trademark of the Dow Chemical Company.	

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Table 4.9-3. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-3.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-3.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-5.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted on eight boxes prior to the 4-ft drop test and the penetration test. As expected, it did not affect the packages or the test results. With the actions required in Section 4.9.3, Restrictions/Specifications, these packagings also satisfy this test requirement with respect to potential inleakage of water. See Appendix D, Table D-5.
Free drop	Pass. These packages were dropped on a lid corner with the box inverted at approximately at 45° angle. There was no loss of contents or significant change in packaging geometry. See Appendix D, Table D-13.a.
Corner drop	The corner drop was conducted on packagings B-1, B-2, and B-6. This allows their potential use at less than 110 lb. See Appendix D, Table D-21.
Compression	Pass. This test was conducted at five times the gross weight for 24 hr with no loss of contents or significant change in package geometry. See Appendix D, Table D-26.
Penetration	Pass. This test was conducted on the top (middle), with only minor dents resulting. See Appendix D, Table D-33.

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Table 4.9-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid application • Mating surfaces flat and smooth, no foreign matter • Geometry, as specified Acceptable conditions:
	Joints/seams	• Dimensions, as specified • Glued
	Closure	• As specified, nail or screw • Caulking on lid • Steel banding of proper size and location • Nail-type and spacing
	Vendor qualification and experience	Vendor data as appropriate. Lot tests/inspections as appropriate by shipper.

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 4.10-1. Dimensions and Weights.				
Model	**Height (in.)**	**Width (in.)**	**Length (in.)**	**Authorized gross weight (lb)**
PF-1	6.0	25.00	25.00	500
PF-2	6.0	31.50	31.50	750
PF-3	6.0	37.50	37.50	1,000
PF-4	10.0	13.50	25.00	500
PF-5	10.0	13.50	31.50	750
PF-6	12.0	15.00	37.50	1,000
PF-7	5.0	22.50	59.50	750
PF-8	12.0	20.00	70.25	1,000
PF-10	14.5	48.00	48.00	2,500

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Table 4.10-2. Materials/Method of Construction.	
Sides and top	0.75-in. exterior grade plywood
Base sheet	1-in. exterior grade plywood
Bottom sheet	0.5-in. exterior grade plywood
Steel bands	0.75-in. per spacing in reference document
Joints/seams	Nailed and glued
Nails	See drawings

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Table 4.10-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-3.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-3.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-5.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Tests conducted on representative packagings demonstrated that this test did not affect the ability of the packaging to meet other Type A test requirements. With the actions required in Section 4.10.3, Restrictions/Specifications, these packagings also satisfy this test requirement with respect to potential inleakage of water. See Appendix D, Table D-5.
Free drop	Pass. These tests were conducted on the corner edge. There was no loss of contents and no significant change in packaging geometry. See Appendix D, Table D-13.a.
Corner drop	Not required.
Compression	Pass. The tests were conducted with greater than five times the gross weight for 24 hr, shown in Table 4.10-1. There was no detectable effect. See Appendix D, Table D-26.
Penetration	Pass. This test was conducted on each package with no significant effect. See Appendix D, Table D-33.

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Table 4.10-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
None	Vendor qualifications and experience	Functional: • Ease of lid application • Mating surfaces flat and smooth, no foreign matter • Geometry, as specified Acceptable conditions:
	Joints/seams	• Dimensions, as specified • Glued
	Closure	• As specified, nail or screw • Caulking on lid • Steel banding of proper size and location • Nail-type and spacing
	Vendor qualification and experience	Vendor data as appropriate. Lot tests/inspections as appropriate by shipper.

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 4.11-1. Dimensions.				
Model		**Height (in.)**	**Width (in.)**	**Length (in.)**
Configuration 1	Interior	6.0	16.625	21.125
	Exterior	14.0	21.125	25.625
Configuration 2	Interior	2.5	26.750	59.125
	Exterior	10.5	31.250	63.625

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Table 4.11-2. Materials/Method of Construction.	
Sides, lid, interior of ends, and bottom	0.75-in. exterior grade plywood
Framing members	2-in. x 4-in. lumber
All joints nailed and glued	
Closure	Lag screws, 4 in. x 0.25-in. diameter
Steel banding	0.625-in. steel bands around top, sides, and bottom
	1.25-in. steel band around sides and ends
	See diagrams for proper spacing
NOTE: For details of construction, see Rockwell RF-PE Drawings D14062-P14974, sheets 1 through 3, and D14061-P14926, sheets 1 through 3.	

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Table 4.11-3. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-3.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-3.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-5.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted prior to the compression test with no loss of contents or significant distortion of packaging geometry. This same package was dropped 4 ft approximately 28 hr later.
	Tests conducted on similar packagings demonstrate that this test did not affect the ability of the packaging to meet other Type A test requirements. With the actions required in Section 4.11.3, Restrictions/Specifications, these packagings also satisfy this test requirement with respect to potential inleakage of water. See Appendix D, Table D-5.
Free drop	Pass. This drop was made on the top corner with the boxes inverted at approximately a 45° angle. There was no loss of contents and no significant change in packaging geometry. See Appendix D, Table D-13.a.
Corner drop	Not required.
Compression	Pass. This test was conducted at five times the gross weight for 24 hr with no loss of contents or significant change in package geometry. See Appendix D, Table D-26.
Penetration	Pass. By analysis and comparison to previous tests on 0.75-in. plywood, which resulted in only minor dents. See Appendix D, Table D-33.

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Table 4.11-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid application • Mating surfaces flat and smooth, no foreign matter • Geometry, as specified Acceptable conditions:
	Joints/seams	• Dimensions, as specified • Glued
	Closure	• As specified, nail or screw • Caulking on lid • Steel banding of proper size and location • Nail-type and spacing
	Vendor qualification and experience	Vendor data as appropriate. Lot tests/inspections as appropriate by shipper.

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 4.12-1. Dimensions and Weights.

Model	External dimension				Internal dimension			Empty weight (lb)	Authorized gross weight (lb)
	Width (in.)	Length (in.)	Height (in.)	Skid (in.)	Width (in.)	Length (in.)	Height (in.)		
G-4214	16.38	34.50	10.0	4.00	14.13	30.00	8.38	70.0	1,260
G-4245	12.25	18.50	10.0	3.13	10.00	14.00	8.50	25.0	225
G-4255	25.63	35.00	10.0	3.50	24.13	30.75	8.00	107.0	1,470
G-4273-5	27.00	41.25	13.0	3.38	25.50	37.00	12.00	132.0	3,035
G-4273-6	27.00	41.25	16.0	3.38	25.50	37.00	14.00	146.0	3,540
G-4292	16.38	34.50	17.0	3.38	14.13	30.00	16.13	85.0	1,330

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Table 4.12-2. Materials/Method of Construction.	
Drawing No. G-4292	
00F-5500-X-00491, Rev. 9	
Drawing No. G-4214	
00F-5500-X-00431, Rev. 19	
00F-5500-X-01490, Rev. 3	
Sides and ends	1.125-in. thick white pine
Bottom	1-in. hardwood
Lids	2, 0.5-in. plywood
Banding	See drawing - 1.25-in. steel
Skids	3 wooden, 3.625 in. or 4 in.
Drawing No. G-4245	
00F-5500-X-00460, Rev. 3	
Lid	1, 0.5-in. plywood
Banding	2 vertical and 2 horizontal
Skids	3.25 in.
Drawing No. G-4255	
00F-5500-X-00468, Rev. 5	
00F-5500-X-00470, Rev. 0	
Drawing No. G-4273	
00F-5500-X-00471, Rev. 14	
00F-5500-X-00472, Rev. 7	
00F-5500-X-00473, Rev. 4	
All construction	0.75-in. exterior grade plywood
Skids	3 wooden, 3.625 in. or 4 in.

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Table 4.12-3. Four-Foot Drop Test Estimates.	
Model	**Decrease in distance to center (in.)**
G-4214	6
G-4245	3
G-4255	6
G-4273-5	12
G-4273-6	13
G-4292	6

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Table 4.12-4. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-3.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-3.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-5.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Water spray tests conducted on all packagings demonstrated that this test did not affect the ability of the packaging to meet other Type A test requirements. With the actions required in Section 4.12.3, Restrictions/Specifications, these packagings also satisfy this test requirement with respect to potential inleakage of water. See Appendix D, Table D-5.
Free drop	Pass. All packages were subjected to 4-ft free drop tests with no loss of contents. See Appendix D, Table D-14.
Corner drop	Not required.
Compression	Pass. One package of each type was subjected to the compression test. There was no distortion or loss of contents. See Appendix D, Table D-26.
Penetration	Pass. One package of each type was subjected to the penetration test. Minor indentations and some cracking of the wooden lids were noted, but there was no loss or dispersal of contents. See Appendix D, Table D-33.

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Table 4.12-5. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid application • Mating surfaces flat and smooth, no foreign matter • Geometry, as specified Acceptable conditions:
	Joints/seams	• Dimensions, as specified • Glued
	Closure	• As specified, nail or screw • Caulking on lid • Steel banding of proper size and location • Nail-type and spacing
	Vendor qualification and experience	Vendor data as appropriate. Lot tests/inspections as appropriate by shipper.

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 4.13-1. Dimensions and Weights.					
Model		**Length (in.)**	**Width (in.)**	**Height (in.)**	**Weight (lb)**
C-1	Exterior	49.500	25.500	29.500	130
	Interior	48.000	24.000	24.000	
C-2	Exterior	67.500	31.500	35.500	200
	Interior	66.000	30.000	30.000	
C-3	Exterior	79.500	31.500	35.500	230
	Interior	78.000	30.000	30.000	
C-280	Exterior	50.375	18.875	18.875	130
	Interior	48.875	17.375	14.000	
C-400	Exterior	49.500	25.500	30.000	142
	Interior	48.000	24.000	25.500	
C-600	Exterior	35.500	31.500	35.500	212
	Interior	34.000	30.000	30.000	
C-1000	Exterior	79.500	31.500	35.500	236
	Interior	78.000	30.000	30.000	

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Table 4.13-2. Materials/Method of Construction.	
Major components	**Material**
Sides, walls, ends, top, and bottom	0.75-in. exterior grade plywood
Base sheet (bottom of skid)	0.50-in. exterior grade plywood
Joint/seams	Nailed and glued
Top	Hinged and closed with Link-Lock Latch #2
Skids - total of 3	4-in. x 4-in. lumber
Corner angle	Aluminum angle, 2 in. x .13 in.
Foam	0.50-in. Ethafoam*
Banding	Steel, 0.75 in. x 0.03 in.
NOTE: See MMES Drawings No. T2E-146358 (C-1, -2, and -3) and No. T2E-123911 (C-230, -400, -600, and -1000).	
*Ethafoam is a trademark of Dow Chemical Company.	

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Table 4.13-3. Weights.	
Model	**Weight (lb)**
C-1	1,130
C-2	1,700
C-3	2,230
C-280	280
C-400	400
C-600	600
C-1000	1,000

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Table 4.13-4. Four-Foot Drop Test Results.	
Model	**Decrease in distance to center (in.)**
C-1	2.125
C-2	5.500
C-3	5.000
C-280	0.750
C-400	0.750
C-600	0.750
C-1000	0.750

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Table 4.13-5. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-3.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-3.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-5.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted on multiple test units and there was no inleakage of water. See Appendix D, Table D-5.
Free drop	Pass. Multiple test units were subjected to the 4-ft drop in varying orientations with successful results. See Appendix D, Tables D-13.a and D-13.b.
Corner drop	Not required.
Compression	Pass. This test was conducted using a test unit for each model with successful results. See Appendix D, Table D-26.
Penetration	Pass. Penetration bar was dropped on the top center and on the latches with successful results. See Appendix D, Table D-33.

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Table 4.13-6. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Body		Functional: • Materials of construction - Thickness - Type - Quality
Nailing		• Nail spacing and type as specified
Banding		• Width of banding • Banding materials • Number of bands • Location
	Joints/seams (cover-body interface)	• Fasteners as specified • Mating surfaces flat and smooth and free of foreign materials
	Surface preparation	• Appropriate paint/or equal
	Closure (hinges and latches)	• Size, material, number screws and location similar
	Cushioning and gaskets	• Thickness • Material as specified • Division of materials per drawing (C-280)
		Acceptable conditions: • Dimensions and materials • Lack of dents, no deformation of sealing surface • Geometry as specified

- Gasket provides seal
- Bands as specified

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*These criteria apply to first time use and to reuse as a DOT-7A Type A packaging.

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Table 5.1-1. Configurations and 4-ft Drop Test Results.				
Configuration	**Height (in.)**	**Width (in.)**	**Length (in.)**	**Decrease in distance from corner to center of package (in.)**
1	8	12	12	0.250
2	12	12	12	0.500
3	12	12	28	0.500
4	16	16	16	0.750
5	8	18	18	0.500
6	12	18	18	0.500
7	27	18	18	0.500
8	8	20	20	0.750
9	12	20	20	0.500
10	12	24	24	0.375
11	24	24	24	0.500
12	8	16	16	0.500
13	12	16	16	0.750

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Table 5.1-2. Materials/Method of Construction.

Fiberboard Box	12B-65 (49 CFR 178.205)
Banding	0.5-in. plastic strapping was used for test purposes; however, any better (or equivalent) banding may be used
Tape (see Section 5.1.6.2)	3-in. plastic tape (or equivalent) or stapled seams and closure
Foam	3-in. thick
Triple-Wall supports (see Section 5.1.6.2)	An inner tri-walled fiberboard liner to provide support during the compression test (0.567 in. thick)

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Table 5.1-3. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-4.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-4.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-7.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Packaging passes only when specified plastic tape is used. This test was conducted prior to each test. See Appendix D, Table D-6.
Free drop	Pass. Packaging passes only when specified plastic tape is used. Note: Each package must be analyzed with respect to the 20% radiation level increase criterion. See Appendix D, Table D-15.
Corner drop	Each size packaging was subjected to this test with no loss of contents. See Appendix D, Table D-22.
Compression	Pass. This test was conducted for 24 hr with five times the gross weight and, when the Triple-Wall supports were used, this test had no significant effect on the packaging. See Appendix D, Table D-27.
Penetration	Pass. The bar routinely penetrated the outer fiberboard surface but, considering the restricted contents, this is not significant. See Section 5.1.3, Restrictions/Specifications, and Appendix D, Table D-34.
49 CFR 178.205, Specification 12B; fiberboard boxes	See Appendix J, Table J-8.

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Table 5.1-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
	Lid or cover/body interface	Functional: • Ease of lid application • Mating surfaces flat and smooth, no foreign matter • Geometry, as specified
Sealing methods/materials	Materials, as specified	Acceptable Conditions: • Tape, water resistant • Staples, type and spacing • Thickness • Composition • Corrugations • Surface treatment, etc. • Dimensions, as specified
	Vendor experience and qualification	Vendor Data/Certification: • Marking • Test data • Type A certification document as appropriate Lot test/inspections as appropriate by shipper.

*These criteria apply to first time use and reuse as a DOT-7A Type A packaging.

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Table 5.2-1. Dimensions.		
Height (in.)	**Width (in.)**	**Length (in.)**
12	12	12

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Table 5.2-2. Materials/Method of Construction.	
Fiberboard box	12B-65 (49 CFR 178.205)
Foam cushioning	4-in. minimum--sides, top, and bottom
No. 10 metal can	Mechanically sealed
Tape	2-in. fiber reinforced paper tape*
*This particular tape withstood the 1-hr water spray test with no significant effects.	

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Table 5.2-3. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-4.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-4.
49 CFR 173.412, Additional requirements for Type A package	Meets applicable requirements. See Appendix C, Table C-7.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted prior to the tests shown below. This test by itself had no significant effect. Because of the sealed metal inner container, the potential inleakage of water will not adversely affect the performance. See Appendix D, Table D-6.
Free drop	Pass. This test was conducted on a top corner with only a minor crumbling of the impacted corner. After each test the metal can was inverted in water in a vacuum chamber and subjected to a reduced pressure. No bubbles were detected, indicating positive containment. See Appendix D, Table D-15.
Corner drop	Pass. The packaging would pass by analysis and comparison to tests on similar packagings. See Appendix D, Table D-22.
Compression	Pass. This test was conducted at 100 lb for 24 hr with no detectable effect. See Appendix D, Table D-27.
Penetration	Pass. This test was conducted on the side (impacted sealed end of can) and on the top of the box (impacted side of can). In each case the bar penetrated the box, but the foam prevented major damage to the can. In each case there was a dent approximately 0.5 in. in the can. After each test the metal can was inverted in water in a vacuum chamber and subjected to a reduced pressure. No bubbles were detected, indicating positive containment. See Appendix D, Table D-34.
49 CFR 178.205, Specification 12B; fiberboard boxes	See Appendix J, Table J-8.

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Table 5.2-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
	Lid or cover/body interface	Functional: • Ease of lid application • Mating surfaces flat and smooth, no foreign matter • Geometry, as specified • Closure "secure"
Sealing methods/materials	Materials, as specified	Acceptable Conditions: • Tape, water resistant • Staples, type and spacing • Thickness • Composition • Corrugations • Surface treatment, etc. • Dimensions, as specified • Test seals conducted for can sealer • Testing of metal can seal as appropriate Vendor Test/Certification: • Marking • Test data • Type A evaluation documentation as appropriate Lot tests/inspections as appropriate by

shipper

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 5.3-1. Dimensions.		
Height (in.)	**Width (in.)**	**Length (in.)**
25	25	52

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Table 5.3-2. Materials/Method of Construction.

Tri-Wall fiberboard box	0.5 in. thick (see Section 5.3.6.2)
Urethane foam inserts	2 in. thick
Banding	Tested with 0.5-in. plastic bands
	2 around sides and ends
	2 around top and ends
	2 around top, sides, and bottom
	Any equivalent or better banding is authorized
Taped closure	3-in. plastic tapes (or equivalent, see Section 5.3.6.2)

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Table 5.3-3. Regulatory Compliance Assessment.	
Regulatory Requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for All packages	Meets applicable requirements. See Appendix A, Table A-4.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-4.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-7.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Packaging passes only when specified plastic tape is used. This test was conducted prior to each test. See Appendix D, Table D-6.
Free drop	Pass. The tests were conducted with the box impacting on the top corner. The only effect was a crumbling of the impacted corner. The maximum decrease in distance was 1.75 in. This is not expected to be significant; however, each shipper must make this determination. See Appendix D, Table D-15.
Corner drop	Not required.
Compression	Pass. This test was conducted at greater than 2,500 lb for 24 hr with no significant effect on the package geometry or loss of contents. See Appendix D, Table D-27.
Penetration	Pass. This test was conducted on the top (middle) and on one side (middle). In each case the bar penetrated the top and side wall, hence the Restriction in Section 5.3.3. See Appendix D, Table D-34.

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Table 5.3-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
	Lid or cover/body interface	Functional: • Ease of lid application • Mating surfaces flat and smooth, no foreign matter • Geometry, as specified
Sealing methods/materials	Materials, as specified	Acceptable Conditions: • Tape, water resistant • Staples, type and spacing • Thickness • Composition • Corrugations • Surface treatment, etc. • Dimensions, as specified
	Vendor experience and qualification	Vendor Test/Certification: • Marking • Test data • Type A certification document, as appropriate Lot tests/inspections as appropriate by shipper.

*These criteria apply to first time use and to reuse as a DOT-7A Type A packaging.

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Table 5.4-2. Materials/Method of Construction.

Sides, walls, and bottom	Fiberboard (49 CFR 178.224)
Supports	Fiberboard Triple-Wall (See Section 5.4.6.2)
Top	Metal
Closure	Metal ring with lever style closure with gasket
Metal chime at bottom edge	
Gasket required	

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Table 5.4-3. Regulatory Compliance Assessment.

Regulatory requirement	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-4.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-4.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-7.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted prior to all the tests shown below. This test by itself had no significant effect on the packagings and there was no evidence of inleakage of water. See Appendix D, Table D-6.
Free drop	Pass. This test was conducted on the top closure ring and bottom chime with no loss of contents and only a crumpling of the edge. The side drop had little detectable effect. Note the 20% radiation level analysis required in Section 5.4.3, Restrictions/Specifications. See Appendix D, Table D-16.
Corner drop	Pass. This test was conducted on each package with no effect. Thus, these packages are authorized at all weights $\leq$ 115 lb. See Appendix D, Table D-23.
Compression	Pass. This test was conducted with five times the gross weight for 24 hr, and when the Triple-Wall supports (required) were used, this test had no significant effect on the packaging. See Section 5.4.3, Restriction/Specifications. See Appendix D, Table D-27.
Penetration	Pass. The bar penetrated the side walls about 50% of the time, but, considering the restricted contents, this should not be of significance. See Section 5.4.3, Restrictions/Specifications. See Appendix D, Table D-34.
49 CFR 178.206, Specification 12C; fiberboard boxes	See Appendix J, Table J-9.

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Table 5.4-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Fiberboard containers are not reusable Functional: • Ease of lid application • Closure ring size • Geometry, as specified Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces • Dimensions, as specified • No sharp edges
Gasket		• Gasket size, material, geometry, adhesives, as specified
Body and chime	Material thickness Composition	Lot tests by shipper as appropriate and/or vendor data/certification: • Marking • Test data • Type A certification document as appropriate
	Protective coating application	Visual: • Surface/coating as specified

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 6.1-1. Dimensions and Weights.				
Model	**Nominal length (in.)**	**Nominal diameter (in.)**	**Tare weight (lb)**	**Gross weight (lb)**
1S	11.0	1.5	1.75	2.0
2S	11.5	3.5	4.20	9.5
5A	36.0	5.0	55.00	110.0
5B	36.0	5.0	55.00	110.0
8A	56.0	8.0	120.00	375.0
12A	54.0	12.0	185.00	645.0
12B	48.5	12.0	190.00	650.0
30A	81.0	30.0	1,400.00	6,350.0
30B	81.0	30.0	1,400.00	6,420.0
48G	145.5	48.0	2,600.00	30,600.0
48H	145.5	48.0	3,120.00	30,150.0
48Hx	145.5	48.0	3,120.00	30,150.0
48X	121.0	48.0	4,500.00	25,530.0
48Y	150.0	48.0	5,200.00	32,760.0

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Table 6.1-2. Materials/Method of Construction.				
Model	**Material**	**Minimum wall thickness (in.)**	**Valve[a]**	**Service pressure (psig)**
1S	Nickel	0.0625	Monel	200
2S	Nickel or Monel	0.0625	Monel	200
5A	Monel	0.1250	Bronze/Monel	200
5B	Nickel	0.1250	Bronze/Monel	200
8A	Monel	0.1250	Bronze/Monel	200
12A	Nickel	0.1875	Bronze/Monel	200
12B	Monel	0.1875	Bronze/Monel	200
30A	A-285 or A-516 Steel	0.3125	Bronze/Monel	192
30B	A-285[b] or A-516 Steel	0.3125	Bronze/Monel	200
48G	A-516 Steel	0.0313	Bronze/Monel	100
48H	A-516 Steel	0.2500	Bronze/Monel	100
48Hx	A-516 Steel	0.2500	Bronze/Monel	100
48X	A-285 or A-516 Steel	0.5000	Bronze/Monel	200
48Y	A-516 Steel	0.5000	Bronze/Monel	200
[a]Shall be in accordance with ANSI N14.1.				
[b]Shall be in accordance with 49 CFR 173.420.				

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Table 6.1-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-5.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-5.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-8.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Test not conducted; however by analysis of the materials and methods of construction it is easily determined that this test would not adversely affect the ability of this packaging to meet this Type A test requirement. See Appendix D, Table D-7.
Free drop	Pass. By analysis and comparison to 30-ft drop tests on the edges of the 5A, 8A, 12B, 30B, and 48X cylinders, it can be determined that the deformation in a 4-ft drop test would not be significant with respect to radiation levels. See Appendix D, Table D-17.
Corner drop	Not required.
Compression	Pass. Computer analysis demonstrated that all cylinders would pass this test. See Appendix D, Table D-28.
Penetration	Pass. By analysis and comparison to tests on thinner metals, this test would result in only minor dents. The valves are protected by covers. See Appendix D, Table D-35.

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Table 6.1-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Body • Support rings • Materials • Valves	Metal thickness	Functional: • Seal--body and valves • Fit--transport cradle • Geometry, as specified
Weld/seams		Acceptable conditions: • Welds radiographed • No sharp edges • Absence of dents or deformations on surfaces • Dimensions, as specified
Leak tests	Vendor qualifications and experience	Vendor data/certification: • Marking • Test data • ASME Boiler and Pressure Vessel Code Certification
		Lot tests by shipper, as appropriate
	Protective coating	Visual: • Surface/coating, as specified • Absence of imperfections in application • Absence of dents, nicks

*These criteria apply to first-time use and reuse as a DOT-7A Type A packaging.
ASME = American Society of Mechanical Engineers.

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Table 6.2-1. Dimensions and Weights.

Model	Overall length (in.)	Outer diameter (in.)	Empty weight (lb)	Gross weight (lb)
Modified 5A	35.625	5.563	55	110
Modified 5B	35.625	5.563	55	110

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Table 6.2-2. Materials/Method of Construction.					
Model	**Shell body material**	**Wall thickness (in.)**	**Cylinder heads**	**Valve coupling**	**Service pressure (psig)**
Modified 5A	Nickel-copper ASTM B-165	0.258	Ellipsoidal nickel	Nickel-copper	200
Modified 5B	Nickel ASTM B-161	0.258	Ellipsoidal nickel	Nickel	200
ASTM = American Society for Testing and Materials.					

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Table 6.2-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-5.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-5.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-8.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted and there was no inleakage of water and no features on the package that retained free standing water. See Appendix D, Table D-7.
Free drop, Fissile Class II	Pass. A series of 1-ft free packaging drops onto each of the quarters of each rim for each package were performed prior to the 4-ft free drop. See Appendix D, Table D-17.
Free drop	Pass. 4-ft drop test conducted on:
	Side--flat, on handles
	Side--flat, opposite handles
	Top--flat on top
	Top--CG over corner
	Bottom--flat on bottom
	Bottom--CG over corner.
	These tests were conducted using two 5A and two 5B cylinders.
	See Appendix D, Table D-17.
Corner drop	Not required.
Compression	Pass. This test was satisfied by performing a stress analysis using a compressive load of 625 lb. See Appendix D, Table D-28.
Penetration	Pass. Penetration bar was dropped on top and side of a 5A and 5B cylinder. See Appendix D, Table D-35.

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Table 6.2-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid/closure ring application • Bolt closure ring--bolt size • Gasket, adhesive, as specified • Geometry, as specified Acceptable conditions: • Lack of dents, no deformation of sealing surfaces
Gasket		• Dimensions, as specified
Weld areas		• Continuous welds, no sharp edges
Body and chime	Metal thickness	Lot tests by shipper, as appropriate.
Air leak tests	Bolt size	Vendor data and/or certification: • Marking • Test data • Type A certification document provided, as appropriate • Air leak tests
	Protective coating application	Visual: • Surface/coating, as specified • Lack of imperfections in application • Lack of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 7.1-1. Dimensions and Weights.

Model	Inside height (in.)	Inside diameter (in.)	Volume (mL)
MS-24347-27	See Table 2.8-1	--	--
Paint can	4	3	--
Glass bottle with screw cap	--	--	50

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Table 7.1-2. Materials/Method of Construction.

MS-24347-27	See Table 2.8-1
Paint can with press fit (friction) seal	3-in. inside diameter x 5-in. height
Cushioning	Rubberized hair--2 in. thick on top, sides, and bottom
Absorbent	Vermiculite
Glass bottle with plastic screw cap	NOTE: The bottle is designated as the primary containment vessel.

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Table 7.1-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-6.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-6.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-10.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Tests conducted on representative drums demonstrated compliance with this test. See Appendix D, Table D-8.
Free drop (30 ft)	Pass. Several tests were conducted with the drum impacting on the bolt, bottom, and side. In one case, the same package was dropped three times before opening for analysis. The only effects were minor dents, and the bolt lugs broke off once. There was no distortion of the package geometry or significant movement of the inner packaging. See Appendix D, Table D-18.a.
Corner drop	Not required.
Compression	Pass. This test was conducted with 100 lb for 24 hr with no significant effect or change in package geometry. See Appendix D, Table D-29.
Penetration	Pass. This test was conducted on the top (middle and near an edge) and on the side from 5.5 ft. A minor dent occurred in the top (middle), and a major dent resulted in the side. See Appendix D, Table D-36.

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Table 7.1-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid/closure ring application • Bolt closure ring--bolt size • Geometry, as specified • Bottle closure secure Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces • Dimensions, as specified
Gasket		• Gasket size, materials, geometry
Weld areas	Metal thickness	• Continuous welds, no sharp edges
Body and chime Air leak tests	Bolt size	Lot tests by shipper, as appropriate and/or vendor data certification: • Marking • Test data • Type A certification document provided as appropriate
Absorbent		Material: • Twice that required • Appropriate for contents • Within shield (good practice, not mandatory)
	Protective coating application	Visual: • Surface/coating, as specified

- Lack of imperfections in application
- Lack of rust, dents, nicks

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*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 7.2-1. Dimensions.

Model	Inside height (in.)	Inside width (in.)	Length (in.)	Diameter (in.)	Depth (in.)
12B-65 box	14	14	14	--	--
Shielded lead container	8	5 (diameter)	--	2.875	4.625
Inner lead shielded container	5	2 (diameter)	--	0.625	4

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Table 7.2-2. Materials/Method of Construction.	
Fiberboard box	Spec 12B-65 (49 CFR 178.205)
	Side seams stapled
	Top and bottom seams taped
	NOTE: Plastic tape withstood water spray tests with no detectable effects.
Cushioning	Rigid polyfoam
Lead shielded containers (2)	Outer--Bolt closure
	Inner--O-ring sealed, screw-top lid
	NOTE: This packaging is considered the primary containment vessel.
Inner container	Glass ampoule with crimped metal top

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Table 7.2-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-6.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-6.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-10.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted prior to each of the following tests with no detectable effect. See Appendix D, Table D-8.
Free drop (30 ft)	Pass. The tests were conducted with the box impacting on a top corner, and the shielded container thus impacted on the top bolted lid. Except for the crumpling of the corner and the movement of the shielded container (see Section 7.2.2.3, Radiological), there was no significant effect. See Appendix D, Table D-18.a.
Corner drop	The corner drop was conducted with no loss of contents or significant change in package geometry. See Appendix D, Table D-22.
Compression	Pass. This test was conducted with more than 325 lb for 24 hr with no significant change in package geometry. See Appendix D, Table D-29.
Penetration	Pass. This test was conducted with the bar impacting the middle of the top (1st test) and side (2nd test). In both cases, the fiberboard was penetrated; however, the bar did not contact the lead container. See Appendix D, Table D-36.
49 CFR 178.205, Specification 12B; fiberboard boxes	See Appendix J, Table J-8.

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Table 7.2-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid application • Geometry, as specified • Bottle closure secure Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces • Dimensions, as specified
Gasket		• Gasket size, materials, geometry
Body	Metal thickness	Lot tests by shipper, as appropriate and/or vendor data certification:
Air leak tests	Bolt size	• Marking • Test data • Type A certification document provided as appropriate
Absorbent		Material: • Twice that required • Appropriate for contents • Within shield (good practice, not mandatory)
	Protective coating application	Visual: • Surface/coating, as specified • Lack of imperfections in application • Lack of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 7.3-1. Dimensions.

Model	Diameter (in.)	Length (in.)	Volume (cm^3)
Spec 17H steel drum (30 gal)	See Table 2.6-2	--	--
3A 1800 cylinder	3	16.00	300
3E 1800 cylinder	2	14.25	1,000

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Table 7.3-2. Materials/Method of Construction.

Spec 17H steel drum (30 gal)	See Table 2.6-3
3A 1800 cylinder	Seamless steel cylinder (see 49 CFR 178.36)
3E 1800 cylinder	Seamless steel cylinder (see 49 CFR 178.42)
Polystyrene foam liner with cover	
Configuration 1	Three 3A 1800 cylinders in polystyrene foam in 17H steel drum
Configuration 2	Four 3E 1800 cylinders in polystyrene foam in 17H steel drum

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Table 7.3-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-6.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-6.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-10.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Tests conducted on representative drums demonstrated compliance with this test. See Appendix D, Table D-8.
Free drop (30 ft)	Pass. This test was conducted on 17H steel drums (30 gal) with both types of cylinders. The impact point was the top (bolt) of the drum, and the cylinders thus were impacting on the valve (upper) portion. There was no loss of containment as determined by measuring internal pressure before and after the tests. There was no significant change in package geometry or orientation of the cylinders that would affect surface radiation levels. See Appendix D, Table D-18.a.
Corner drop	Not required.
Compression	Pass. Based on successful testing of 17H 30-gal drum. See Appendix D, Table D-29.
Penetration	Pass. This test was conducted on the top (middle) and side of the drum with only slight dents resulting. See Appendix D, Table D-36.
49 CFR 178.118, Specification 17H; steel drums	See Appendix J, Table J-7.

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Table 7.3-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface	Vendor qualifications and experience	Functional: • Ease of assembly, protective cap and body
Body materials, as specified	Metal thickness	• Seal, body and valves • Geometry, as specified • Fit within shipping case
Weld/seams		Acceptable conditions: • Welds radiographed or suitably monitored • No sharp edges • Absence of dents and deformations on surfaces • Dimensions, as specified
Leak tests	Vendor qualifications and experience	Vendor data/certification: • Marking • Test data • Type A certification document, as appropriate Lot tests by shipper, as appropriate.

Protective coating	Visual:	• Surface/coating, as specified • Absence of application imperfections • Absence of rust, dents, nicks

NOTE: See Figure 7-9 for criteria to be applied to cylinders.
*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 7.4-1. Dimensions.	
Fiberboard box	8 in. high x 8 in. wide x 8 in. long
Metal can	4.5-in. inside diameter x 7 in. high
Sch. 40 steel pipe	3 in. long

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Table 7.4-2. Materials/Method of Construction.	
Fiberboard box	Spec 12B-120 (40 CFR 178.205) Stapled closure (10.625-in. steel staples)
Metal can	Spec 2N (49 CFR 178.32) Mechanically sealed
Glass bottles	15, 25, 50, and 100 mL
Absorbent	Kimpack*
*Kimpack is a trademark of Kimberly-Clark Corporation.	

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Table 7.4-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-6.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-6.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-10.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Water spray test was conducted prior to each of the following tests. See Appendix D, Table D-8.
Free drop (30 ft)	Pass. Test conducted with a maximum of 1-in. deformation of surface and no loss of contents. See Appendix D, Table D-18.a.
Corner drop	Pass. Test conducted with a maximum of 0.5-in. deformation of the impacted corner, and there was no loss of contents.
Compression	Pass. Test was conducted with more than five times the gross weight for 24 hr. There was only minor distortion of package geometry (less than in 30-ft drop) and no loss of contents. See Appendix D, Table D-29.
Penetration	Pass. This test resulted in a non-penetrating deformation of the box and a 0.055-in. dent in the metal can. There was no loss of contents. See Appendix D, Table D-36.
49 CFR 178.205, Specification 12B; fiberboard boxes	See Appendix J, Table J-8.

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Table 7.4-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
	Lid or cover/body interface	Functional: • Ease of lid, cover, and flap closure • Mating surfaces flat and smooth, no foreign matter • Geometry, as specified • Closure "secure"
Sealing methods/materials	Materials, as specified	Acceptable Conditions: • Tape • Staples, type and spacing • Thickness • Composition • Corrugations • Surface treatment, etc. • Dimensions, as specified • Test seals conducted for can sealer • Testing of metal can seal as appropriate
Absorbent		• Twice that required • Appropriate for contents • Within shield (good practice, not mandatory)
	Vendor qualifications and experience	Vendor data/certification: • Marking • Test data

- Type A certification document, as appropriate

Lot tests by shipper, as appropriate.

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*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 7.5-1. Dimensions.	
Fiberboard box	8 in. high x 8 in. wide x 8 in. long
Metal can	4.5-in. inside diameter x 7 in. high

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Table 7.5-2. Materials/Method of Construction.	
Fiberboard box	Spec 12B-12O (40 CFR 178.205) Stapled closure (10.625-in. steel staples)
Metal can	Spec 2N (49 CFR 178.32) Mechanically sealed
Glass bottles	15, 25, 50, and 100 mL
Glass ampules	2, 5, 10, and 20 cm^3
Absorbent	Kimpack*
*Kimpack is a trademark of Kimberly-Clark Corporation.	

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Table 7.5-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-6.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-6.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-10.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted prior to each of the following tests with no detectable effect. See Appendix D, Table D-8.
Free drop (30 ft)	Pass. Test conducted with a maximum of 1-in. deformation of surface and no loss of contents. See Appendix D, Table D-18.a.
Corner drop	Pass. Test conducted with a maximum of 0.5-in. deformation of the impacted corner, and there was no loss of contents.
Compression	Pass. Test was conducted with more than five times the gross weight for 24 hr. There was only minor distortion of package geometry (less than in 30-ft drop) and no loss of contents. See Appendix D, Table D-29.
Penetration	Pass. This test resulted in a non-penetrating deformation of the box and a 0.055-in. dent in the metal can. There was no loss of contents. See Appendix D, Table D-36.
49 CFR 178.32, Specification 2N; inside containers, metal cans	See Appendix J, Table J-2.
49 CFR 178.205, Specification 12B; fiberboard boxes	See Appendix J, Table J-8.

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Table 7.5-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
	Lid or cover/body interface	Functional: • Ease of lid, cover, and flap closure • Mating surfaces flat and smooth, no foreign matter • Geometry, as specified • Closure "secure"
Sealing methods/materials	Materials, as specified	Acceptable Conditions: • Tape • Staples, type and spacing • Thickness • Composition ,li>Corrugations • Surface treatment, etc. • Dimensions, as specified • Test seals conducted for can sealer • Testing of metal can seal as appropriate
Absorbent		• Twice that required • Appropriate for contents • Within shield (good practice, not mandatory)
	Vendor qualifications and experience	Vendor data/certification: • Marking • Test data

- Type A certification document, as appropriate

Lot tests by shipper, as appropriate.

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*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 7.6-1. Dimensions.				
Description	**Height (in.)**	**Width (in.)**	**Length (in.)**	**Volume (mL)**
Box 1	17.50	17.50	16.50	--
Box 2	21.50	21.50	16.50	--
Duraglass* bottle	--	--	--	15 - 200
Lead	--	1.5-3	--	--
*Duraglass is a trademark of Owens-Illinois Glass Container, Inc.				

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Table 7.6-2. Materials/Method of Construction.	
Box	Aluminum clad--0.75-in. marine plywood
	Closure, hinged lid with fastener
Stainless steel clad lead shield	--
Stainless steel 2R container	--
Duraglass[a] bottle	15 - 200 mL
Absorbent	Kimpack[b]
[a]Duraglass is a trademark of Owens-Illinois Glass Container, Inc.	
[b]Kimpack is a trademark of Kimberly-Clark Corporation.	

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Table 7.6-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-6.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-6.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-10.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted prior to each of the following tests with no detectable effect. See Appendix D, Table D-8.
Free drop (30 ft)	Pass. The test was conducted with the box impacting on the top corner. The top and bottom plywood sheets were loosened and the aluminum cladding was torn; however, the package geometry was not significantly changed. There was no release of contents from the glass bottle. For volumes greater than 50 cm^3, the 2R container with O-ring seal meets the requirement of "secondary outer containment components designed to assure retention of the liquid contents within the secondary outer components in the event the primary inner components leak." See Appendix D, Table D-18.a.
Corner drop	The corner drop was successfully conducted on the package weighing 110 lb. The only effects were minor dents, and there was no loss of contents.
Compression	Pass. This test was conducted at 1,040 lb for 24 hr with no significant distortion of the package. See Appendix D, Table D-29.
Penetration	Pass. This test was conducted with the bar impacting the center of the top of the box. Only a minor dent (non-penetrating) resulted. See Appendix D, Table D-36.
49 CFR 178.34, Specification 2R; inside containment vessel	See Appendix J, Table J-3.

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Table 7.6-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid or cover/body interface	Vendor qualifications and experience	Functional: • Ease of lid, cover, and flap closure • Geometry, as specified • Closure "secure" Acceptable Conditions: • Dimensions, as specified • No sharp edges
Gasket		• Gasket size, material, geometry
Absorbent		• Twice that required • Appropriate for contents • Within shield (good practice, not mandatory)
Body materials, as specified		Vendor data/certification: • Marking • Test data • Type A certification document as appropriate

* These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 7.7-1. Dimensions.

Description	Height (in.)	Width (in.)	Length (in.)
Plastic box	9	9	26
Hoke gas cylinders	See Figure 7-10	--	--

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Table 7.7-2. Materials/Method of Construction.

Plastic box	See Figure 7-8
Hoke gas cylinder	See Figure 7-9 and 7-10

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Table 7.7-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-6.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-6.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-10.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted (on the cylinder itself) prior to each of the following tests with no detectable effect. See Appendix D, Table D-8.
Free drop	Pass. The test was conducted with valve cover facing down. In each case there was no loss of contents and the package geometry was not significantly changed. See Appendix D, Table D-18.a.
Corner drop	This test was successfully conducted with no loss of contents or significant distortion of package geometry.
Compression	Pass. This test was conducted at 580 lb with no change in geometry of the package or loss of contents. See Appendix D, Table D-29.
Penetration	Pass. This test was conducted with the bar impacting the center of the top of the protective cap. There was no damage or loss of contents. See Appendix D, Table D-36.

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Table 7.7-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface	Vendor qualifications and experience	Functional: • Ease of assembly, protective cap and body
Body materials, as specified	Metal thickness	• Seal, body and valves • Geometry, as specified • Fit within shipping case (where used)
Welds/seams		Acceptable conditions: • Welds radiographed or suitably monitored • No sharp edges • Absence of dents or deformation on surface • Dimensions, as specified
Leak tests	Vendor qualifications and experience	Vendor data/certification: • Marking • Test data • Type A certification document, as appropriate Lot tests by shipper, as appropriate.
	Protective coating	Visual: • Surface/coating, as specified • Absence of application imperfections • Absence of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 7.8-1. Dimensions and Weights.				
Cylinder	**Outside diameter (in.)**	**Length (in.)**	**Volume (cm^3)**	**Authorized gross weight (lb)**
1	6.5	12.5	150	24
2	6.5	16.5	300	40
3	6.5	21.5	500	60

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Table 7.8-2. Materials/Method of Construction.

Inner cylinder	Stainless steel
Lead shielding	0.5 in. to 0.75 in. thick
Outer case	Steel
Bellows valve	--

NOTE: These packages are shipped with the overpack shown in Figure 7-7 or its equivalent.

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Table 7.8-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-6.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-6.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-10.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Tests on similar cylinders demonstrated no effect and, since they are gas-leak tight, there will be no inleakage of water. See Appendix D, Table D-8.
Free drop	Pass. A J. L. Shephard Model 394-500L was dropped with the valve cover facing down. There was no loss of contents and the package geometry was not significantly changed. Other cylinders were certified based on these test data. See Appendix D, Table D-18.a.
Corner drop	Not required.
Compression	Pass. Authorized based on tests of similar packagings. See Appendix D, Table D-29.
Penetration	Pass. Authorized based on tests of similar packagings. See Appendix D, Table D-36.

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Table 7.8-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface	Vendor qualifications and experience	Functional: • Ease of assembly, protective cap and body
Body materials, as specified	Metal thickness	• Seal, body and valves • Geometry, as specified • Fit within shipping case (where used)
Welds/seams		Acceptable conditions: • Welds radiographed or suitably monitored • No sharp edges • Absence of dents or deformation on surface • Dimensions, as specified
Leak tests	Vendor qualifications and experience	Vendor data/certification: • Marking • Test data • Type A certification document, as appropriate Lot tests by shipper, as appropriate.
	Protective coating	Visual: • Surface/coating, as specified • Absence of application imperfections • Absence of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 7.9-1. Dimensions.

DOT-17C 55-gal steel drum	See Figure 7-12
Fenton Hill Pig (inner container)	See Figure 7-13

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Table 7.9-2. Materials/Method of Construction.	
DOT-17C steel drum	Steel
Cushioning/spacing	Celotex[a]--22.5-in. diameter x 0.5 in. thick (some sheets with holes to accommodate inner container). Total of 66 sheets.
	6-in. x 0.187-in. Shelby[b] tubing (MA-3138)
Fenton Hill Pig	Base plate, 9-in. diameter x 0.25 in.
• Bottom - Handles (sides)	Steel flange, 9-in. diameter x 0.375 in. 2.5 in. high, 0.5-in. round stock
• Cover (lead lining, top and sides) - Handle (cover) - Steel flange	8-in. x 0.250-in. Shelby tubing (MA-3154) 3.5 in. high, 0.5-in. round stock 9.5-in. diameter x 0.25 in.
• Bolt closure for cover	6 steel bolts, 0.313 in. x 2.5 in.
• Valves	2 Hoke Swagelock[c] ball valves, 0.375 in.
• Lead shielding	As shown in Figures 7-12 and 7-13.
[a]Celotex is a trademark of the Celotex Corporation.	
[b]Shelby is a trademark of USX Corporation.	
[c]Swagelock is a trademark of Crawford Fitting Company.	

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Table 7.9-3. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-6.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-6.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-10.
49 CFR 173.465, Type A packaging tests, and 49 CFR 173.466, Additional test for Type A packagings designed for liquids and gases	Meets applicable requirements.
Water spray	Pass. This test was conducted on nine different types of steel drums and a total of 26 packagings. Three 17C 55-gal steel drums were involved in these tests. In all cases there was no detectable effect on the ability of the packaging to meet the subsequent Type A tests. Also there was no evidence of inleakage of water. See Appendix D, Table D-8.
Free drop (4 ft)	Pass. Many tests were conducted on 17C 55-gal drums at weights far exceeding the weight of these drums. See Appendix D, Tables D-10.a and D-10.b.
Free drop (30 ft)	Pass. Three 30-ft drops were conducted using the same inner packaging materials. A different 55-gal drum was used for each test. The impact angle was about 45° with the lid locking bolt facing downward. The packaging remained intact with no release of contents from the inner container in each case. See Appendix D, Table D-18.a.
Corner drop	Not required.
Compression	Pass. This test was conducted with more than five times the gross weight for 24 hr and no detectable effect on the packaging was observed. See Appendix D, Table D-29.
Penetration	Pass. This test was performed on the top and side of the 17C 55-gal drum with minimal effects. See Appendix D, Table D-36.
49 CFR 178.115, Specification 17C; steel drums	See Appendix J, Table J-6.

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Table 7.9-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface	Vendor qualification	Functional: • Ease of lid/closure application • Bolt closure and size
Sealing surface		• Gasket, as specified • Material, as specified • Geometry, as specified
Valves		• Seal • Type, as specified • Leak check, as appropriate
		Acceptable Conditions: • Lack of dents, no deformation of sealing surface • Dimensions, as specified • Continuous welds, no sharp edges
Body and chime	Metal thickness	Lot tests by shipper as appropriate and/or vendor data certification:
Air leak check	Bolt size	• Marking • Test data • Type A document provided, as appropriate
Absorbent		Materials • Quality and quantity, as specified • Appropriate for contents
	Protective coating	Visual:

		Surface coatings, as specified • Lack of imperfections • Lack of rust, dents, nicks
	Shielding	• Bolt closure, as specified • Position within drum
Cushioning		• Material, as specified • Geometry, as specified • Intact, without cracks, crumbling, holes, excessive wear

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*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 7.10-1. Dimensions.		
DOT-17C drum (8 gal)	**Height (in.)**	**Diameter (in.)**
Exterior	13.50	14.75
Interior	12.75	14.00

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Table 7.10-2. Materials/Method of Construction.	
Drum	
• Body and head sheet	• 20 gauge
• Rolling hoops	• One 4 in. from top edge, one 4 in. from inside bottom
• Ring	• 12 gauge
• Bolt	• 0.625 in.
• Gasket	• Darex[a] Cover Compound 740 or Styrene/butadiene copolymer
Foam	• Silicone RTV foam
Bottle	• HDPE wide mouth (3.5-in. diameter), 1 gal Nalgene[b] catalog number 2120-0010 or 0.5 gal Nalgene catalog number 2120-0005 and 0.5 gal size
Bottle lid	• Polypropylene, screw closure
Sealant	• General Electric, RTV silicone rubber adhesive sealant, RTV 102 White
[a]Darex is a trademark of W.R. Grace and Company.	
[b]Nalgene is a trademark of Nalge Company, Incorporated.	
HDPE = high-density polyethylene.	
RTV = room temperature vulcanizing.	

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Table 7.10-3. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-6.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-6.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-10.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted and there was no inleakage of water. See Appendix D, Table D-8.
Free drop	Pass. Each of the packages were subjected to a 4-ft and 30-ft drop with the package being oriented with the CG over top rim hitting the lock ring bolt. There was no distortion of the package geometry or significant movement of the inner packaging. See Appendix D, Table D-18.a.
Corner drop	Not required.
Compression	Pass. This test was conducted with 331 lb for 24 hr with no adverse effect on the package. See Appendix D, Table D-29.
Penetration	Pass. Penetration bar was dropped on the top center and on the side from 5.5 ft. See Appendix D, Table D-36.
49 CFR 178.115, Specification 17C; steel drums	See Appendix J, Table J-6.

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Table 7.10-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid/closure ring application • Bolt closure ring, bolt size • Gasket, adhesive, as specified • Geometry, as specified Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces
Gasket		• Dimensions, as specified
Weld areas		• Continuous welds, no sharp edges
Body and chime Air leak tests	Metal thickness Bolt size	Lot tests by shipper, as appropriate. Vendor data and/or certification: • Marking • Test data • Type A document provided, as appropriate • Air leak tests
	Protective coating application	Visual: • Surface/coating, as specified • Lack of imperfections in application • Lack of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 7.11-1. Dimensions.			
Description	**Length (in.)**	**Height (in.)**	**Width (in.)**
Polymer box	53.375	19	21.125
Description	**Height (in.)**	**Diameter (in.)**	**Volume**
Secondary containment vessel	12	12	5.500 gal
Primary containment bottles	2.4 - 8.5	1.3 - 3.6	30 - 1,000 mL

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Table 7.11-2. Materials/Method of Construction.	
Polymer box	High impact resistant polymer
Secondary containment vessel	Aluminum
Primary containment bottles	High density polyethylene (0.959 g/cc), DOT-2E
Secondary containment vessel gasket	Rubber, 63 durometer, shore-A
Foam spacers	Closed-cell polyethylene foam, density 2.2 lb/ft^3

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Table 7.11-3. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-6.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-6.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-10.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted twice during the test sequence with no adverse effects. See Appendix D, Table D-8.
Free drop	Pass. Two 4-ft drop tests were conducted with successful results. The impact orientations included: Top--CG over corner Top--Flat on top Two 30-ft drop tests were conducted with successful results. The impact orientations included: Top--CG over corner Top--Flat on top See Appendix D, Table D-18.a.
Corner drop	Not required.
Compression	Pass. This test was conducted with an applied load of 2,006 lb with no adverse effects. See Appendix D, Table D-29.
Penetration	Pass. The penetration test was conducted with a drop height of 5.5 ft, targeting the weakest external feature, with no adverse affects on the packaging. See Appendix D, Table D-36.
49 CFR 178.24a, Specification 2E; inside polyethylene bottle	See Appendix J, Table J-1.

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Table 7.11-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Truck bed box and outer assembly		• General arrangement per drawing
Foam spacers		• Undamaged and clean
Containment vessels:		
Metal parts		• Geometry, as specified
		• General arrangement per drawing
		• Undamaged and clean
		• Dimensions, as specified
Gaskets		• Undamaged and clean
		• Dimensions, as specified
Foam spacers		• Undamaged and clean
		• Geometry, as specified
Containment bottles		• Undamaged and clean
		• Dimensions, as specified

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 7.12-1. Dimensions.			
Model	**Height (in.)**	**Diameter (in.)**	**Volume (gal)**
Exterior	14.12	10.50	4

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Table 7.12-2. Materials/Method of Construction.	
Material	**Description**
Drum	
- Assembly	MS27684-2
- Body	MS27684-12
- Cover	MS27684-21
- Gasket	MS27684-25
- Locking ring	MS27684-31
Foam	Polyethylene foam, density 1.6 lb/ft^3 minimum. Ethafoam[a] #220 or equivalent. Per Rocky Flats Plant drawing numbers P32905 and P32906.
Produce can	Per Federal Spec. PPP-C-96D, Type 1 Class 3, round open-top style, welded side seam with compound lined, double seamed ends. All cans 0.25 electrolytic tinplate. Part number 14653-03, can industry size - 401 x 509, and nominal dimensions 4 1/16 in. outside diameter x 5 9/16 in.
Absorbent	Kimpack[b] absorbent, as required by contents to absorb twice the liquid present.
Vials	Savillex Corp. 6 ml - 1.5 oz capacity CAT number 026R or equivalent. Material: Teflon[c] - perfluoralkoxy. Color: semi-clear
[a]Ethafoam is a trademark of Dow Chemical Company.	
[b]Kimpack is a trademark of Kimberly-Clark Corporation.	
[c]Teflon is a trademark of E.I. DuPont de Nemours and Company.	
NOTE: The vials are designated as the primary containment vessel.	

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Table 7.12-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-6.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-6.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-10.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted and there was no inleakage of water. See Appendix D, Table D-8.
Free drop	Pass. The package was subjected to 4-ft and 30-ft drops. Three drop orientations were used: (1) the package oriented with the center of gravity over top rim position to strike on the closure bolt area, (2) the package oriented to drop directly onto the bottom, and (3) the package oriented to drop flat on the side. There was no distortion of the package geometry. The inner packaging moves within the space provided in the foam. The movement could influence the radiation readings. See Appendix D, Table D-18.a.
Corner drop	Not required.
Compression	Pass. This test was conducted with 200 lb for 24 hr with no adverse effect on the package. See Appendix D, Table D-29.
Penetration	Pass. Penetration bar was dropped on the top center and on the side from 3.3 ft and 5.5 ft. The movement of the surface inward was less than 1 in. See Appendix D, Table D-36.

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Table 7.12-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Vial	Vendor qualifications and experience	Functional: • Ease of lid, cover/closure ring application
Absorbent		• Bolt closure ring, bolt size
Produce can		• Gasket, adhesive, as specified
Foam		• Geometry, as specified
Drum assembly		Acceptable conditions: • Lack of dents, no deformation of sealing surfaces
Gasket		• Dimensions, as specified
Weld areas		• Continuous welds, no sharp edges
Body and chime	Metal thickness Bolt size	Lot tests by shipper, as appropriate Vendor Data and/or certification: • Marking • Test data • Type A document provided, as appropriate • Air leak tests
	Protective coating application	Visual: • Surface/coating, as specified • Lack of imperfections in applications • Lack of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 7.13-1. Dimensions and Weights.			
Model	**Height (in.)**	**Width (in.)**	**Length (in.)**
Outer Suitcase	8.0	14.5	21.5
Empty cylinder weight		**Sketch no.**	
10 cc - 0.74 lb		KYE 91003	
50 cc - 1.11 lb		KYE 91004	
150 cc - 1.74 lb		KYE 91005	
300 cc - 2.28 lb		KYE 91006	
500 cc - 3.17 lb		KYE 91007	

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Table 7.13-2. Materials/Method of Construction.	
Material	**Description**
Outer case	Andiamo Inc. 700 x 150-AERO-F21-CH 21-in. black case w/foam
	GE Xenoy[a] 522OU thermoplastic resin
Gasket	Silicone (GE)
Foam	Polyurethane
Insert	Polystyrene hard foam
Cylinders	See sketches KYE 91003-91007
Nupro[b] valves	See sketches KYE 91003-91007
Steel bolt (nut and washers, 3/16 in.)	
[a]Xenoy is a trademark of General Electric Company.	
[b]Nupro is a trademark of Nupro Company, a Swagelok Company.	
GE = General Electric Company.	

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Table 7.13-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-6.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-6.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-10.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted on each of the packagings prior to conducting the drop, penetration, and compression tests. This test also was conducted on two empty packagings to ensure that there would be no inleakage of water. See Appendix D, Table D-8.
Free drop	Pass. Fifteen different tests were conducted on six separate packagings with varying points of impact. There was no loss of contents in any instance; however, in some instances one or two of the latches came loose. See Appendix D, Tables D-18.b and D-19.a.
Corner drop	Pass. Eight 1-ft. drops were conducted on one packaging (one on each corner) with no loss of contents and no significant effect on the packaging.
Compression	Pass. This test was conducted with a 500-lb compressive load applied to the top of the packaging for greater than 24 hr. There was no effect and no loss of contents. See Appendix D, Table D-29.
Penetration	Pass. This test was conducted eight times on two separate packagings. In seven of the cases there was only a scratch (no dent). In one case the case split, but the foam prevented the bar from contacting the cylinder. See Appendix D, Table D-36.

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Table 7.13-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Cylinder		Materials and methods of construction per sketch (specs)
		Testing as required by customer
		Testing as required by manufacturer
Valve		Same as for cylinder
	Case	Materials and construction per description in this document
		Latches as described and functional
	Gasket	Per specs in this document
		Inspected for (lack of) defects
	Bolt	Bolt in one (or both) side of handle

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 7.14-1. Dimensions and Weights.

Description	Height cm (in.)		Outside diameter cm (in.)		Inside diameter cm (in.)		Nominal weight kg (lb)		Volume ml (oz)	
Overpack	109.22	(43.0)	75.883	(29.875)	22.860	(9.0*)	97.156	(214)	--	--
Secondary container	33.655	(13.250)	21.593	(8.501)	14.989	(5.901)	53.572	(118)	--	--
Primary container	20.955	(8.250)	14.227	(5.601)	5.593	(2.202)	26.332	(58)	--	--
Sample bottle	11.588	(4.562)	4.826	(1.9)	--	--	0.237	(0.52)	100	(4)

*Foam.

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Table 7.14-2. Materials/Method of Construction.	
Component	**Description**
Primary container	Lead shield, stainless steel, plastic
Primary container seal	Silicone
Primary container O-ring	Nitrile
Secondary container	Stainless steel
Secondary container O-ring	Neoprene
Overpack	416-L (110-gal) steel drum
Foam	Rigid polyurethane

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Table 7.14-3. Westinghouse Hanford Company Drawing Information.

Drawing number	Page number	Revision number	Title
H-2-131500	1	1	Liquid Sample Packaging - Type A Assembly and Views
	2	1	
	3	0	
	4	0	
H-2-131501	1	2	Primary Container Assembly
	2	4	
	3	2	
H-2-131502	1	4	Secondary Container 100-ml (4-oz) Liquid Sample
	2	4	
	3	2	
H-2-131503	1	4	Handling Tool for Primary Container Assembly

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Table 7.14-4. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-6.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-6.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-10.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. The package was tested satisfactorily with no inleakage of water. See Appendix D, Table D-8.
Free drop	Pass. The package was tested satisfactorily from 1.2 m (4 ft) and three orientations: flat on bottom, flat on top, and flat on side with bolt down. See Appendix D, Table D-18.b.
Corner drop	Not required.
Compression	Pass. The package was tested satisfactorily with 1,387 kg (3,058 lb) for 27 hours with no adverse effect. See Appendix D, Table D-29.
Penetration	Pass. The package was tested satisfactorily from 1 m (3.3 ft), targeting the center and the drum lid and on the side at the midpoint of the drum. See Appendix D, Table D-36.
49 CFR 173.466, Additional tests for Type A packagings designed for liquids and gases	Meets applicable requirements.
Free drop	Pass. The package was tested satisfactorily from 9 m (30 ft) and three orientations: flat on bottom, flat on top, and flat on side with bolt down. See Appendix D, Table D-19.a.
Penetration	Pass. The package was tested satisfactorily from 1.7 m (5.5 ft), targeting the center and the drum lid and on the side at the midpoint of the drum. See Appendix D, Table D-36.

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Table 7.14-5. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria[a]
Shielding Containment Seals/O-rings[b]		Functional: • Size, materials, and geometry, as specified
Sealing surfaces		• Lack of rust, dents, nicks
	Weld seams	Acceptable conditions: • Continuous welds, no sharp edges • Lack of dents, no deformations of mating surfaces
Foam	Metal thickness	• Dimensions, as specified • Lot tests by shipper, as appropriate
	Vendor data/certification	• Marking • Test data • Type A certification document provided, as appropriate
	Verification of shielding and containment	Visual: • Lack of corrosion, rust, dents, nicks

[a]These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

[b]NOTE: Inspect and replace seals and O-rings in accordance with applicant-provided operating instructions.

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Table 7.15-1. Dimensions and Weights.

Steel drum	MS-27684-18 (body) See Section 2.8 for further information
Gas vessel	Overall height - 29.21 cm (11 1/2 in.)
	Overall width - 17.78 cm (7 in.)
	Cylinder diameter - 10.16 cm (4 in.)
	Cylinder weight - 1.59 kg (3 lb 8 oz)

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Table 7.15-2. Materials/Method of Construction.

Component	Description
MS Steel drum	Refer to Section 2.8 for further information
Gas vessel	Stainless steel (T 1000-P Quantum Mechanics Corp.)
	[-2.3 kPa at 93 °C (-15/45 psi at 200 °F)]
	Two Nupro* BG series bellows valves
Cushioning	Polyurethane foam

*Nupro is a trademark of Nupro Company, a Swagelok Company.

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APPENDIX D
SUMMARY OF TYPE A PACKAGING TESTS (49 CFR 173.465)

D1.0 INTRODUCTION

The purpose of this section is to provide more details concerning the Type A packaging tests that were conducted or against which the packages were analyzed for compliance. The tests involved are as follow:

1. Water spray
2. Free drop
3. Compression
4. Penetration.

These tests, test methods, and determination of pass/fail criteria are discussed at length in Section 1.0.

D1.1 49 CFR 173.465(a)

(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.

Requirement D-1. Water Spray Test.

49 CFR 173.465	Discussion
(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	Major Points (1) Must precede each test (2) 2 in./hr (3) 1-hr duration Comments This is usually a conditioning of a package, rather than a test as such. One would not expect a loss of contents or significant increase in dose rate resulting from just the water spray test. However, consideration must be given to the possibility of water leakage into the package with subsequent transport of radioactive contents out as leakage. Designer, tester, and evaluator to do and shipper responsibility to ensure.

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.

D1.2 PACKAGING CATEGORY--STEEL DRUMS

In evaluating steel drums against this requirement, one would consider the following:

- The effect the water spray would have on the ability of the steel drums to meet the other Specification 7A performance requirements
- The potential for inleakage of water with the subsequent potential for transport of the radioactive contents out of the packagings
- Because these same packagings are air-leak tight, prevention of the inleakage of water under such passive conditions as a water spray (rain) is expected.

As shown in Tables D-1.a and D-1.b, nine different types of steel drums (a total of 26 different packagings)

were subjected to this test. In all cases, as one would expect based on materials and methods of construction, closure mechanisms, gaskets, and the painted surfaces, the water spray had no effect that could possibly be interpreted as decreasing the ability of the steel drums to meet all Specification 7A performance criteria. This is not surprising since there are years of experience demonstrating that lengthy exposures to rain have not had a negative effect on containment integrity. In addition, in each of the 26 individual tests, a careful inspection demonstrated there was no inleakage of water as a result of these tests. Because these same packagings are air-leak tight, one would also expect them to prevent the inleakage of water under such passive conditions as a water spray (rain).

Table D-1.a. Water Spray Test Results for Steel Drums.

Table D-1.b. Water Spray Test Results for Steel Drums.

As a final point of mainly academic discussion, because the steel drums are air-leak tight to begin with, in the unlikely event of an inleakage of water, it would be equally unlikely that this expected minute quantity of water would leak out. Thus, based on the test data below and after comparison of the similarity in materials and methods of construction of the untested steel drums, one can readily conclude that these steel drums meet this requirement.

D1.3 PACKAGING CATEGORY--STEEL BOXES

In evaluating steel boxes against this requirement, one would consider the following:

- The effect the water spray would have on the ability of the steel boxes to meet the other Specification 7A performance requirements
- The potential for inleakage of water with the subsequent potential for transport of the radioactive contents out of the packagings
- Because these same packagings are air-leak tight, prevention of the inleakage of water under such passive conditions as a water spray (rain) is expected.

In all cases but one (the Argonne National Laboratory - West [ANL-W] 7A-960 steel box), as one would expect based on materials and methods of construction, closure mechanisms, gaskets, and painted surfaces, the water spray would have no effect that could be interpreted as decreasing the ability of the steel boxes to meet all Specification 7A performance criteria. This is not surprising since there are years of experience demonstrating that lengthy exposures to rain have no negative effect on containment integrity. Because these same packagings are air-leak tight, one would also expect them to prevent the inleakage of water under such passive conditions as a water spray (rain).

As a final point of mainly academic discussion, because the steel boxes are air-leak tight to begin with, in the unlikely event of an inleakage of water, it would be equally unlikely that this expected minute quantity of water would leak out. Thus, based on the information below and after comparison of the similarity in materials and methods of construction of the steel boxes, one can readily conclude that all the steel boxes meet this requirement (with the exception of the ANL-W 7A-960, as discussed in Table D-2).

Table D-2. Water Spray Test Results for Steel Boxes.

D1.4 PACKAGING CATEGORY--WOODEN BOXES

In evaluating wooden boxes against this requirement, one would consider the following:

- The effect the water spray would have on the ability of the wooden boxes to meet the other

Specification 7A performance requirements

- The potential for inleakage of water with the subsequent potential for transport of radioactive contents out of the packagings.

As shown in Table D-3, 14 different types of wooden boxes (a total of 24 different packagings) were subjected to this test. In all cases, as one would expect based on materials and methods of construction, closure mechanisms, and caulking/glue, the water spray had no effect that could be interpreted as decreasing the ability of the wooden boxes to meet the remaining Specification 7A performance criteria. This is not surprising since there are years of experience demonstrating that exposure to rain has not had a significant effect on containment integrity.

Table D-3. Water Spray Test Results for ANL and LLNL Wooden Boxes.

With respect to the potential for inleakage of water, some boxes constructed of normal exterior grade plywood did allow small amounts of water to penetrate. For test purposes, the insides of the test boxes were lined with paper, and the box was subjected to the water spray test for 1 hr and allowed to sit for 2 hr. At the end of this period, the paper was inspected for spots which would indicate the presence of water.

Table D-4. Water Spray Test Results for Mound Wooden Boxes.

Table D-5. Water Spray Test Results for Wooden Boxes.

D1.5 WATER INLEAKAGE--WOODEN BOXES

As shown in Table D-4, small amounts of water did appear at times on the paper, indicating an inleakage of water. The majority of the inleakage occurred at the corners and at some points in the seams; however, a few spots occurred that indicated inleakage through the walls themselves. Three possible approaches are described that are acceptable with respect to addressing this inleakage and ensuring that there is no transport of radioactive materials out of the packaging.

- Securely enclose the radioactive contents within the box so that any inleaking water cannot come in contact with the radioactive material.

- Seal the box using GEOCEL or its equivalent. If the box is reused, it must be re-coated with at least one coat to cover the seal areas before each shipment.

- Ensure that there is no loose or removable contamination that could be entrained in any liquid and that the radioactive material is not soluble in the liquid. Thus, even if the liquids come in contact with the radioactive material, there could be no transport from the package.

NOTE: These three approaches are presented in the Restrictions/Specifications sections for each of the evaluated packagings in Section 4.0. There are obviously other possible approaches; however, if an alternative approach is chosen, the basis for the choice must be supported and documented. The use of one of these alternatives or an equivalent allows these wooden boxes to meet this requirement.

Table D-6. Water Spray Test Results for Fiberboard Containers.

D1.6 WATER INLEAKAGE--FIBERBOARD CONTAINERS

The following two possible approaches are acceptable with respect to addressing this potential inleakage and ensuring that there is no transport of radioactive materials out of the packaging.

- Securely enclose the radioactive contents within the box so that any inleaking water cannot come in

contact with the radioactive material.

- Ensure that there is no loose or removable contamination which could be entrained in any liquid and that the radioactive material is not soluble in the liquid. Thus, even if the liquids come in contact with the radioactive material, there could be no transport from the package.

NOTE: These two approaches are presented in the Restrictions/Specifications section for each of the evaluated packagings in Section 5.0. There are obviously other possible approaches; however, if an alternative approach is chosen, the basis for the choice must be supported and documented. The use of one of these alternatives or an equivalent method allows these fiberboard packagings to meet this requirement.

Table D-7. Water Spray Test Results for UF_6 Cylinders.

Table D-8. Water Spray Test Results for Liquid and Gas Packagings.

Table D-9. Water Spray Test Results for Miscellaneous Packagings.

Requirement D-2. Free Drop Test.

49 CFR 173.465	Discussion
(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:	Major Points (1) 4-ft drop (2) Manner to cause maximum damage
(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).	Comments (1) The orientation causing maximum damage may not be readily apparent. Typically, the following guidelines should be considered: (a) Drums - side drop with bolt closure ring (BCR) at impact point; - Angle drop (approximately 45° on BCR and on bottom at intersection of chime and side seam); (b) Boxes - Top (lid) corner near features, such as lifting rings and filters, if any exist; (c) Approximate center of gravity over impact point. (2) A quick release device is required to ensure no change in package orientation.
(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:	Straightforward
Table 11. Free-fall distance for packaging weighing more than 5,000 kilograms. Packaging weight: kilograms; pounds Free-fall distance: feet; meters > 5,000 to 10,000 kilograms; >11,000 to 22,000 pounds; 3 feet; 0.9 meters	Comments Designer, tester, and evaluator to do and shipper responsibility to ensure.

>10,000 to 15,000	>22,000 to 33,000	2	0.6
>15,000	>33,000	1	0.3

(3) For Fissile Class II packagings, the free drop specified in subparagraph (1) or (2) of this paragraph shall be preceded by a free 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.	For packagings to be used for Fissile Class II shipments, further testing and evaluation per subparagraph (3) are required.
(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 meters (1 foot).	Designer, tester, evaluator to do and shipper responsibility to ensure.
(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 meters (1 foot).	Designer, tester, evaluator to do and shipper responsibility to ensure.
(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.	As a rule of thumb, an essentially nonyielding surface is one at least five times the mass of the impacting object. Tester and evaluator to do and shipper responsibility to ensure.

Table D-10.a. Free Drop Test Results for Steel Drums.

Table D-10.b. Free Drop Test Results for Steel Drums.

Table D-10.c. Free Drop Test Results for Steel Drums.

Table D-10.d. Free Drop Test Results for Steel Drums.

Table D-10.e. Free Drop Test Results for Steel Drums.

Table D-11.a. Free Drop Test Results for Steel Boxes.

Table D-11.b. Free Drop Test Results for Steel Boxes

Table D-12. Free Drop Test Results for ANL and LLNL Wooden Boxes.

Table D-13.a. Free Drop Test Results for Wooden Boxes.

Table D-13.b. Free Drop Test Results for Wooden Boxes.

Table D-14. Free Drop Test Results for NLO Family of Banded Wooden Boxes.

Table D-15. Free Drop Test Results for Fiberboard Boxes.

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Table 7.15-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-6.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-6.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-10.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted to demonstrate no inleakage of water and as conditioning prior to the performance tests. There was no inleakage of water and there was no significant effect on the ability of the packaging to meet the Type A tests. See Appendix D, Table D-8.
Free drop - 9 m (30 ft)	Pass. Four drops were conducted on three different packagings: three drops at an angle and one side drop, flat on the bolt. There was no loss of contents after any of these tests, as determined by monitoring pressure before and after and by water immersion after completing all four drop tests. See Appendix D, Table D-18.b.
- 1.2 m (4 ft)	Pass. One drop was conducted on the top (bolt). This was done on the same packaging that had been dropped 9 m (30 ft). There was no loss of contents. See Appendix D, Table D-19.a.
Corner drop	Not required.
Compression	Pass. An empty drum was tested with a weight of 56.75 kg (125 lb) (>5 times the gross weight) for >24 hours. There was no detectable effect. See Appendix D, Table D-29.
Penetration 1.7 m (5 1/2 ft)	Pass. The test was done twice on the same packaging: once at the center of the lid and once at the center of the side. The only results were dents of 0.635 cm (1/4 in.) and 2.54 cm (1 in.), respectively. See Appendix D, Table D-36.

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Table 7.15-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid/closure ring application • Bolt-closure ring, bolt size • Gasket, adhesive, as specified • Geometry, as specified Acceptance conditions: • Lack of dents, deformation of sealing areas • Dimensions as specified
Gasket		• Gasket size, materials, geometry
Weld areas		• Continuous welds, no sharp edges
Body and chime	Metal thickness	• Lot tests by shipper, as appropriate
Air leak tests	Bolt size	Vendor data and/or certification: • Marking • Test data • Type A Certification Document provided, as appropriate • Air leak tests
	Protective coating application	Visual: • Surface/coating, as specified • Lack of imperfections in application • Lack of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 7.16-1. Dimensions and Weights.			
Model	**Height** **cm (in.)**	**Width** **cm (in.)**	**Length** **cm (in.)**
Outer Suitcase	20.32 (8.0)	36.83 (14.5)	54.61 (21.5)
Empty cylinder weight		**Sketch no.**	
500 cc - 1.45 kg (3.2 lb)		SS-4BAW-5417	

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Table 7.16-2. Materials/Method of Construction.	
Material	**Description**
Outer case	Andiamo Inc. 700 x 150-AERO-F21-CH 53.34-cm (21-in.) black case w/foam
	GE Xenoy[a] 522OU thermoplastic resin
Gasket	Silicone (GE)
Foam	Polyurethane
Insert	Polystyrene hard foam
Cylinder	See sketch SS-4BAW-5417
Nupro[b] valve	See sketch SS-4BAW-5417
Steel bolt (nut and washers, 0.48 cm [3/16 in.])	
[a]Xenoy is a trademark of General Electric Company.	
[b]Nupro is a trademark of Nupro Company, a Swagelok Company.	
GE = General Electric Company.	

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Table 7.16-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-6.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-6.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-10.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted on each of the packagings prior to conducting the drop, penetration, and compression tests. This test also was conducted on two empty packagings to ensure that there would be no inleakage of water. See Appendix D, Table D-8.
Free drop	Pass. Fifteen different tests were conducted on six separate packagings with varying points of impact. There was no loss of contents in any instance; however, in some instances one or two of the latches came loose. See Appendix D, Tables D-18.b and D-19.a.
Corner drop	Pass. Eight 0.3-m (1-ft) drops were conducted on one packaging (one on each corner) with no loss of contents and no significant effect on the packaging.
Compression	Pass. This test was conducted with a 227-kg (500-lb) compressive load applied to the top of the packaging for greater than 24 hr. There was no effect and no loss of contents. See Appendix D, Table D-29.
Penetration	Pass. This test was conducted eight times on two separate packagings. In seven of the cases there was only a scratch (no dent). In one case the case split, but the foam prevented the bar from contacting the cylinder. See Appendix D, Table D-36.

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Table 7.16-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Cylinder		Materials and methods of construction per sketch (specs)
		Testing as required by customer
		Testing as required by manufacturer
Valve		Same as for cylinder
	Case	Materials and construction per description in this document
		Latches as described and functional
	Gasket	Per specs in this document
		Inspected for (lack of) defects
	Bolt	Bolt in one (or both) side of handle

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 7.17-1. Dimensions (Nominal).

Item	External dimensions nominal--cm (in.)	Internal dimensions nominal--cm (in.)
Hardigg Case[a]	64 L x 48 W x 48 H (25 L x 19 W x 19 H)	Internal cavity: 32 L x 18 W x 18 H (12.6 L x 7.25 W x 7.25 H)
Spacer assembly		
Round disk	0.64 thick x 17.7 dia. (0.25 thick x 7 dia.)	
Half-moons	4.9 W x 3.0 thick (1.937 W x 1.187 thick)	
SafeSend SP-R1L kit		
Canister	16.51 (6.5) dia. 31.5 (12.4) tall	12.40 (4.88) dia. 21.00 (8.25) tall
Outer container assembly (30-, 125-, and 250-mL)	17.8 tall x 11.3 dia. (7 tall x 4.5 dia.)	15.2 tall x 9.4 dia. (6 tall x 3.7 dia.)
Inner container assembly (125-mL)	13.7 tall x 8.9 dia. (5.4 tall x 3.5 dia.)	10.9 tall x 6.6 dia. (4.3 tall x 2.6 dia.)
Inner container assembly (30-mL)	13.2 tall x 8.9 dia. (5.2 tall x 3.5 dia.)	9.9 tall x 3.8 dia. (3.9 tall x 1.5 dia.)

[a]Hardigg Case is a trademark of Hardigg Industries, Inc.

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Table 7.17-2. Materials/Method of Construction.

Item/component	Description
Hardigg Case	Part No. AL2216-1205-14274-HHBA00. Polyethylene case that includes zinc chromate hardware, steel butterfly latches, cardholder, 2-PCF polyethylene foam, and 0.32-cm (1/8-in.) thick ABS load spreader.
Spacer assembly	WHC Drawing No. H-2-824999. Consists of maple half-moon spacers glued onto a fir plywood disk.
SafeSend SP-R1L[a] kit	Labelmaster 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 mocrowebs, powersorb, universal white with surfactant.
Quad ring gasket	Teflon[b]-coated ethylene propylene. The ring has a thin film of Dow Corning #7 Silicone Paste Lubricant[c] 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.
Outer container assembly (30-, 125-, and 250-mL)	WHC Drawing Number H-2-824999.
Cover	Type 304 stainless steel (ss), ASTM A 240. Screws are alloy steel, ASTM F 835, hexagon socket flat countersunk head cap screws; #8-32UNC-3A x 1-in.
Wall	Type 304 ss, ASTM A 511, cold finish, or ASTM A 276.
Base	Type 304 ss, ASTM A 240. Screws are alloy steel, ASTM F 835, hexagon flat countersunk head cap screw; #8-32UNC-3A x 3/4 in.
O-rings	Nitrile, Parker #2-153-N304-75 or #2-153-N103-70; 8.9-cm (3.487-in.) inner diameter (ID), 0.26-cm (0.103-in.) cross section.
Lifting cable	SAVA #2065, 19.05-cm (7.5-in) long by 0.159-cm (0.063-in.) diameter, uncoated ss, 7 by 19 construction.
Cable fitting	SAVA #805-C, for 0.159-cm (0.063-in.) cable, 0.528-cm (0.208-in.) diameter by 0.762-cm (0.3-in.) long sleeve, copper. To be crimped onto lifting cable

	using SAVA tool T-188.
Inner container assembly (125-mL)	WHC Drawing Number H-2-824999.
Cover and base	Type 304 ss, ASTM A 240. Screws are alloy steel, ASTM F 835, hexagon socket flat countersunk head cap screws; #8-32UNC-3A x 3/4-in.
Wall	Type 304 ss, ASTM A 511, cold finish, or ASTM A 276.
O-rings	Nitrile, Parker #2-153-N304-75 or #2-153-N103-70; 6.0-cm (2.362-in.) ID, 0.26-cm (0.103-in.) cross section.
Inner container assembly (30-mL)	WHC Drawing Number H-2-824999.
Cover and base	Type 304 ss, ASTM A 240. Screws are alloy steel, ASTM F 835, hexagon socket flat countersunk head cap screws; #8-32UNC-3A x 1-in.
Wall	Type 304 ss, ASTM A 511, cold finish, or ASTM A 276.
O-rings	Nitrile, Parker #2-153-N304-75 or #2-153-N103-70; 3.3-cm (1.299-in.) ID, 0.26-cm (0.103-in.) cross section.
Lifting cable	SAVA #2065, 14-cm (5.5-in.) long by 0.159-cm (0.063-in.) diameter, uncoated ss, 7 by 19 construction.
Cable fitting	SAVA #805-C, for 0.159-cm (0.063-in.) cable, 0.528-cm (0.208-in.) diameter by 0.76-cm (0.3-in.) long sleeve, copper. To be crimped onto lifting cable using SAVA tool T-188.
1-L bottle and lid	Nalgene,[d] PVC-coated, 70-mm (2.76-in.) wide-mouth glass bottle, 946-mL (32-oz) capacity, 89 tare weight. Overall dimensions 19.4-cm (7.64-in.) tall by 9.14-cm (3.60-in.) dia. (Labelmaster Catalog Part No. KG3280) with Teflon-lined phenolic lid (Labelmaster Catalog Part No. KC70PTW).
30-, 125-, and 250-mL bottles and lid	User to supply as they desire (considered as packaging not required).

[a]SafeSend SP-R1L is a trademark of 3M Company.

[b]Teflon is a trademark of E. I. du Pont de Nemours & Company.

[c]Dow Corning #7 Silicone Paste Lubricant is a trademark of Dow Corning Corporation.

[d]Nalgene is a trademark of Sybron Corporation.
ABS = Acrylonitrile-butadiene-styrene.
ASTM = American Society for Testing and Materials.
PCF = Pounds per cubic foot.
PVC = Polyvinyl chloride.

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Table 7.17-3. Maximum Gross Weights for Packaging Configurations (Nominal).		
Version	**Bottle and contents g (lb)**	**Packaging gross weight g (lb)**
30-mL	Bottle and contents = 99.3 (0.219)	28,576 (63)
	Contents only = 88.9 (0.196)	
125-mL	Bottle and contents = 364.9 (0.805)	27,216 (60)
	Contents only = 340.2 (0.749)	
250-mL	Bottle and contents = 562.9 (1.24)	24,040 (53)
	Contents only = 524.3 (1.156)	
1-L	Bottle and contents = 2,495 (5.5)	18,144 (40)
	Contents only = 2,041.1 (4.5)	

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Table 7.17-4. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages (pre-HM-181)	Appendix A contains pre-HM-181 information. This packaging was designed and tested after 10/94; therefore, this appendix is not applicable to this packaging.
49 CFR 173.24, Compliance with general requirements for packages and packaging (post-HM-181)	Meets applicable requirements. See Appendix F, Table F-6.
49 CFR 173.24a, Compliance with additional general requirements for non-bulk packaging and packages (post-HM-181)	Meets applicable requirements. See Appendix G, Table G-6.
49 CFR 173.24b, Compliance with additional general requirements for bulk packagings (post-HM-181)	Meets applicable requirements. See Appendix H, Table H-6.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-6.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-10.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted on an empty Hardigg Case with no detectable effect. See Appendix D, Table D-8.
Free drop 9 m (30 ft)	Pass. Drop tests were conduced on the 30-mL and 1-L configurations, in several orientations. In the 30-mL configuration, there was no loss of contents. In the 1-L configuration, there was a slight discharge of contents noted around the bottle lid. See Appendix D, Table D-18.b.
Free drop 1.2 m (4 ft)	Pass. Drop tests were conducted on the 30-mL and 1-L configurations, several orientations. In all cases there was no loss of contents. See Appendix D, Table D-19.a.
49 CFR 173.465, Type A packaging tests (cont.)	Meets applicable requirements.
Compression	Pass. The test was conducted for over a 24-hr period by applying a load of 318 kg (700 lb). There was no significant distortion of the packaging or loss of contents. See Appendix D, Table D-29.
Penetration	Pass. The test was conducted on center of the lid of the packaging with no significant effect. See Appendix D, Table D-36.
49 CFR 178.608, Vibration standards (applied to demonstrate compliance with 49 CFR 173.412[e])	Meets applicable requirements. See Appendix E, Table E-6.

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Table 7.17-5. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria[a]
Shielding Containment O-rings[b] Gasket Sealing surfaces 1-L bottle & lid		Functional: • Size, materials, and geometry, as specified • Lack of dust, dents, nicks, cracks
Identical identification numbers (SafeSend lid & base; ss Pig assemblies)	Weld Seams	Acceptable conditions: • Continuous welds, no cracks • Lack of dents, no deformations of mating surfaces
Spacer assembly	Wood thickness	• Dimensions, as specified • Lot tests by shipper, as appropriate
	Vendor data/certification	• Marking • Test data • Type A certification document provided, as appropriate
	Verification of shielding and containment	Visual: • Lack of corrosion, rust, dents, nicks

[a]These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

[b]NOTE: Inspect and replace O-rings in accordance with applicant-provided operating instructions.

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Table 7.18-1. 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	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.	

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Table 7.18-2. 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 Nm (45-55 inlb).
Bag	Gusseted, polyethylene.
Foam inserts	Open cell, urethane foam.
1-L internal bottle	Narrow-mouth, Teflon, FEP bottle with a ETFE lid. Nalgene[e] Part Number: 1600-0032 (Fisher[f] Part Number: 02-923-30D).

[a]SafeSend is a trademark of the 3M Company.

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

[c]Teflon is a trademark of E. I. du Pont de Nemours & Company.

[d]Dow Corning #7 Silicone Paste Lubricant is a trademark of the Dow Corning Corporation.

[e]Nalgene is a trademark of Sybron Corporation.

[f]Fisher is a trademark of Fisher Scientific.
ETFE = ethylene-tetrafluorethylene
FEP = fluorinated ethylene propylene.

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Table 7.18-3. Weight (Nominal).		
Item	**Description**	**Nominal Weight g (lb)**
SafeSend[a] SP-R1L kit	Includes SafeSend canister and lid; 6 foam inserts; and plastic bag.	1663.0 (3.66)
1-L internal bottle	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)
[a]SafeSend is a trademark of the 3M Company.		
[b]Teflon is a trademark of E.I. du Pont de Nemours & Company.		
[c]Tefzel is a trademark of E.I. du Pont de Nemours & Company.		
ETFE = ethylene tetrafluoroethylene		
FEP = fluorinated ethylene propylene.		

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Table 7.18-4. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages (pre HM-181)	Appendix A contains pre HM-181 information. This packaging was designed and tested for use after 10/94; therefore, this Appendix is not applicable to this packaging.
49 CFR 173.24, Compliance with general requirements for packages and packaging (post HM-181)	Meets applicable requirements. See Appendix F, Table F-6.
49 CFR 173.24a, Compliance with additional general requirements for non-bulk packaging and packages (post HM-181)	Meets applicable requirements. See Appendix G, Table G-6.
49 CFR 173.24b, Compliance with additional general requirements for bulk packagings (post HM-181)	Appendix H contains compliance information. This requirement is not applicable as this is not a bulk packaging.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-6.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-10.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted and there was no inleakage of water; there was no detectable influence on the performance of the package. See Appendix D, Table D-8.
Free drop 9 m (30 ft)	Pass. Drop tests were conducted in several orientations with two bottle types. Due to test results, a restriction on bottle type is required. See Appendix D, Table D-18.c.
Free drop 1.2 m (4 ft)	Pass. Drop tests were conducted in several orientations with no loss of contents. See Appendix D, Table D-19.b.
49 CFR 173.465, Type A packaging tests (cont.)	Meets applicable requirements.
Compression	Pass. The test was conducted for over a 24 hr period by applying a load of 51 kg (112 lb). 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. No effect on the packaging was observed. See Appendix D, Table D-29.
Penetration	Pass. The test was conducted to hit the locking mechanism on the SafeSend lid, and to impact the center of the SafeSend, with no significant effect. See

	Appendix D, Table D-36.
49 CFR 178, Vibration standards [applied to demonstrate compliance with 49 CFR 173.412(e)]	Pass. Testing resulted in no release of material. See Appendix E, Table E-6.

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Table 7.18-5. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Containment		Functional:
Gasket		• Size, materials, and geometry, as specified
Sealing surfaces		• Lack of dust, dents, nicks, cracks
1-L bottle & lid		• 1-L bottle lid diameter same as as-tested bottle
Identical identification numbers (SafeSend lid & base)		
	Weld Seams	Acceptable conditions: • Continuous welds, no cracks
		• Lack of dents, no deformations of mating surfaces
	Vendor data/certification	• Dimensions, as specified
		• Lot tests by shipper, as appropriate
		• Marking
		• Test data
		• Type A certification document provided, as appropriate

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 8.1-1. Dimensions.		
Description	**Height (in.)**	**Diameter (in.)**
Spec 7A	9.875	--
Outside	--	4.5
Inner cavity	--	2.0

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Table 8.1-2. Materials/Method of Construction.	
Body	Mild steel tubing, 0.12 in. thick
Bottom	Mild steel sheet, 11 gauge
Top	304 SST plate, 0.625 in. thick
Lead	Minimum 95% density in all directions
Bolts	Stainless steel aircraft, 1/4-28NC, 3 required
O-Ring	Round, 0.525-in. diameter x 1 15/16-in. inside diameter

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Table 8.1-3. Regulatory Compliance Assessments.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-7.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-7.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-13.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Tests on similar materials demonstrate that this test would have no effect and, since the package was water leak tight after the 4-ft drop, there will be no inleakage of water. See Appendix D, Table D-9.
Free drop	Pass. This package was dropped 4 ft on the top edge with water as contents. There was no loss of contents or change in package geometry. See Appendix D, Table D-20.a.
Corner drop	Not required.
Compression	Pass. This test was conducted with more than five times the gross weight for 24 hr with no effect on the packaging. See Appendix D, Table D-30.
Penetration	Pass. This test was performed on one bolt of the bolt closure cover. There was no significant effect. See Appendix D, Table D-37.
49 CFR 178.250, Specification 55; metal-encased, lead or uranium metal-shielded, radioactive materials container	See Appendix J, Table J-10.

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Table 8.1-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid/closure application • Bolt closure, bolt size • Gasket, as specified • Geometry, as specified Acceptable conditions: • Lack of dents, no deformation of sealing surfaces • Dimensions, as specified
Gasket		• Gasket size, materials, geometry
Weld seams		• Continuous welds, no sharp edges
Body	Metal thickness Bolt size	Lot tests by shipper, as appropriate and/or vendor data certification: • Marking • Test data • Type A certification document provided, as appropriate
	Protective coating	Visual: • Surface/coating, as specified • Absence of application imperfections • Absence of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 8.2-1. Dimensions.		
Description	**Height (in.)**	**Diameter (in.)**
Container (w/o base plate and tie-downs)	48	44

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Table 8.2-2. Materials/Method of Construction.	
Container	10-gauge steel sheet
	Welded seams
Shielding	Water extended polyester

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Table 8.2-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-7.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-7.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-13.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Tests on similar materials demonstrate that this test would have no effect and, since only special form contents are authorized, any inleakage of water will not have a significant effect. See Appendix D, Table D-9.
Free drop	Pass. The drop was conducted on the top rim with no significant effect on the packaging and no change in the package geometry. See Appendix D, Table D-20.a.
Corner drop	Not required.
Compression	Pass. An analysis demonstrated that a compression load of 18,500 lb will not adversely affect this packaging and will not result in significant change in the package geometry or loss of contents. See Appendix D, Table D-30.
Penetration	Pass. An analysis demonstrated and tests on comparable steel sheet confirmed that this test would result in only minor dents. See Appendix D, Table D-37.

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Table 8.2-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface	Vendor qualifications and experience	Functional: • Ease of lid/closure application • Closure size • Geometry, as specified Acceptable conditions: • Lack of dents, no deformation of sealing surfaces • Dimensions, as specified
Weld seams		• Continuous welds, no sharp edges
Body and chime	Metal thickness Bolt size	Lot tests by shipper, as appropriate and/or vendor data certification: • Marking • Test data • Type A certification document provided as appropriate
	Protective coating	Visual: • Surface/coating, as specified • Lack of imperfections in application • Lack of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 8.3-1. Dimensions.		
Description	**Height (in.)**	**Diameter (in.)**
CDV-792 (excluding handles)	8.6250	8.750 outside diameter
Internal cavity	3.4375	4.375 inside diameter

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Table 8.3-2. Materials/Method of Construction.	
Body and lid	Steel clad lead
Lid	Secured with four bolts
CDV-791	Inner assembly which may be used to provide additional shielding

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Table 8.3-3. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-7.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-7.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-13.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Tests on similar materials demonstrate that this test would have no effect and, since the package was water leak tight after the 4-ft drop, there will be no inleakage of water. See Appendix D, Table D-9.
Free drop	Pass. This test was conducted on the upper lid with the package at a 45° angle. There was little effect other than wrinkling of the lid and bending of a handle. See Appendix D, Table D-20.a.
Corner drop	Not required.
Compression	Pass. This test was conducted at 1,070 lb with no detectable effect on the packaging. See Appendix D, Table D-30.
Penetration	Pass. This test was conducted on the side of the package with only slight paint chipping. See Appendix D, Table D-37.

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Table 8.3-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface	Vendor qualifications and experience	Functional: • Ease of lid/closure application • Closure size • Geometry, as specified Acceptable conditions: • Lack of dents, no deformation of sealing surfaces • Dimensions, as specified
Weld seams		• Continuous welds, no sharp edges
Body and chime	Metal thickness Bolt size	Lot tests by shipper, as appropriate and/or vendor data certification: • Marking • Test data • Type A certification document provided as appropriate
	Protective coating application	Visual: • Surface/coating, as specified • Lack of imperfections in application • Lack of rust, dents, nicks

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 8.4-1. Dimensions.	
Drum number	**Volume (gal)**
DOT-17H	30
5C-304	15

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Table 8.4-2. Materials/Method of Construction.

DOT-17H 30-gal steel drum	See 49 CFR 178.118, Specification 17H, Steel Drums
DOT 5C-304 stainless steel drum (15 gal) (modified)	See 49 CFR 178.83, Specification 5C, Steel Drum
Valve	Dyna Quip* Type 3/8 VPA2-82 (WSP-150 psi) welded in place
Absorbent	See Section 8.4.6.2
Steel wool	
Asphalt	

*Dyna Quip is a trademark of Chemetron Corporation.

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Table 8.4-3. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-7.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-7.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-13.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Tests on representative drums demonstrate that this test would have no effect on the package and there would be no inleakage of water. See Appendix D, Table D-9.
Free drop	Pass. The inner container was dropped 6 ft on a chime and 4 ft on the protected valve with no loss of containment integrity. The entire package was then dropped 4 ft on the bolt closure ring with no loss of containment integrity. See Appendix D, Table D-20.a.
Corner drop	Not required.
Compression	Pass. This test was conducted with more than five times the gross weight for 24 hr and no detectable effect on packaging was observed. See Appendix D, Table D-30.
Penetration	Pass. This test was performed on the cylindrical and flat surface of the 17H drum. Only minor dents resulted. See Appendix D, Table D-37.
49 CFR 178.83, Specification 5C; steel barrels or drums	See Appendix J, Table J-4.

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Table 8.4-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid/closure application • Bolt closure, bolt size • Gasket, as specified • Geometry, as specified • Seal, body and valve
Valves		Acceptable conditions: • Lack of dents, no deformation of sealing surfaces • Dimensions, as specified
Gasket		• Gasket size, materials, geometry
Weld seams		• Continuous welds, no sharp edges
Body and chime Air leak tests Helium leak tests of new 5Cs	Metal thickness Bolt size	Lot tests by shipper, as appropriate and/or vendor data certification: • Marking • Test data • Type A certification document provided, as appropriate • Air leak tests
Absorbent		Materials: • Quality • Appropriate for contents

Protective coating application	Visual:	• Surface/coating, as specified • Lack of imperfections in application • Lack of rust, dents, nicks

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*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 8.5-1. Dimensions.			
Description	**Length (in.)**	**Diameter (in.)**	**Height (in.)**
Interior	17.375	17.000	--
Exterior	--	--	--
Including flange	21.500	19.000	--
W/O flange	17.750	15.250	--
Handles	5.625	0.625	2.250

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Table 8.5-2. Materials/Methods of Construction.

Body, flanges, ends	Aluminum 6061 - 0.375 in.		
10 threaded bolt holes in flanges	Stainless steel threaded inserts 10 x 0.375-16 UNC-2B x .38LG		
Welding	ANSI A2.4 - 1979		
Gasket	0.125-in. Neoprene[a], 60 durometer		
Bolts, eyebolts, and washers	Bolts	0.375-16 UNC	- 6 required
	Eyebolts	0.375-16 UNC	- 4 required
	Washers	0.375 flat	-10 required
Aluminum inner container	See Figure 8-5		
Cushioning foam	Silastic[b] RTV S-5370 foam		

[a]Neoprene is a trademark of E. I. duPont de Nemours and Company.
[b]Silastic is a trademark of Dow Corning Corporation.
RTV = room temperature vulcanizing.

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Table 8.5-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-7.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-7.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-13.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was not conducted; however, as has been demonstrated in actual tests on similar materials and configurations, this test would not have any effect on the ability of the packaging to meet the Type A tests. Also there would not be any inleakage of water expected. See Appendix D, Table D-9.
Free drop	Pass. Three 4-ft drop tests were conducted on this packaging: (1) an angle drop on the top corner, (2) a drop flat on the side flange, and (3) a drop flat on the end flange. In all cases there was no loss of contents, no distortion of the packaging and no significant dents. See Appendix D, Table D-20.a.
Corner drop	Not required.
Compression	Pass. This test was not conducted, since the geometry of the packaging does not allow stacking. However, considering the materials and methods of construction, there is no question that it would pass this test/evaluation. See Appendix D, Table D-30.
Penetration	Pass. This test was conducted on the center of the cover, on the side flange, and on one of the bolts. Only minor dents occurred. See Appendix D, Table D-37.

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Table 8.5-4. Packaging/Acceptance Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface	Vendor qualifications	Functional: • Ease of lid/closure ring application • Bolt closure, bolt size • Gasket, as specified Acceptable conditions: • Lack of dents, no deformation of sealing surfaces • Dimensions, as specified
Gasket		• Gasket size, materials and geometry
Weld areas		• Continuous welds, no sharp edges
Body and chime	Metal thickness Bolt thickness	Lot tests by shipper, as appropriate • Vendor data and/or certification - Marking - Test data

*These criteria apply to first-time use and to reuse as a DOT Type A packaging.

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Table 8.6-1. Dimensions and Weight.			
Description	**Height (in.)**	**Diameter (in.)**	**Packaging empty weight (lb)**
Exterior	121	26.0	1,700
Interior	108	25.5	

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Table 8.6-2. Materials/Method of Construction.		
Major Components	**Material**	**Thickness (in.)**
Pintle protector	ASTM A516-78 GR 55 or GR 60 for all major components	0.375
Cylinder wall		0.250
Bottom protector		0.375
Pintle bar		--
Dished head		0.375
NOTE: Container is all-welded construction, including welded-on lid. Filter is a Nuclear Filter Technology, Inc. (NFTI) Model NucFil-018. NucFil is a trademark of NFTI. ASTM = American Society for Testing and Materials.		

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Table 8.6-3. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-7.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-7.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-13.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted and there was no inleakage of water and no features on the package that would retain free standing water. See Appendix D, Table D-9.
Free drop	Pass. Drop tests from a height of 4-ft were conducted as follows: • Flat on top end • Flat on side • Center of gravity over struck corner with top end facing down • Oblique angle drop on bottom end, container at 30° from horizontal • Oblique angle drop on top end, container at 30° from horizontal. See Appendix D, Table D-20.a.
Compression	Pass. A compressive load of 30,040 lb was horizontally applied to the package for 24 hr. See Appendix D, Table D-30.
Penetration	Pass. The 1.25-in diameter, 13.2-lb penetration bar was dropped from a height of 40 in. on the filter and on the side of the container. See Appendix D, Table D-37.

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Table 8.6-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface	Vendor qualifications	Functional: • Ease of lid/closure ring application • Bolt closure, bolt size • Gasket, as specified Acceptable conditions: • Lack of dents, no deformation of sealing surfaces • Dimensions, as specified
Gasket		• Gasket size, materials and geometry
Weld areas		• Continuous welds, as appropriate
Body and chime	Metal thickness	• Lot tests by shipper, as appropriate
	Bolt thickness	• Vendor data and/or certification - Marking - Test data

*These criteria apply to first-time use and to reuse as a DOT Type A packaging.

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Table 8.7-1. Dimensions and Weight.			
Height (in.)	**Length (in.)**	**Diameter (in.)**	**Net Weight (lb)**
24.188	24.375	24	576

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Table 8.7-2. Materials.	
Major Components	**Material**
Shield container (1)	24-in. dia. x 24.375-in. length
	Right circular cylinder
	10-gauge (0.135-in.) steel
End pieces (2)	24-in. dia. x 0.1875-in. steel
Filler plate (1)	8-in. dia. x 0.1875-in. steel
Lifting lugs (2)	1-in. x 2.0625-in. C-channel x 3.0625-in. length
Saddle assembly (2)	3-in. x 3-in. angle iron (0.25 in.) and 0.25-in. steel plate
Cask filler material	0.9% borated polyethylene (poly/cast)
Access tube (1)	3.0625-in. ID; 3.5-in. OD steel pipe x 11.469-in. with 0.25-in. steel end plate
Access tube plug (1)	3-in. dia. x 10.1875-in. length, 30% borated polyethylene rod; internal cavity: 1.8125-in. dia. x 2.75-in. (accommodates source holder)
Source holder (1)	1.5-in. (flat to flat) x 3.0625-in. stainless steel, 1.482 in. x 12 threads/in. externally threaded body (mates with source holder retainer); internal cavity: 0.8125-in. dia. x 1 in. (defines maximum size of neutron source)
Source holder retainer (1)	1.482 in. x 12 threads/in. internally threaded steel pipe x 0.594 in. (mates with source holder)
Lead shield	0.125 in. thick
Lock assembly (1)	0.375-in. x 4.5-in. bolt, lock, and key

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Table 8.7-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-7.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-7.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-13.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Reduced pressure test	Pass. Testing was not needed. See Appendix C, Table C-14.
Water spray	Pass. This test was conducted and there was no inleakage of water. See Appendix D, Table D-9.
Free drop	Pass. The package was subjected to a 4-ft drop oriented so the protrusion caused by the access tube would take the force of impact. The access tube was pushed back into the package by a maximum of 0.875 in. See Appendix D, Table D-20.a.
Corner drop	Not required.
Compression	Pass. This test was conducted with 2,945 lb for 24 hr with no adverse effect on the package. See Appendix D, Table D-30.
Penetration	Pass. The penetration bar was dropped on the end piece with the access tube from 3.3 ft. See Appendix D, Table D-37.

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Table 8.7-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Special form source	Vendor qualifications and experience	Functional: • Ease of source holder and access tube plug operation and closure
	Source holder	• Assembled and installed to restrain special form source in the event of damage
	Lock assembly	• Bolt and lock sized to prevent tampering and loss of access tube plug in the event of damage • Geometry, as specified
		Acceptable conditions: • Provide adequate shielding
Cask filler material access tube/shield container interface	Weld seams	• Continuous welds, no sharp edges
		• Lack of dents, no deformations of mating surfaces • Dimensions, as specified
Shield container body and end pieces	Metal thickness	• Marking • Test data • Type A certification document provided, as appropriate

Protective coating	Visual: • Surface/coating, as specified • Lack of rust, dents, nicks

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*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 8.8-1. Dimensions.	
Drum number	**Volume (gal)**
DOT-17C	55
5C-304	15 1/2

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Table 8.8-2. Materials/Method of Construction.

DOT-17C 55-gal steel drum	See 49 CFR 178.115, Specification 17C, Steel Drums
DOT 5C-304 stainless steel drum (15 1/2 gal) (modified)	See 49 CFR 178.83, Specification 5C, Steel Drum
Valve	Whitey, 60 series, SS-67TSW24T
Absorbent	See Section 8.8.6.2
Sand	

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Table 8.8-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results***
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-1.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-1.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-1.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted and there was no inleakage of water. See Appendix D, Table D-1.a.
Free drop	Pass. Multiple 4-ft drop tests have been conducted on a number of test units with successful results. The impact orientations included:
	Top - CG over corner on bolt
	Top - flat on top
	Bottom - CG over corner
	Bottom - flat on bottom
	Side - flat on bolt.
	See Appendix D, Tables D-10.a and D-10.b.
Corner drop	Not required.
Compression	Pass. This test was conducted on a number of test units with successful results. See Appendix D, Table D-24.
Penetration	Pass. Penetration bar was dropped on a number of test units impacting all potentially vulnerable features with no adverse effects on the packaging. The features impacted included the lid, the filter, the side, and the bottom center. See Appendix D, Table D-31.
49 CFR 178.83, Specification 5C; steel barrels or drums	See Appendix J, Table J-4.

49 CFR 178.115, Specification 17C; steel drums	See Appendix J, Table J-6.
*The reader is referred to the requirements for steel drums because this tritium waste package steel drum was evaluated by comparison with the DOT-17C 55 gal steel drum.	

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Table 8.8-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualifications and experience	Functional: • Ease of lid/closure application • Bolt closure, bolt size • Gasket, as specified • Geometry, as specified • Seal, body and valve
Valves		Acceptable conditions: • Lack of dents, no deformation of sealing surfaces • Dimensions, as specified
Gasket		• Gasket size, materials, geometry
Weld seams		• Continuous welds, no sharp edges
Body and chime Air leak tests Leak tests of new modified 5Cs	Metal thickness Bolt size	Lot tests by shipper, as appropriate and/or vendor data certification: • Marking • Test data • Type A certification document provided, as appropriate • Air leak tests
Absorbent		Materials: • Quality • Appropriate for contents

Protective coating application	Visual:	• Surface/coating, as specified • Lack of imperfections in application • Lack of rust, dents, nicks

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*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 8.9-1. Dimensions.

Model		Height cm (in.)	Diameter cm (in.)
TRUPACT II Ten-Drum Overpack	External	186 (73 1/4)	181 (71 1/4)
	Internal	184.5 (72 5/8)	167 (65 3/4)

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Table 8.9-2. Materials/Method of Construction.

Bottom pan, side panel, and lid panel	ASTM A-36, steel plate, 0.48 cm (3/16 in.), commercial quality, structural grade
Bumper	ASTM A-513 commercial quality, structural grade carbon steel
Flange plates	ASTM A-516 GR 70 Normalized or ASTM A-537 CL 1 Normalized, 3.8 cm x 7.6 cm (1 1/2 in. x 3 in.) or 3.18 cm x 5 cm (1 1/4 in. x 2 in.)
Closure	Capscrew, socket button head, 1.3 cm x 7.6 cm (1/2 in. -3UNC-2B x 3 in.) long ASTM F-835
Gasket	EPDM material, 1.3 cm (1/2 in.) thick, 3.8 cm (1 1/2 in.) wide, 548.6 cm (216 in.) long, 50 $\pm$5 Durometer, ASTM-D-1056-67
Filter	Carbon Composite Filter Assembly, Nuclear Filter Technology, Inc. (NFT), Rocky Flats Plant Std. SX 233

NOTE: Packagings tested in October 1993 were built to Engineering Design & Systems Drawing No. 2018-100, Rev. C.

ASTM = American Society for Testing and Materials.
EPDM = ethylenepropylenediene-monomer.

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Table D-16. Free Drop Test Results for DOT-21C Fiberboard Drums.

Table D-17. Free Drop Test Results for UF_6 Cylinders.

Table D-18.a. Additional Free Drop Test Results for Liquid and Gas Packagings.

Table D-18.b. Additional Drop Test Results for Liquid and Gas Packagings.

Table D-18.c. Additional Free Drop Test Results for Liquid and Gas Packagings.

Table D-19.a. Free Drop Test Results for Liquid and Gas Packagings.

Table D-19.b. Free Drop Test Results for Liquid and Gas Packagings.

Table D-20.a. Free Drop Test Results for Miscellaneous Packagings.

Table D-20.b. Free Drop Test Results for Miscellaneous Packagings.

Table D-20.c. Free Drop Test Results for Miscellaneous Packagings.

Table D-20.d. Free Drop Test Results for Miscellaneous Packagings.

Table D-21. Corner Free Drop Test Results for Wooden Boxes.

Table D-22. Corner Free Drop Test Results for Fiberboard Boxes.

Table D-23. Corner Free Drop Test Results for DOT-21C Fiberboard Drums.

Requirement D-3. Compression Test.

49 CFR 173.465	Discussion
(d) Compression Test The compression test shall last for a period of at least 24 hours and consist of a compressive load equivalent to the greater of the following:	Major Points (1) 5 times actual weight (2) 265 lb/ft^2 times the area of package
(1) Five times the weight of the actual package; or	Comments
(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	(1) Be alert. For packages with a large top surface area, the 265 lb/ft^2 can quickly become very large. (2) Any decreases in distances to package surfaces should be documented for use in evaluating the "no significant dose rate increase" requirement.

opposite sides of the packaging specimen, one of which must be the base on which the package would normally stand.	
	Tester and evaluator to do and shipper responsibility to ensure.

Table D-24. Compression Test Results for Steel Drums.

Table D-25. Compression Test Results for Steel Boxes.

Table D-26. Compression Test Results for Wooden Boxes.

Table D-27. Compression Test Results for Fiberboard Containers.

Table D-28. Compression Test Results for UF_6 Cylinders.

Table D-29. Compression Test Results for Liquid and Gas Packagings.

Table D-30. Compression Test Results for Miscellaneous Packagings.

Requirement D-4. Penetration Test.

49 CFR 173.465	Discussion
(e) Penetration Test	**Major Points**
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) 13-lb bar** **(2) 1 m (3.3 ft)** **(3) Most vulnerable point**
	Comments
(1) A bar 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	**Penetration of the outer packaging(s) is not necessarily a cause for failure. The question is, "Did the test result in a loss of contents?" For outer packaging components not meeting this requirement, one could specify an inner component(s) that will meet the requirement or design protective devices to ensure that the bar cannot reach the primary containment system.**
(2) The distance of the fall of the bar measured from its lower end to the upper	**Tester and evaluator to do and shipper responsibility to ensure.**

surface of the packaging specimen shall not be less than 1 meter (3.3 feet).

Table D-31. Penetration Test Results for Steel Drums.

Table D-32. Penetration Test Results for Steel Boxes.

Table D-33. Penetration Test Results for Wooden Boxes.

Table D-34. Penetration Test Results for Fiberboard Containers.

Table D-35. Penetration Test Results for UF_6 Cylinders.

Table D-36. Penetration Test Results for Liquid and Gas Packagings.

Table D-37. Penetration Test Results for Miscellaneous Packagings.

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Table 8.9-3. Regulatory Compliance Assessment.

Regulatory requirements	Testing/analysis results
49 CFR 173.24, Standard requirements for all packages	Meets applicable requirements. See Appendix A, Table A-7.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-7.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-13.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. Tests were conducted which demonstrated no inleakage of water. The water spray test preceded each of the remaining tests. In no case was there any effect on the ability of the packaging to meet the remaining tests. See Appendix D, Table D-9.
Free drop 1.2 m (4 ft)	Pass. Three separate drop tests were conducted on top and bottom corners and on the side. In all cases there was no loss of contents. See Appendix D, Table D-20.a.
Corner drop	Not required.
Compression	Pass. The test was conducted with greater than five times the gross weight for more than 24 hr. There was no significant distortion of the packaging or loss of contents. See Appendix D, Table D-30.
Penetration	Pass. The test was conducted on the top center and on the side of the packaging with no significant effect. An ultraviolet inspection indicated no leakage of contents. See Appendix D, Table D-37.

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Table 8.9-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface Sealing surface	Vendor qualification and experience	Functional: • Ease of lid application • Flange--flat surface; no foreign matter
Gasket		• Geometry as specified • Size, material, geometry as specified Acceptable conditions: • Lack of dents, no deformation of sealing surfaces • Dimensions as specified
Welds		• Continuous, no sharp edges
Body		• Metal type, thickness, and quality as specified • Bolt number, locations, and materials as specified Lot test by shipper as appropriate and/or vendor data certification: • Marking • Test data • Type A certification document provided, as appropriate
	Protective coating	Visual:

	• Surface coating as specified • Lack of imperfections • Lack of rust, dents, nicks
Filter	Acceptable: • Type, location, and installation as specified

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*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 8.10-1. Dimensions.			
Description	**Length cm (in.)**	**Width cm (in.)**	**Height cm (in.)**
Body and lid (closed [overall dimensions])	243.84 (96)	121.92 (48)	121.92 (48)
Body	243.84 (96)	121.92 (48)	113.665 (44.75)
Lid (overall dimensions)	243.84 (96)	121.92 (48)	15.24 (6)
Top impact limiter-optional (overall dimensions)	287.02 (113)	165.1 (65)	38.1 (15)

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Table 8.10-2. Materials/Method of Construction.

Item	Description
Concrete	Shall be per sponsor's document specification ES-51294. Portland cement, ASTM C150, Type I-II. The cement shall contain no more than 0.60% by weight of alkalies calculated as (Na_2O + 0.658 K_2O). Aggregate shall be fine and coarse and conform to ASTM C33. Maximum size of aggregate shall be 0.9525 cm (3/8 in.).
Polyethylene liner	Ultra-Lock[a] 33-5 or approved equivalent (an approved equivalent is Mobil[b] NRP-135 polyethylene ground pellets). Two pieces, welded together. (Applies to body and lid).
Reinforcing	Welded wire fabric, ASTM A497, D16 x 6 x 6, grade 75. Reinforcing bars, ASTM A615, grade 60.
Lid plug	A 2.54-cm (1-in.) NPT carbon steel square-head plug. Plug inserts into a 2.54-cm (1-in.) NPT carbon steel 90° street ell Schedule 40, that is connected to a 2.54-cm (1-in.) NPT carbon steel 90° ell, that is connected to a 2.54-cm NPT by 6.35-cm long (1-in. NPT by 2.5-in. long), carbon steel Schedule 40 nipple.
Lid washers	Six Carbon steel, ASTM A36, 0.3175-cm (1/8 in.) thick by 7.62 cm (3 in.) by 7.62 cm (3 in.).
Lid bolts	Six 2.54-cm by 15.24-cm (1-in. by 6-in.) coil bolts, B-14, heavy, ASTM A325, Dayton Superior[c].
Body drains	Two plugged drains, located underneath the container body, consisting of two 2.54-cm (1-in.) Schedule 40 by 5.08-cm (2-in.) long nipples, two 2.54-cm (1-in.) ball valves, and two 2.54-cm (1-in.) NPT countersunk plugs. Access to the ball valves is obtained by removing two additional 3.81-cm (1.5-in.) NPT countersunk plugs located on the side of the container body. Two 5.08-cm (2-in.) Schedule 160S, Type 304, ASTM A312 pipe sleeves are contoured to fit the valve body and tack welded into place.
Lifting anchors	Four 15.24-cm by 15.24-cm by 0.635-cm (6-in. by 6-in. by 1/4-in.) thick ASTM A36 plate welded onto ASTM A36 pipe.
Gasket	Astro-Foam[d], 1.27-cm (0.5-in.) thick polyethylene foam, Density of 1.8-1.9, Material Code No. 350-48, Federal Specification PPP-C-1752D.
Glue	Weldwood Contact Cement[e], "The Original, Fast Dry Formula."
Top impact limiter-optional	Douglas Fir, Commercial Grade #2, 20.32 cm by 20.32 cm (8 in. by 8 in.) (nominal). Overall finished size is 165.1 cm (65 in.) wide by 287.02 cm (113

in.) long. Four corner braces consist of 1.27-cm (0.5-in.) carbon steel plate, ASTM A36, with spikes.

[a]Ultra-Lock is a trademark of UltraTech International, Inc.

[b]Mobil is a trademark of Mobil Chemical Company.

[c]Dayton Superior is a trademark of the Dayton Superior Corporation.

[d]Astro-Foam is a trademark of Astro-Valcour, Inc.

[e]Weldwood Contact Cement is a trademark of United States Plywood Corporation.
ASTM = American Society for Testing and Materials.

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Table 8.10-3. Weight.		
Description	**Weight kg (lb)**	
Container lid	816.5	(1,800) - approximate
Container body	3,629	(8,000) - approximate
Empty packaging (without top impact limiter)	4,445	(9,800) - approximate
Content weight (dry)	5,443	(12,000) - maximum
Top impact limiter	340	(750) - approximate
Packaging shipping weight without top impact limiter	9,888	(21,800) - maximum gross
Packaging shipping weight with top impact limiter	10,228.5	(22,550) - maximum gross
Design weight of lifted package (includes 1,724 kg (3,800 lb) of water temporarily in box)	11,703	(25,800) - approximate

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Table 8.10-4. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages (pre-HM-181)	Meets applicable requirements. See Appendix A, Table A-7.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-7.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-13.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted, and there was no inleakage of water; there was no significant affect on the performance of the wooden top impact limiter. See Appendix D, Table D-9.
Free drop 0.6 m (2 ft)	Pass. Drop tests were conduced with and without the top wooden impact limiter, in several orientations, and with no release of contents. See Appendix D, Tables D-20.b and D-20.c.
Compression	Pass. The test was conducted for over a 24-hr period by applying a load of 53,369.681 kg (117,660 lb). There was no cracking or bulging on the interior or exterior of the packaging and no loss of contents. See Appendix D, Table D-30.
Penetration	Pass. The test was conducted to hit the vent plug located on the lid of the container, with no significant effect. See Appendix D, Table D-37.

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Table 8.10-5. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Lid/body interface	Vendor qualification and experience	Functional: • Mating surfaces flat and smooth, no foreign matter • Geometry as specified
Gasket		• Size, material, and geometry as specified
Sealing surfaces		• Lack of dust, dents, nicks, cracks • Surface must be smooth and even
	Weld Seams	Acceptable conditions: • Continuous welds, no cracks • Lack of dents, no deformations of mating surfaces
Lid coil bolts		• Verify that bolts fit down properly into container body for tightening purposes
Body		Lot tests/inspections as appropriate by shipper

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 8.11-1. Dimensions.

Item	Measurements (Nominal)
Cylindrical Tube:	
Length (maximum)	127.0-cm (50.0-in)
Diameter	OD = 27.30-cm (10.75-in) ID = 22.34-cm (8.796-in)
Wall thickness	2.532-cm (0.997-in) (minimum)
End Caps (2 each):	
Length (maximum)	30.48-cm (12-in) (each)
Diameter	OD = 27.30-cm (10.75-in) ID = 22.34-cm (8.796-in)
End-cap thickness	2.532-cm (0.997-in) (minimum)
Overall Length (maximum)	187.96-cm (74-in)
Plywood Spacers (2 - optional):	
Top, OD	21.9-cm (8.625-in)
Bottom, OD	20.6-cm (8.125-in)
Thickness	1.9-cm (0.75-in)

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Table 8.11-2. Materials/Method of Construction.	
Item/component	**Description**
Cylindrical pipe/tube	Phillips-Driscopipe, Inc.; Marlex* M-8000 resin Series 8000 (gas) or Series 8600 (industrial)
End caps (2)	Phillips-Driscopipe, Inc.; 10 (SDR 11) IPS; Part No. 80M100110CPSTB
Wooden spacers (2 - optional)	Plywood, 1.9-cm (0.75-in)
*Marlex is a trademark of Phillips Petroleum Company.	

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Table 8.11-3. Weight.	
Item	**Nominal Weight kg (lb)**
Cylindrical Tube	24.95 (55.0)
End Caps (2 each)	5.67 (12.5) each
Content Fill Weight	483.53 (1066.0)
Gross Weight	519.82 (1146.0)

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Table 8.11-4. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages (pre-HM-181)	Appendix A contains pre HM-181 information. This packaging was designed and tested for use after 10/94; therefore, this Appendix is not applicable to this packaging.
49 CFR 173.24, Compliance with general requirements for packages and packaging (post HM-181)	Meets applicable requirements. See Appendix F, Table F-7.
49 CFR 173.24a, Compliance with additional general requirements for non-bulk packaging and packages (post HM-181)	Meets applicable requirements. See Appendix G, Table G-7.
49 CFR 173.24b, Compliance with additional general requirements for bulk packagings (post HM-181)	Appendix H contains compliance information. This requirement is not applicable as this is not a bulk packaging.
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-7.
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-13.
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted and there was no inleakage of water; there was no detectable influence on the performance of the package. See Appendix D, Table D-9.
Free drop 1.2 m (4 ft)	Pass. Drop tests were conducted with no release of contents. Drop orientations were vertical, horizontal, and center-of-gravity over the edge of the end cap. See Appendix D, Table D-20.d.
Compression	Pass. The test was conducted for over a 24-hr period by applying a load of 2920.0 kg (6437.5 lb), which is 5 times the gross weight of the packaging. No significant effect on the packaging was observed. See Appendix D, Table D-30.
Penetration	Pass. The test was conducted to hit the cylindrical tube/pipe, at the center of the package, with no significant effect. See Appendix D, Table D-37.

49 CFR 178, Vibration standards [applied to demonstrate compliance with 49 CFR 173.412(e)]	Pass. Testing resulted in no release of material. See Appendix E, Table E-7.

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Table 8.11-5. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Pipe/tubing and end cap interface	Vendor qualification and experience	Functional: • Mating surfaces flat and smooth, no foreign matter • Geometry as specified
Sealing surfaces		• Lack of dust, dents, nicks, cracks • Surface must be smooth and even
Weld Joints/Seams	Visual inspection	• Fusion joints should be a continuous bead and smooth • Lack of dents, no deformations of mating surfaces • Lot tests by shipper, as appropriate
	Vendor data/certification	• Marking • Test data • Type A certification document provided, as appropriate

*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table 8.12-1. Dimensions.		
WRAP-1 Drum	**Diameter cm (in.)**	**Height cm (in.)**
Interior	57.15 (22.5)	83.421 (32.843)
Exterior	60.96 (24.0)	88.417 (34.81)

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Table 8.12-2. Materials/Method of Construction.	
Item	**Description**
Drum body*	208-L (55-gal), UN-1A2 full removable head, 16 ga low carbon steel, galvanized.
Drum head and gasket*	Drum head is 16 ga low carbon steel, galvanized. NucFil[1]-013, 3/4-in. - 14 NPT, carbon-activated, HEPA filter. Gasket is FKM or EPDM type, both materials are acceptable. Tubular gaskets are not acceptable.
Bolt ring, nut, and bolt*	Bolt ring is 12 ga (ASTM A109), low carbon steel. Bolt: 5/8-in. - 11 threads/in/ x 4 UNC-2A, hex bolt, steel, zinc plated (ANSI B18.2.1) with corresponding locking nut.
Inner drum lid and filter	Inner drum lid is 16 ga low carbon steel. Lid is fitted with NucFil-013 filter and locking nut.
Inner ring	16 ga low carbon steel. The inner ring shall be adhered and sealed around its circumference at its interface with the drum body with E-6000[2] black adhesive.
Inner seal	22-7/16-in. OD x 20-1/2-in. ID x 5/16-in. thick Neoprene/sbr foam, adhesive backed and satin finish, density 3.5 - 5.0 lb/cu ft, 25% compression resistance: 2.0 - 5.0 psi.
Inner gasket	1/8-in. thick sheet, Neoprene/sbr rubber, 35-45 durometer shore A.

* Per Hanford Standard HS-V-P-0010, Rev. C.

[1]NucFil is a trademark of Nuclear Filter Technology Corporation, Lakewood, Colorado.

[2]E-6000 is a trademark of Eclectic Products Incorporated, Carson, California.

ANSI = American National Standards Institute
ASTM = American Society for Testing and Materials
EPDM = Ethylene/Propylene/Diene
FKM = Fluorocarbon Rubber
HEPA = high-efficiency particulate air
NPT = National Pipe Thread
PSI = pounds per square inch.

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Table 8.12-3. Regulatory Compliance Assessment.	
Regulatory requirements	**Testing/analysis results**
49 CFR 173.24, Standard requirements for all packages (pre-HM-181)	Appendix A contains pre HM-181 information. This packaging was designed and tested for use after 10/94; therefore, this Appendix is not applicable to this packaging.
49 CFR 173.24, Compliance with general requirements for packages and packaging (post HM-181)	Meets applicable requirements. See Appendix F, Table F-1.*
49 CFR 173.24a, Compliance with additional general requirements for non-bulk packaging and packages (post HM-181)	Meets applicable requirements. See Appendix G, Table G-1.*
49 CFR 173.24b, Compliance with additional general requirements for bulk packagings (post HM-181)	Meets applicable requirements. See Appendix H, Table H-1.*
49 CFR 173.411, General design requirements	Meets applicable requirements. See Appendix B, Table B-1.*
49 CFR 173.412, Additional requirements for Type A packages	Meets applicable requirements. See Appendix C, Table C-1.*
49 CFR 173.465, Type A packaging tests	Meets applicable requirements.
Water spray	Pass. This test was conducted and there was no inleakage of water. See Appendix D, Table D-1.a.*
Free drop 1.2 m (4 ft)	Pass. Drop tests were conducted on the WRAP-1 drum to impact the top corner (cog) at the bolt closure and flat onto the side to impact at the bolt closure. There was no loss of material. See Appendix D, Table D-20.d.
	For qualitative damage information from DOT-17C, 55-gal steel drums, refer to Appendix D, Tables D-10.a.* and D-10.b.*
Corner drop	Not required.
Compression	Pass. This test was conducted on a number of test units with successful results. See Appendix D, Table D-24.*
Penetration	Pass. The penetration bar was dropped on a number

	of test units impacting all potentially vulnerable features with no adverse effects on the packaging. The features impacted included the lid, the filter, the side, and the bottom center. See Appendix D, Table D-31.*
49 CFR 178, Vibration standards [applied to demonstrate compliance with 49 CFR 173.412(e)]	Pass. Testing of the WRAP-1 drum resulted in no release of material and no loosening of closure bolt. See Appendix E, Table E-7. For additional information, see Appendix E, Table E-1.*
*The reader is referenced to the requirements for steel drums because this WRAP-1 drum was evaluated by comparison with the DOT-17C, 55-gal steel drum.	

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Table 8.12-4. Packaging/Acceptance/Use Criteria.

Critical	Major	Acceptance/pre-use/inspection criteria*
Outer lid/body and inner lid/ring interface and sealing surface	Vendor qualification and experience	Functional: • Ease of lid/closure ring application • Bolt closure ring--bolt size • Gaskets, seal, and adhesive, as specified • Geometry, as specified Acceptable Conditions: • Lack of dents, no deformation of sealing surfaces
Inner seal and inner lid gasket		• Size, material, and geometry as specified
Weld areas		• Continuous welds, no sharp edges
Body and chime	Metal thickness	Lot tests by shipper, as appropriate
	Protective coating application	Visual: • Surface/coating as specified • Lack of imperfections in application • Lack of rust, dents, nicks
Air leak tests	Bolt size	Vendor Data and/or Certification:

	Marking • Test data • Type A document provided as appropriate • Air leak tests
Filter outer drum lid inner lid	Acceptable: • Type, location, and installation as specified

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*These criteria apply to first-time use and to reuse as a DOT-7A Type A packaging.

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Table A-1. Steel Drums--Compliance with Standard Requirements for All Packages (49 CFR 173.24).		
Regulatory requirement: 49 CFR 173.24	**Action required/by whom**	**Packaging category--steel drums**
(a) Each package used for shipping hazardous materials under this subchapter shall be so designed and constructed, and its contents so limited, that under conditions normally incident to transportation:		
(1) There will be no significant release of the hazardous materials to the environment;	To be considered during package design evaluation. Shipper responsibility to ensure.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.411, .412, .465, and/or .466 as demonstrated in Section 2.0 and Appendixes B, C, and D.
(2) The effectiveness of the packaging will not be substantially reduced; and	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.411, .412, .465, and/or .466 as demonstrated in Section 2.0 and Appendixes B,

		C, and D. NOTE: Shipper responsibility to consider and evaluate, if necessary, the effect of the contents.
(3) There will be no mixture of gases or vapors in the package which could, through any credible spontaneous increase of heat or pressure, or through an explosion, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(b) Materials for which detailed specifications for packaging are not set forth in this part must be securely packaged in strong, tight packages meeting the requirements of this section.	Does not apply.	Does not apply.
(c) Packaging used for the shipment of hazardous materials under this subchapter shall, unless otherwise specified or exempted therein, meet all of the following design and construction criteria:		
(1) Each specification container must be marked as follows:		
(i) In an unobstructed area with letters and numerals identifying the container specification (e.g., DOT-1A, DOT-17E-304HT, DOT-23G40). See §178.0-2 of this subchapter.	Package must be marked "DOT 7A Type A." Shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) The name and address or symbol of person making the mark specified in paragraph (c)(1)(i) of this section. Symbol letters, if used, must be registered with the Director, OHMT. Duplicate symbols are not authorized.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iii) The markings must be stamped, embossed, burned, printed, or otherwise marked on the packaging to provide adequate accessibility, permanency, and contrast so as to be readily apparent and understood.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iv) Unless otherwise specified, letters and numerals must be at least 1/2 inch high.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(v) Packaging which does not comply with	Shipper responsibility to ensure.	Shipper

<table>
<tr><td>the applicable specification listed in Parts 178 and 179 of this subchapter must not be marked to indicate such compliance (see §178.0-2 and §179.1 of this subchapter).</td><td></td><td>responsibility to ensure.</td></tr>
<tr><td>(2) Steel used shall be low-carbon, commercial quality steel. Stainless, open hearth, electric, basic oxygen, or other similar quality steels are acceptable. Steel sheets of specified gauges shall comply with the following:

<table><tr><th>Gauge No.</th><th>Normal thickness (inch)</th><th>Minimum thickness (inch)</th></tr><tr><td>12</td><td>0.1046</td><td>0.0946</td></tr><tr><td>13</td><td>0.0897</td><td>0.0817</td></tr><tr><td>14</td><td>0.0747</td><td>0.0677</td></tr><tr><td>15</td><td>0.0673</td><td>0.0603</td></tr><tr><td>16</td><td>0.0598</td><td>0.0533</td></tr><tr><td>17</td><td>0.0538</td><td>0.0478</td></tr><tr><td>18</td><td>0.0478</td><td>0.0428</td></tr><tr><td>19</td><td>0.0418</td><td>0.0378</td></tr><tr><td>20</td><td>0.0359</td><td>0.0324</td></tr><tr><td>22</td><td>0.0299</td><td>0.0269</td></tr><tr><td>23</td><td>0.0269</td><td>0.0239</td></tr><tr><td>24</td><td>0.0239</td><td>0.0209</td></tr><tr><td>26</td><td>0.0179</td><td>0.0159</td></tr><tr><td>28</td><td>0.0149</td><td>0.0129</td></tr><tr><td>30</td><td>0.0120</td><td>0.0110</td></tr></table></td><td>Designer and fabricator to do and shipper responsibility to ensure.</td><td>Shipper responsibility to ensure.</td></tr>
<tr><td>(3) Lumber used shall be well seasoned, commercially dry, and free from decay, loose knots, knots that would interfere with nailing, and other defects that would materially lessen the strength.</td><td>Designer and fabricator to do and shipper responsibility to ensure.</td><td>Shipper responsibility to ensure.</td></tr>
<tr><td>(4) Welding and brazing shall be performed in a workmanlike manner using suitable and appropriate techniques, materials, and equipment.</td><td>Fabricator to do and shipper responsibility to ensure.</td><td>Shipper responsibility to ensure.</td></tr>
<tr><td>(5) Packaging materials and contents shall be such that there will be no significant</td><td>Designer to do and shipper responsibility to ensure.</td><td>Shipper responsibility to</td></tr>
</table>

chemical or galvanic reaction among any of the materials in the package.		ensure.
(6) Closure shall be adequate to prevent inadvertent leakage of the contents under normal conditions incident to transportation. Gasketed closures shall be fitted with gaskets of efficient materials which will not be deteriorated by the contents of the container.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(7) 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 cause failures.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(8) The nature and thickness of the packaging shall be such that friction during transport does not generate any heating likely to decrease the chemical stability of the contents.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(d) Polyethylene packagings and receptacles.		
(1) Polyethylene 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 occurs during transportation, handling, or refilling.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Each polyethylene 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 Polyethylene Packagings and Receptacles") and the maximum rate of permeation of hazardous lading through or into the polyethylene packaging or receptacles may not exceed the following rates:	Designer, tester, and evaluator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to a temperature no lower than 18°C (64°F) for 180 days in accordance with Test Method 1;		
(ii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to a temperature no lower than 50°C (122°F) for 28 days in accordance with Test Method 2;		

or		
(iii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to a temperature no lower than 60°C (140°F) for 14 days in accordance with Test Method 3.		
(3) Alternative procedures or rates of permeation are permitted if they yield a level of safety equivalent to or greater than that provided by paragraph (d)(2) of this section and are approved by the Director, OHMT.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Each polyethylene packaging used as an outside packaging for materials meeting the definition of a poison according to this subchapter shall be permanently marked, by embossment or other durable means, with the word "POISON" in letters of at least 1/4 inch in height. Additional text or symbols may be included in the marking. The marking shall be located within six inches of the packaging's closure. The requirements of this subparagraph do not apply prior to September 1, 1985.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(e) For specification containers, compliance with the applicable specifications in Parts 178 and 179 of this subchapter shall be required in all details, except as otherwise provided in this subchapter.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table A-2. Steel Boxes--Compliance with Standard Requirements for All Packages (49 CFR 173.24).		
Regulatory requirement: 49 CFR 173.24	**Action required/by whom**	**Packaging category--steel boxes**
(a) Each package used for shipping hazardous materials under this subchapter shall be so designed and constructed, and its contents so limited, that under conditions normally incident to transportation:		
(1) There will be no significant release of the hazardous materials to the environment;	To be considered during package design evaluation. Shipper responsibility to ensure.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.411, .412, .465, and/or .466 as demonstrated in Section 3.0 and Appendixes B, C, and D.
(2) The effectiveness of the packaging will not be substantially reduced; and	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.411, .412, .465, and/or .466 as demonstrated in Section 3.0 and Appendixes B,

		C, and D.
		NOTE: Shipper responsibility to consider and evaluate, if necessary, the effect of the contents.
(3) There will be no mixture of gases or vapors in the package which could, through any credible spontaneous increase of heat or pressure, or through an explosion, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(b) Materials for which detailed specifications for packaging are not set forth in this part must be securely packaged in strong, tight packages meeting the requirements of this section.	Does not apply.	Does not apply.
(c) Packaging used for the shipment of hazardous materials under this subchapter shall, unless otherwise specified or exempted therein, meet all of the following design and construction criteria:		
(1) Each specification container must be marked as follows:		
(i) In an unobstructed area with letters and numerals identifying the container specification (e.g., DOT-1A, DOT-17E-304HT, DOT-23G40). See §178.0-2 of this subchapter.	Package must be marked "DOT 7A Type A." Shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) The name and address or symbol of person making the mark specified in paragraph (c)(1)(i) of this section. Symbol letters, if used, must be registered with the Director, OHMT. Duplicate symbols are not authorized.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iii) The markings must be stamped, embossed, burned, printed, or otherwise marked on the packaging to provide adequate accessibility, permanency, and contrast so as to be readily apparent and understood.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iv) Unless otherwise specified, letters and numerals must be at least 1/2 inch high.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(v) Packaging which does not comply with	Shipper responsibility to ensure.	Shipper

<table>
<tr><td>the applicable specification listed in Parts 178 and 179 of this subchapter must not be marked to indicate such compliance (see §178.0-2 and §179.1 of this subchapter).</td><td></td><td>responsibility to ensure.</td></tr>
<tr><td>(2) Steel used shall be low-carbon, commercial quality steel. Stainless, open hearth, electric, basic oxygen, or other similar quality steels are acceptable. Steel sheets of specified gauges shall comply with the following:

<table><tr><th>Gauge No.</th><th>Normal thickness (inch)</th><th>Minimum thickness (inch)</th></tr><tr><td>12</td><td>0.1046</td><td>0.0946</td></tr><tr><td>13</td><td>0.0897</td><td>0.0817</td></tr><tr><td>14</td><td>0.0747</td><td>0.0677</td></tr><tr><td>15</td><td>0.0673</td><td>0.0603</td></tr><tr><td>16</td><td>0.0598</td><td>0.0533</td></tr><tr><td>17</td><td>0.0538</td><td>0.0478</td></tr><tr><td>18</td><td>0.0478</td><td>0.0428</td></tr><tr><td>19</td><td>0.0418</td><td>0.0378</td></tr><tr><td>20</td><td>0.0359</td><td>0.0324</td></tr><tr><td>22</td><td>0.0299</td><td>0.0269</td></tr><tr><td>23</td><td>0.0269</td><td>0.0239</td></tr><tr><td>24</td><td>0.0239</td><td>0.0209</td></tr><tr><td>26</td><td>0.0179</td><td>0.0159</td></tr><tr><td>28</td><td>0.0149</td><td>0.0129</td></tr><tr><td>30</td><td>0.0120</td><td>0.0110</td></tr></table></td><td>Designer and fabricator to do and shipper responsibility to ensure.</td><td>Shipper responsibility to ensure.</td></tr>
<tr><td>(3) Lumber used shall be well seasoned, commercially dry, and free from decay, loose knots, knots that would interfere with nailing, and other defects that would materially lessen the strength.</td><td>Designer and fabricator to do and shipper responsibility to ensure.</td><td>Shipper responsibility to ensure.</td></tr>
<tr><td>(4) Welding and brazing shall be performed in a workmanlike manner using suitable and appropriate techniques, materials, and equipment.</td><td>Fabricator to do and shipper responsibility to ensure.</td><td>Shipper responsibility to ensure.</td></tr>
<tr><td>(5) Packaging materials and contents shall be such that there will be no significant</td><td>Designer to do and shipper responsibility to ensure.</td><td>Shipper responsibility to</td></tr>
</table>

chemical or galvanic reaction among any of the materials in the package.		ensure.
(6) Closure shall be adequate to prevent inadvertent leakage of the contents under normal conditions incident to transportation. Gasketed closures shall be fitted with gaskets of efficient materials which will not be deteriorated by the contents of the container.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(7) Nails, staples, and other packaging shall not protrude into the interior of the outer packaging in such a manner as to be likely to cause failures.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(8) The nature and thickness of the packaging shall be such that friction during transport does not generate any heating likely to decrease the chemical stability of the contents.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(d) Polyethylene packagings and receptacles.		
(1) Polyethylene 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 occurs during transportation, handling, or refilling.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Each polyethylene 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 Polyethylene Packagings and Receptacles") and the maximum rate of permeation of hazardous lading through or into the polyethylene packaging or receptacles may not exceed the following rates:	Designer, tester, and evaluator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to a temperature no lower than 18°C (64°F) for 180 days in accordance with Test Method 1;		
(ii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to a temperature no lower than 50°C (122°F) for 28 days in accordance with Test Method 2;		

or		
(iii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to a temperature no lower than 60°C (140°F) for 14 days in accordance with Test Method 3.		
(3) Alternative procedures or rates of permeation are permitted if they yield a level of safety equivalent to or greater than that provided by paragraph (d)(2) of this section and are approved by the Director, OHMT.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Each polyethylene packaging used as an outside packaging for materials meeting the definition of a poison according to this subchapter shall be permanently marked, by embossment or other durable means, with the word "POISON" in letters of at least 1/4 inch in height. Additional text or symbols may be included in the marking. The marking shall be located within six inches of the packaging's closure. The requirements of this subparagraph do not apply prior to September 1, 1985.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(e) For specification containers, compliance with the applicable specifications in Parts 178 and 179 of this subchapter shall be required in all details, except as otherwise provided in this subchapter.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table A-3. Wooden Boxes--Compliance with Standard Requirements for All Packages (49 CFR 173.24).		
Regulatory requirement: 49 CFR 173.24	**Action required/by whom**	**Packaging category--wooden boxes**
(a) Each package used for shipping hazardous materials under this subchapter shall be so designed and constructed, and its contents so limited, that under conditions normally incident to transportation:		
(1) There will be no significant release of the hazardous materials to the environment;	To be considered during package design evaluation. Shipper responsibility to ensure.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.411, .412, .465, and/or .466 as demonstrated in Section 4.0 and Appendixes B, C, and D.
(2) The effectiveness of the packaging will not be substantially reduced; and	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.411, .412, .465, and/or .466 as demonstrated in Section 4.0 and Appendixes B,

		C, and D.
		NOTE: Shipper responsibility to consider and evaluate, if necessary, the effect of the contents.
(3) There will be no mixture of gases or vapors in the package which could, through any credible spontaneous increase of heat or pressure, or through an explosion, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(b) Materials for which detailed specifications for packaging are not set forth in this part must be securely packaged in strong, tight packages meeting the requirements of this section.	Does not apply.	Does not apply.
(c) Packaging used for the shipment of hazardous materials under this subchapter shall, unless otherwise specified or exempted therein, meet all of the following design and construction criteria:		
(1) Each specification container must be marked as follows:		
(i) In an unobstructed area with letters and numerals identifying the container specification (e.g., DOT-1A, DOT-17E-304HT, DOT-23G40). See §178.0-2 of this subchapter.	Package must be marked "DOT 7A Type A." Shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) The name and address or symbol of person making the mark specified in paragraph (c)(1)(i) of this section. Symbol letters, if used, must be registered with the Director, OHMT. Duplicate symbols are not authorized.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iii) The markings must be stamped, embossed, burned, printed, or otherwise marked on the packaging to provide adequate accessibility, permanency, and contrast so as to be readily apparent and	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iv) Unless otherwise specified, letters and numerals must be at least 1/2 inch high.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(v) Packaging which does not comply with	Shipper responsibility to ensure.	Shipper

<table>
<tr><td>the applicable specification listed in Parts 178 and 179 of this subchapter must not be marked to indicate such compliance (see §178.0-2 and §179.1 of this subchapter).</td><td></td><td>responsibility to ensure.</td></tr>
<tr><td>(2) Steel used shall be low-carbon, commercial quality steel. Stainless, open hearth, electric, basic oxygen, or other similar quality steels are acceptable. Steel sheets of specified gauges shall comply with the following:

<table><tr><th>Gauge No.</th><th>Normal thickness (inch)</th><th>Minimum thickness (inch)</th></tr><tr><td>12</td><td>0.1046</td><td>0.0946</td></tr><tr><td>13</td><td>0.0897</td><td>0.0817</td></tr><tr><td>14</td><td>0.0747</td><td>0.0677</td></tr><tr><td>15</td><td>0.0673</td><td>0.0603</td></tr><tr><td>16</td><td>0.0598</td><td>0.0533</td></tr><tr><td>17</td><td>0.0538</td><td>0.0478</td></tr><tr><td>18</td><td>0.0478</td><td>0.0428</td></tr><tr><td>19</td><td>0.0418</td><td>0.0378</td></tr><tr><td>20</td><td>0.0359</td><td>0.0324</td></tr><tr><td>22</td><td>0.0299</td><td>0.0269</td></tr><tr><td>23</td><td>0.0269</td><td>0.0239</td></tr><tr><td>24</td><td>0.0239</td><td>0.0209</td></tr><tr><td>26</td><td>0.0179</td><td>0.0159</td></tr><tr><td>28</td><td>0.0149</td><td>0.0129</td></tr><tr><td>30</td><td>0.0120</td><td>0.0110</td></tr></table></td><td>Designer and fabricator to do and shipper responsibility to ensure.</td><td>Shipper responsibility to ensure.</td></tr>
<tr><td>(3) Lumber used shall be well seasoned, commercially dry, and free from decay, loose knots, knots that would interfere with nailing, and other defects that would materially lessen the strength.</td><td>Designer and fabricator to do and shipper responsibility to ensure.</td><td>Shipper responsibility to ensure.</td></tr>
<tr><td>(4) Welding and brazing shall be performed in a workmanlike manner using suitable and appropriate techniques, materials, and equipment.</td><td>Fabricator to do and shipper responsibility to ensure.</td><td>Shipper responsibility to ensure.</td></tr>
<tr><td>(5) Packaging materials and contents shall be such that there will be no significant</td><td>Designer to do and shipper responsibility to ensure.</td><td>Shipper responsibility to</td></tr>
</table>

chemical or galvanic reaction among any of the materials in the package.		ensure.
(6) Closure shall be adequate to prevent inadvertent leakage of the contents under normal conditions incident to transportation. Gasketed closures shall be fitted with gaskets of efficient materials which will not be deteriorated by the contents of the container.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(7) 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 cause failures.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(8) The nature and thickness of the packaging shall be such that friction during transport does not generate any heating likely to decrease the chemical stability of the contents.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(d) Polyethylene packagings and receptacles.		
(1) Polyethylene 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 occurs during transportation, handling, or refilling.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Each polyethylene 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 Polyethylene Packagings and Receptacles") and the maximum rate of permeation of hazardous lading through or into the polyethylene packaging or receptacles may not exceed the following rates:	Designer, tester, and evaluator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to a temperature no lower than 18°C (64°F) for 180 days in accordance with Test Method 1;		
(ii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to a temperature no lower than 50°C (122°F) for 28 days in accordance with Test Method 2;		

or		
(iii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to a temperature no lower than 60°C (140°F) for 14 days in accordance with Test Method 3.		
(3) Alternative procedures or rates of permeation are permitted if they yield a level of safety equivalent to or greater than that provided by paragraph (d)(2) of this section and are approved by the Director, OHMT.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Each polyethylene packaging used as an outside packaging for materials meeting the definition of a poison according to this subchapter shall be permanently marked, by embossment or other durable means, with the word "POISON" in letters of at least 1/4 inch in height. Additional text or symbols may be included in the marking. The marking shall be located within six inches of the packaging's closure. The requirements of this subparagraph do not apply prior to September 1, 1985.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(e) For specification containers, compliance with the applicable specifications in Parts 178 and 179 of this subchapter shall be required in all details, except as otherwise provided in this subchapter.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table A-4. Fiberboard Containers--Compliance with Standard Requirements for All Packages (49 CFR 173.24).		
Regulatory requirement: 49 CFR 173.24	**Action required/by whom**	**Packaging category--fiberboard containers**
(a) Each package used for shipping hazardous materials under this subchapter shall be so designed and constructed, and its contents so limited, that under conditions normally incident to transportation:		
(1) There will be no significant release of the hazardous materials to the environment;	To be considered during package design evaluation. Shipper responsibility to ensure.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.411, .412, .465, and/or .466 as demonstrated in Section 5.0 and Appendixes B, C, and D.
(2) The effectiveness of the packaging will not be substantially reduced; and	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.411, .412, .465, and/or .466 as demonstrated in

		Section 5.0 and Appendixes B, C, and D.
		NOTE: Shipper responsibility to consider and evaluate, if necessary, the effect of the contents.
(3) There will be no mixture of gases or vapors in the package which could, through any credible spontaneous increase of heat or pressure, or through an explosion, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(b) Materials for which detailed specifications for packaging are not set forth in this part must be securely packaged in strong, tight packages meeting the requirements of this section.	Does not apply.	Does not apply.
(c) Packaging used for the shipment of hazardous materials under this subchapter shall, unless otherwise specified or exempted therein, meet all of the following design and construction criteria:		
(1) Each specification container must be marked as follows:		
(i) In an unobstructed area with letters and numerals identifying the container specification (e.g., DOT-1A, DOT-17E-304HT, DOT-23G40). See §178.0-2 of this subchapter.	Package must be marked "DOT 7A Type A." Shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) The name and address or symbol of person making the mark specified in paragraph (c)(1)(i) of this section. Symbol letters, if used, must be registered with the Director, OHMT. Duplicate symbols are not authorized.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iii) The markings must be stamped, embossed, burned, printed, or otherwise marked on the packaging to provide adequate accessibility, permanency, and contrast so as to be readily apparent and understood.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iv) Unless otherwise specified, letters and numerals must be at least 1/2 inch high.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

(v) Packaging which does not comply with the applicable specification listed in Parts 178 and 179 of this subchapter must not be marked to indicate such compliance (see §178.0-2 and §179.1 of this subchapter).	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Steel used shall be low-carbon, commercial quality steel. Stainless, open hearth, electric, basic oxygen, or other similar quality steels are acceptable. Steel sheets of specified gauges shall comply with the following:	Designer and fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

Gauge No.	Normal thickness (inch)	Minimum thickness (inch)
12	0.1046	0.0946
13	0.0897	0.0817
14	0.747	0.0677
15	0.0673	0.0603
16	0.0598	0.0533
17	0.0538	0.0478
18	0.0478	0.0428
19	0.0418	0.0378
20	0.0359	0.0324
22	0.0299	0.0269
23	0.0269	0.0239
24	0.0239	0.0209
26	0.0179	0.0159
28	0.0149	0.0129
30	0.0120	0.0110

(3) Lumber used shall be well seasoned, commercially dry, and free from decay, loose knots, knots that would interfere with nailing, and other defects that would materially lessen the strength.	Designer and fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Welding and brazing shall be performed in a workmanlike manner using suitable and appropriate techniques, materials, and equipment.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

(5) Packaging materials and contents shall be such that there will be no significant chemical or galvanic reaction among any of the materials in the package.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(6) Closure shall be adequate to prevent inadvertent leakage of the contents under normal conditions incident to transportation. Gasketed closures shall be fitted with gaskets of efficient materials which will not be deteriorated by the contents of the container.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(7) Nails, staples, and other packaging shall not protrude into the interior of the outer packaging in such a manner as to be likely to cause failures.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(8) The nature and thickness of the packaging shall be such that friction during transport does not generate any heating likely to decrease the chemical stability of the contents.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(d) Polyethylene packagings and receptacles.		
(1) Polyethylene 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 occurs during transportation, handling, or refilling.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Each polyethylene 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 Polyethylene Packagings and Receptacles") and the maximum rate of permeation of hazardous lading through or into the polyethylene packaging or receptacles may not exceed the following rates:	Designer, tester, and evaluator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to a temperature no lower than 18°C (64°F) for 180 days in accordance with Test Method 1;		
(ii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to a		

temperature no lower than 50°C (122°F) for 28 days in accordance with Test Method 2; or		
(iii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to a temperature no lower than 60°C (140°F) for 14 days in accordance with Test Method 3.		
(3) Alternative procedures or rates of permeation are permitted if they yield a level of safety equivalent to or greater than that provided by paragraph (d)(2) of this section and are approved by the Director, OHMT.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Each polyethylene packaging used as an outside packaging for materials meeting the definition of a poison according to this subchapter shall be permanently marked, by embossment or other durable means, with the word "POISON" in letters of at least 1/4 inch in height. Additional text or symbols may be included in the marking. The marking shall be located within six inches of the packaging's closure. The requirements of this subparagraph do not apply prior to September 1, 1985.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(e) For specification containers, compliance with the applicable specifications in Parts 178 and 179 of this subchapter shall be required in all details, except as otherwise provided in this subchapter.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table A-5. UF_6 Cylinders--Compliance with Standard Requirements for All Packages (49 CFR 173.24).

Regulatory requirement: 49 CFR 173.24	**Action required/by whom**	**Packaging category--UF_6 cylinders**
(a) Each package used for shipping hazardous materials under this subchapter shall be so designed and constructed, and its contents so limited, that under conditions normally incident to transportation:		
(1) There will be no significant release of the hazardous materials to the environment;	To be considered during package design evaluation. Shipper responsibility to ensure.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.411, .412, .465, and/or .466 as demonstrated in Section 6.0 and Appendixes B, C, and D.
(2) The effectiveness of the packaging will not be substantially reduced; and	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.411, .412, .465, and/or .466 as demonstrated in Section 6.0 and

		Appendixes B, C, and D.
		NOTE: Shipper responsibility to consider and evaluate, if necessary, the effect of the contents.
(3) There will be no mixture of gases or vapors in the package which could, through any credible spontaneous increase of heat or pressure, or through an explosion, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(b) Materials for which detailed specifications for packaging are not set forth in this part must be securely packaged in strong, tight packages meeting the requirements of this section.	Does not apply.	Does not apply.
(c) Packaging used for the shipment of hazardous materials under this subchapter shall, unless otherwise specified or exempted therein, meet all of the following design and construction criteria:		
(1) Each specification container must be marked as follows:		
(i) In an unobstructed area with letters and numerals identifying the container specification (e.g., DOT-1A, DOT-17E-304HT, DOT-23G40). See §178.0-2 of this subchapter.	Package must be marked "DOT 7A Type A." Shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) The name and address or symbol of person making the mark specified in paragraph (c)(1)(i) of this section. Symbol letters, if used, must be registered with the Director, OHMT. Duplicate symbols are not authorized.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iii) The markings must be stamped, embossed, burned, printed, or otherwise marked on the packaging to provide adequate accessibility, permanency, and contrast so as to be readily apparent and understood.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iv) Unless otherwise specified, letters and numerals must be at least 1/2 inch high.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

(v) Packaging which does not comply with the applicable specification listed in Parts 178 and 179 of this subchapter must not be marked to indicate such compliance (see §178.0-2 and §179.1 of this subchapter).	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Steel used shall be low-carbon, commercial quality steel. Stainless, open hearth, electric, basic oxygen, or other similar quality steels are acceptable. Steel sheets of specified gauges shall comply with the following:	Designer and fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

Gauge No.	Normal thickness (inch)	Minimum thickness (inch)
12	0.1046	0.0946
13	0.0897	0.0817
14	0.0757	0.0677
15	0.0673	0.0603
16	0.0598	0.0533
17	0.0538	0.0478
18	0.0478	0.0428
19	0.0418	0.0378
20	0.0359	0.0324
22	0.0299	0.0269
23	0.0269	0.0239
24	0.0239	0.0209
26	0.0179	0.0159
28	0.0149	0.0129
30	0.0120	0.0110

(3) Lumber used shall be well seasoned, commercially dry, and free from decay, loose knots, knots that would interfere with nailing, and other defects that would materially lessen the strength.	Designer and fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Welding and brazing shall be performed in a workmanlike manner using suitable and appropriate techniques, materials, and equipment.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(5) Packaging materials and contents shall be	Designer to do and shipper	Shipper

such that there will be no significant chemical or galvanic reaction among any of the materials in the package.	responsibility to ensure.	responsibility to ensure.
(6) Closure shall be adequate to prevent inadvertent leakage of the contents under normal conditions incident to transportation. Gasketed closures shall be fitted with gaskets of efficient materials which will not be deteriorated by the contents of the container.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(7) 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 cause failures.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(8) The nature and thickness of the packaging shall be such that friction during transport does not generate any heating likely to decrease the chemical stability of the contents.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(d) Polyethylene packagings and receptacles.		
(1) Polyethylene 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 occurs during transportation, handling, or refilling.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Each polyethylene 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 Polyethylene Packagings and Receptacles") and the maximum rate of permeation of hazardous lading through or into the polyethylene packaging or receptacles may not exceed the following rates:	Designer, tester, and evaluator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to a temperature no lower than 18°C (64°F) for 180 days in accordance with Test Method 1;		
(ii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to a temperature no lower than 50°C (122°F) for		

28 days in accordance with Test Method 2; or		
(iii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to a temperature no lower than 60°C (140°F) for 14 days in accordance with Test Method 3.		
(3) Alternative procedures or rates of permeation are permitted if they yield a level of safety equivalent to or greater than that provided by paragraph (d)(2) of this section and are approved by the Director, OHMT.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Each polyethylene packaging used as an outside packaging for materials meeting the definition of a poison according to this subchapter shall be permanently marked, by embossment or other durable means, with the word "POISON" in letters of at least 1/4 inch in height. Additional text or symbols may be included in the marking. The marking shall be located within six inches of the packaging's closure. The requirements of this subparagraph do not apply prior to September 1, 1985.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(e) For specification containers, compliance with the applicable specifications in Parts 178 and 179 of this subchapter shall be required in all details, except as otherwise provided in this subchapter.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table A-6. Liquid and Gas Packagings--Compliance with Standard Requirements for All Packages (49 CFR 173.24).		
Regulatory requirement: 49 CFR 173.24	**Action required/by whom**	**Packaging category--liquid and gas packagings**
(a) Each package used for shipping hazardous materials under this subchapter shall be so designed and constructed, and its contents so limited, that under conditions normally incident to transportation:		
(1) There will be no significant release of the hazardous materials to the environment;	To be considered during package design evaluation. Shipper responsibility to ensure.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.411, .412, .465, and/or .466 as demonstrated in Section 7.0 and Appendixes B, C, and D.
(2) The effectiveness of the packaging will not be substantially reduced; and	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.411, .412, .465, and/or .466 as demonstrated in

		Section 7.0 and Appendixes B, C, and D.
		NOTE: Shipper responsibility to consider and evaluate, if necessary, the effect of the contents.
(3) There will be no mixture of gases or vapors in the package which could, through any credible spontaneous increase of heat or pressure, or through an explosion, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(b) Materials for which detailed specifications for packaging are not set forth in this part must be securely packaged in strong, tight packages meeting the requirements of this section.	Does not apply.	Does not apply.
(c) Packaging used for the shipment of hazardous materials under this subchapter shall, unless otherwise specified or exempted therein, meet all of the following design and construction criteria:		
(1) Each specification container must be marked as follows:		
(i) In an unobstructed area with letters and numerals identifying the container specification (e.g., DOT-1A, DOT-17E-304HT, DOT-23G40). See §178.0-2 of this subchapter.	Package must be marked "DOT 7A Type A." Shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) The name and address or symbol of person making the mark specified in paragraph (c)(1)(i) of this section. Symbol letters, if used, must be registered with the Director, OHMT. Duplicate symbols are not authorized.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iii) The markings must be stamped, embossed, burned, printed, or otherwise marked on the packaging to provide adequate accessibility, permanency, and contrast so as to be readily apparent and understood.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iv) Unless otherwise specified, letters and numerals must be at least 1/2 inch high.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

(v) Packaging which does not comply with the applicable specification listed in Parts 178 and 179 of this subchapter must not be marked to indicate such compliance (see §178.0-2 and §179.1 of this subchapter).	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Steel used shall be low-carbon, commercial quality steel. Stainless, open hearth, electric, basic oxygen, or other similar quality steels are acceptable. Steel sheets of specified gauges shall comply with the following:	Designer and fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

Gauge No.	Normal thickness (inch)	Minimum thickness (inch)
12	0.1046	0.0946
13	0.0897	0.0817
14	0.0747	0.0677
15	0.0673	0.0603
16	0.0598	0.0533
17	0.0538	0.0478
18	0.0478	0.0428
19	0.0418	0.0378
20	0.0359	0.0324
22	0.0299	0.0269
23	0.0269	0.0239
24	0.0239	0.0209
26	0.0179	0.0159
28	0.0149	0.0129
30	0.0120	0.0110

(3) Lumber used shall be well seasoned, commercially dry, and free from decay, loose knots, knots that would interfere with nailing, and other defects that would materially lessen the strength.	Designer and fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Welding and brazing shall be performed in a workmanlike manner using suitable and appropriate techniques, materials, and equipment.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

(5) Packaging materials and contents shall be such that there will be no significant chemical or galvanic reaction among any of the materials in the package.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(6) Closure shall be adequate to prevent inadvertent leakage of the contents under normal conditions incident to transportation. Gasketed closures shall be fitted with gaskets of efficient materials which will not be deteriorated by the contents of the container.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(7) 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 cause failures.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(8) The nature and thickness of the packaging shall be such that friction during transport does not generate any heating likely to decrease the chemical stability of the contents.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(d) Polyethylene packagings and receptacles.		
(1) Polyethylene 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 occurs during transportation, handling, or refilling.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Each polyethylene 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 Polyethylene Packagings and Receptacles") and the maximum rate of permeation of hazardous lading through or into the polyethylene packaging or receptacles may not exceed the following rates:	Designer, tester, and evaluator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to a temperature no lower than 18°C (64°F) for 180 days in accordance with Test Method 1;		
(ii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to a		

temperature no lower than 50°C (122°F) for 28 days in accordance with Test Method 2; or		
(iii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to a temperature no lower than 60°C (140°F) for 14 days in accordance with Test Method 3.		
(3) Alternative procedures or rates of permeation are permitted if they yield a level of safety equivalent to or greater than that provided by paragraph (d)(2) of this section and are approved by the Director, OHMT.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Each polyethylene packaging used as an outside packaging for materials meeting the definition of a poison according to this subchapter shall be permanently marked, by embossment or other durable means, with the word "POISON" in letters of at least 1/4 inch in height. Additional text or symbols may be included in the marking. The marking shall be located within six inches of the packaging's closure. The requirements of this subparagraph do not apply prior to September 1, 1985.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(e) For specification containers, compliance with the applicable specifications in Parts 178 and 179 of this subchapter shall be required in all details, except as otherwise provided in this subchapter.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table A-7. Miscellaneous Packagings--Compliance with Standard Requirements for All Packages (49 CFR 173.24).		
Regulatory requirement: 49 CFR 173.24	**Action required/by whom**	**Packaging category--miscellaneous packagings**
(a) Each package used for shipping hazardous materials under this subchapter shall be so designed and constructed, and its contents so limited, that under conditions normally incident to transportation:		
(1) There will be no significant release of the hazardous materials to the environment;	To be considered during package design evaluation. Shipper responsibility to ensure.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.411, .412, .465, and/or .466 as demonstrated in Section 8.0 and Appendixes B, C, and D.
(2) The effectiveness of the packaging will not be substantially reduced; and	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.411, .412, .465, and/or .466 as demonstrated in

		Section 8.0 and Appendixes B, C, and D.
		NOTE: Shipper responsibility to consider and evaluate, if necessary, the effect of the contents.
(3) There will be no mixture of gases or vapors in the package which could, through any credible spontaneous increase of heat or pressure, or through an explosion, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(b) Materials for which detailed specifications for packaging are not set forth in this part must be securely packaged in strong, tight packages meeting the requirements of this section.	Does not apply.	Does not apply.
(c) Packaging used for the shipment of hazardous materials under this subchapter shall, unless otherwise specified or exempted therein, meet all of the following design and construction criteria:		
(1) Each specification container must be marked as follows:		
(i) In an unobstructed area with letters and numerals identifying the container specification (e.g., DOT-1A, DOT-17E-304HT, DOT-23G40). See §178.0-2 of this subchapter.	Package must be marked "DOT 7A Type A." Shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) The name and address or symbol of person making the mark specified in paragraph (c)(1)(i) of this section. Symbol letters, if used, must be registered with the Director, OHMT. Duplicate symbols are not authorized.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iii) The markings must be stamped, embossed, burned, printed, or otherwise marked on the packaging to provide adequate accessibility, permanency, and contrast so as to be readily apparent and	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iv) Unless otherwise specified, letters and numerals must be at least 1/2 inch high.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

(v) Packaging which does not comply with the applicable specification listed in Parts 178 and 179 of this subchapter must not be marked to indicate such compliance (see §178.0-2 and §179.1 of this subchapter).	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Steel used shall be low-carbon, commercial quality steel. Stainless, open hearth, electric, basic oxygen, or other similar quality steels are acceptable. Steel sheets of specified gauges shall comply with the following:	Designer and fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

Gauge No.	Normal thickness (inch)	Minimum thickness (inch)
12	0.1046	0.0946
13	0.0897	0.0817
14	0.0747	0.0677
15	0.0673	0.0603
16	0.0598	0.0533
17	0.0538	0.0478
18	0.0478	0.0428
19	0.0418	0.0378
20	0.0359	0.0324
22	0.0299	0.0269
23	0.0269	0.0239
24	0.0239	0.0209
26	0.0179	0.0159
28	0.0149	0.0129
30	0.0120	0.0110

(3) Lumber used shall be well seasoned, commercially dry, and free from decay, loose knots, knots that would interfere with nailing, and other defects that would materially lessen the strength.	Designer and fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Welding and brazing shall be performed in a workmanlike manner using suitable and appropriate techniques, materials, and equipment.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

(5) Packaging materials and contents shall be such that there will be no significant chemical or galvanic reaction among any of the materials in the package.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(6) Closure shall be adequate to prevent inadvertent leakage of the contents under normal conditions incident to transportation. Gasketed closures shall be fitted with gaskets of efficient materials which will not be deteriorated by the contents of the container.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(7) 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 cause failures.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(8) The nature and thickness of the packaging shall be such that friction during transport does not generate any heating likely to decrease the chemical stability of the contents.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(d) Polyethylene packagings and receptacles.		
(1) Polyethylene 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 occurs during transportation, handling, or refilling.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Each polyethylene 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 Polyethylene Packagings and Receptacles") and the maximum rate of permeation of hazardous lading through or into the polyethylene packaging or receptacles may not exceed the following rates:	Designer, tester, and evaluator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to a temperature no lower than 18°C (64°F) for 180 days in accordance with Test Method 1;		
(ii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to a		

temperature no lower than 50°C (122°F) for 28 days in accordance with Test Method 2; or		
(iii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to a temperature no lower than 60°C (140°F) for 14 days in accordance with Test Method 3.		
(3) Alternative procedures or rates of permeation are permitted if they yield a level of safety equivalent to or greater than that provided by paragraph (d)(2) of this section and are approved by the Director, OHMT.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Each polyethylene packaging used as an outside packaging for materials meeting the definition of a poison according to this subchapter shall be permanently marked, by embossment or other durable means, with the word "POISON" in letters of at least 1/4 inch in height. Additional text or symbols may be included in the marking. The marking shall be located within six inches of the packaging's closure. The requirements of this subparagraph do not apply prior to September 1, 1985.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(e) For specification containers, compliance with the applicable specifications in Parts 178 and 179 of this subchapter shall be required in all details, except as otherwise provided in this subchapter.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table B-1. Steel Drums--Compliance with General Design Requirements (49 CFR 173.411).		
Regulatory requirement	**Guidance for application**	**Packaging category--steel drums**
Except for a package that contains a limited quantity or excepted instrument or article under §§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;	This does not necessarily mean handles are required. The intent is to maintain a package size and geometry that allow conformance to paragraph (a). For example, a package 4 ft × 6 ft × 4 ft cannot be easily handled by hand. For such a package, other handling methods would be designed. A package with sharp edges or components may not be easily handled manually. Also, package stability is required during transport. A round-shaped package, a top-heavy package, or any similar package that would not maintain its initial orientation and load position under conditions incidental to routine transportation would not meet these requirements. Tie-downs are required for the packagings mentioned in this paragraph, and exclusive use shipments or documented special provisions with the carrier are required. Designer to do and shipper responsibility to ensure.	All the drums evaluated meet the intent of this requirement. In all cases, the shipper should avoid loading a top-heavy package and should be aware of the need for tie-downs for any such packages.
(b) A package with a gross weight exceeding 10 kilograms (22 pounds) and	This does not necessarily mean that handles are required. As in the previous comment on paragraph (a), physical size, geometry, and exterior surface design should be conducive to manual handling. Excluded are:	All the drums evaluated meet the intent of this requirement when in the 10-kg (22-lb) to 50-kg (110-lb) range.

up to 50 kilograms (110 pounds) has a means for manual handling;		
	- Large, awkward packages or odd-shaped packages with no reasonable way to lift, hold, or move by hand;	
	- Surfaces with sharp edges or points which make handling difficult.	
	Designer to do and shipper responsibility to ensure.	
(c) A package with a gross weight of 50 kilograms (110 pounds) or more can safely be handled by mechanical means;	Thought should be given to how the packages will be handled; and they should be designed accordingly. If skids are used, the balance stability of the package on the forklift must be considered. One must also ensure that, when lifted by a forklift, the bottom structure can support the weight without significant distortion or loss of containment integrity. If hooks/lifting devices are used, they must meet 49 CFR 173.411(d). In most cases, this is for the shipper to evaluate, particularly the requirements that failure "would not impair the ability of the package to meet all other requirements." Designer to do and shipper responsibility to ensure.	All the drums evaluated meet the intent of this requirement. There are many drum/barrel handling devices that have proven effective and safe for drums weighing more 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	A sign saying "Do Not Use As A Lifting Device," "Not A Lifting Device," etc. is not adequate to prevent the use of the unauthorized lifting devices. The procedures for use of the packaging should also state the intended use of any attachment points for other purposes (e.g., "For lifting the lid only--not entire packaging"). Designer, and perhaps tester and evaluator, to do and shipper responsibility to ensure.	All the drums evaluated meet the intent of this requirement. **The only drum with a handle is the 17C (49 CFR 178.115) 5-gal drum**. This packaging was tested (1) at greater than 300 lb with no failure of handle, and (2) at 400 lb where the handle did fail, but only pulled free from the side coupling. Thus, the failure was in an acceptable mode. There were no other lifting devices or attachments.

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 of being made inoperable for transport, or shall be designed with strength equivalent to that required for lifting attachments;		
(e) The external surfaces, as far as practicable, may be easily decontaminated;	Plywood, although not normally thought of as easily decontaminated, is acceptable. The intent is to promote surfaces that are relatively smooth and that minimize cracks and crevices in which surface contamination could reside. Consideration should be given to actions such as sanding or painting surfaces. Designer to do and shipper responsibility to ensure.	All the drums evaluated meet the intent of this requirement.
(f) The outer layer of packaging will avoid, as far as practicable, pockets or crevices where water might collect; and	This is not intended to eliminate 55-gal drums as Specification 7A packaging. The intent is for packaging design personnel to consider this aspect. Avoid designing a packaging that provides cavities to collect water, which could spill during transport or handling or could promote rusting and general deterioration of the packaging, possibly in locations difficult to detect. Designer to do and shipper responsibility to ensure.	All the drums evaluated meet the intent of the regulation. A newly designed package should consider this requirement.
(g) Each feature that is added to the package at the time of transport, and that is not part of the package, will not reduce the safety of the package.	For example, a canvas cover placed over a package for protection against the rain must not adversely affect heat transfer requirements. Shipper responsibility to ensure.	This is a shipper responsibility because the regulation addresses items added to the packaging that was already evaluated.

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Table B-2. Steel Boxes--Compliance with General Design Requirements (49 CFR 173.411).

Regulatory requirements	**Guidance for application**	**Packaging category--steel boxes**
Except for a package that contains a limited quantity or excepted instrument or article under §§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;	This does not necessarily mean handles are required. The intent is to maintain a package size and geometry that allow conformance to paragraph (a). For example, a package 4 ft × 6 ft × 4 ft cannot be easily handled by hand. For such a package, other handling methods would be designed. A package with sharp edges or components may not be easily handled manually. Also, package stability is required during transport. A round-shaped package, a top-heavy package, or any similar package that would not maintain its initial orientation and load position under conditions incidental to routine transportation would not meet these requirements. Tie-downs are required for the packagings mentioned in this paragraph, and exclusive use shipments or documented special provisions with the carrier are required. Designer to do and shipper responsibility to ensure.	All the steel boxes evaluated meet the intent of this requirement. None are intended for manual handling and all have a large, stable base.
(b) A package with a gross weight exceeding 10 kilograms (22 pounds) and	This does not necessarily mean that handles are required. As in the previous comment on paragraph (a), physical size, geometry, and exterior surface design should be conducive to manual handling. Excluded are:	This does not apply because all the steel boxes will weigh more than 50 kg (110 lb).

up to 50 kilograms (110 pounds) has a means for manual handling;		
	- Large, awkward packages or odd-shaped packages with no reasonable way to lift, hold, or move by hand;	
	- Surfaces with sharp edges or points which make handling difficult.	
	Designer to do and shipper responsibility to ensure.	
(c) A package with a gross weight of 50 kilograms (110 pounds) or more can safely be handled by mechanical means;	Thought should be given to how the packages will be handled; and they should be designed accordingly. If skids are used, the balance stability of the package on the forklift must be considered. One must also ensure that, when lifted by a forklift, the bottom structure can support the weight without significant distortion or loss of containment integrity. If hooks/lifting devices are used, they must meet 49 CFR 173.411(d). In most cases, this is for the shipper to evaluate, particularly the requirements that failure "would not impair the ability of the package to meet all other requirements." Designer to do and shipper responsibility to ensure.	These boxes are typically designed for handling with a truck or forklift. In all the steel box packagings, experience, testing, and/or design analysis have demonstrated compliance.
(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.	A sign saying "Do Not Use As A Lifting Device," "Not A Lifting Device," etc. is not adequate to prevent the use of the unauthorized lifting devices. The procedures for use of the packaging should also state the intended use of any attachment points for other purposes (e.g., "For lifting the lid only--not entire packaging"). Designer, and perhaps tester and evaluator, to do and shipper responsibility to ensure.	The **M-4 bin** and the **SAND box** have lifting devices that far exceed the required safety factor of 3; however, because of the strength of the lifting device, in each case the box will fail before the lifting device. This will not negatively affect the evaluation of these boxes because both are used within overpacks and the lifting devices are not used during transportation. RoGar boxes have lifting devices on the lid. These are intended only for lifting the lid and must be removed or rendered inoperable before transport. This is the shipper's responsibility.

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 of being made inoperable for transport, or shall be designed with strength equivalent to that required for lifting attachments;		
(e) The external surfaces, as far as practicable, may easily decontaminated;	Plywood, although not normally thought of as easily decontaminated, is acceptable. The intent is to promote surfaces that are relatively smooth and that minimize cracks and crevices in which surface contamination could reside. Consideration should be given to actions such as sanding or painting surfaces. Designer to do and shipper responsibility to ensure.	All the boxes evaluated meet the intent of this requirement.
(f) The outer layer of packaging will avoid, as far as practicable, pockets or crevices where water might collect; and	This is not intended to eliminate 55-gal drums as Specification 7A packaging. The intent is for packaging design personnel to consider this aspect. Avoid designing a packaging that provides cavities to collect water, which could spill during transport or handling or could promote rusting and general deterioration of the packaging, possibly in locations difficult to detect. Designer to do and shipper responsibility to ensure.	All the boxes evaluated meet the intent of the requirement.
(g) Each feature that is added to the package at the time of transport, and that is not part of the package, will not reduce the safety of the package.	For example, a canvas cover placed over a package for protection against the rain must not adversely affect heat transfer requirements. Shipper responsibility to ensure.	This is a shipper responsibility because the regulation addresses items added to the packaging that was already evaluated.

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Table B-3. Wooden Boxes--Compliance with General Design Requirements (49 CFR 173.411).

Regulatory requirement	Guidance for application	Packaging category--wooden boxes
Except for a package that contains a limited quantity or excepted instrument or article under §§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;	This does not necessarily mean handles are required. The intent is to maintain a package size and geometry that allow conformance to paragraph (a). For example, a package 4 ft × 6 ft × 4 ft cannot be easily handled by hand. For such a package, other handling methods would be designed. A package with sharp edges or components may not be easily handled manually. Also, package stability is required during transport. A round-shaped package, a top-heavy package, or any similar package that would not maintain its initial orientation and load position under conditions incidental to routine transportation would not meet these requirements. Tie-downs are required for the packagings mentioned in this paragraph, and exclusive use shipments or documented special provisions with the carrier are required. Designer to do and shipper responsibility to ensure.	All the wooden boxes evaluated meet the intent of this requirement. In all cases the shipper should avoid loading a top-heavy package and should be aware of the need for tie-downs for any such packages.
(b) A package with a gross weight exceeding 10 kilograms (22 pounds) and	This does not necessarily mean that handles are required. As in the previous comment on paragraph (a), physical size, geometry, and exterior surface design should be conducive to manual handling. Excluded are:	All the wooden boxes evaluated meet the intent of this requirement when used in the 10-kg (22-lb) to 50-kg (110-lb) range.

up to 50 kilograms (110 pounds) has a means for manual handling;		
	- Large, awkward packages or odd-shaped packages with no reasonable way to lift, hold, or move by hand;	
	- Surfaces with sharp edges or points which make handling difficult.	
	Designer to do and shipper responsibility to ensure.	
(c) A package with a gross weight of 50 kilograms (110 pounds) or more can safely be handled by mechanical means;	Thought should be given to how the packages will be handled; and they should be designed accordingly. If skids are used, the balance stability of the package on the forklift must be considered. One must also ensure that, when lifted by a forklift, the bottom structure can support the weight without significant distortion or loss of containment integrity. If hooks/lifting devices are used, they must meet 49 CFR 173.411(d). In most cases, this is for the shipper to evaluate, particularly the requirements that failure "would not impair the ability of the package to meet all other requirements." Designer to do and shipper responsibility to ensure.	These boxes are typically designed for handling with a truck or forklift. For all of these packagings, experience, testing, and/or design analysis have demonstrated compliance.
(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.	A sign saying "Do Not Use As A Lifting Device," "Not A Lifting Device," etc. is not adequate to prevent the use of the unauthorized lifting devices. The procedures for use of the packaging should also state the intended use of any attachment points for other purposes (e.g., "For lifting the lid only--not entire packaging"). Designer, and perhaps tester and evaluator, to do and shipper responsibility to ensure.	None of the wooden boxes have lifting attachments; this requirement does not apply.

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 of being made inoperable for transport, or shall be designed with strength equivalent to that required for lifting attachments;		
(e) The external surfaces, as far as practicable, may easily decontaminated;	Plywood, although not normally thought of as easily decontaminated, is acceptable. The intent is to promote surfaces that are relatively smooth and that minimize cracks and crevices in which surface contamination could reside. Consideration should be given to actions such as sanding or painting surfaces. Designer to do and shipper responsibility to ensure.	All the boxes evaluated meet the intent of this requirement. If contamination is a significant potential problem, then sanding, painting, or similar surface preparation should be completed.
(f) The outer layer of packaging will avoid, as far as practicable, pockets or crevices where water might collect; and	This is not intended to eliminate 55-gal drums as Specification 7A packaging. The intent is for packaging design personnel to consider this aspect. Avoid designing a packaging that provides cavities to collect water, which could spill during transport or handling or could promote rusting and general deterioration of the packaging, possibly in locations difficult to detect. Designer to do and shipper responsibility to ensure.	All the boxes evaluated meet the intent of the requirement.
(g) Each feature that is added to the package at the time of transport, and that is not part of the package, will not reduce the safety of the package.	For example, a canvas cover placed over a package for protection against the rain must not adversely affect heat transfer requirements. Shipper responsibility to ensure.	This is a shipper responsibility because the regulation addresses items added to the packaging that was already evaluated.

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Table B-4. Fiberboard Containers--Compliance With General Design Requirements (49 CFR 173.411).

Regulatory requirement	Guidance for application	Packaging category--fiberboard containers
Except for a package that contains a limited quantity or excepted instrument or article under §§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;	This does not necessarily mean handles are required. The intent is to maintain a package size and geometry that allow conformance to paragraph (a). For example, a package 4 ft × 6 ft × 4 ft cannot be easily handled by hand. For such a package, other handling methods would be designed. A package with sharp edges or components may not be easily handled manually. Also, package stability is required during transport. A round-shaped package, a top-heavy package, or any similar package that would not maintain its initial orientation and load position under conditions incidental to routine transportation would not meet these requirements. Tie-downs are required for the packagings mentioned in this paragraph, and exclusive use shipments or documented special provisions with the carrier are required. Designer to do and shipper responsibility to ensure.	All the fiberboard boxes and drums meet the intent of this requirement. In all cases the shipper should avoid loading a top-heavy package and should be aware of the need for tie-downs for any such packages.
(b) A package with a gross weight exceeding	This does not necessarily mean that handles are required. As in the previous comment on paragraph (a), physical size, geometry, and exterior surface design should be conducive	All fiberboard boxes and drums meet the intent of this requirement when used in the 10-kg (22-lb) to 50-kg (110-lb) range. Obviously, the Tri-wall

10 kilograms (22 pounds) and up to 50 kilograms (110 pounds) has a means for manual handling;	to manual handling. Excluded are:	packaging (Appendix D) is intended for weights exceeding 50 kg and will require mechanical handling equipment.
	- Large, awkward packages or odd-shaped packages with no reasonable way to lift, hold, or move by hand;	
	- Surfaces with sharp edges or points which make handling difficult.	
	Designer to do and shipper responsibility to ensure.	
(c) A package with a gross weight of 50 kilograms (110 pounds) or more can safely be handled by mechanical means;	Thought should be given to how the packages will be handled; and they should be designed accordingly. If skids are used, the balance stability of the package on the forklift must be considered. One must also ensure that, when lifted by a forklift, the bottom structure can support the weight without significant distortion or loss of containment integrity. If hooks/lifting devices are used, they must meet 49 CFR 173.411(d). In most cases, this is for the shipper to evaluate, particularly the requirements that failure "would not impair the ability of the package to meet all other requirements." Designer to do and shipper responsibility to ensure.	These boxes and drums evaluated are typically designed for handling with hand-trucks and/or forklifts when weighing in excess of 50 kg. For all of these packagings, experience, testing, and/or design analysis have demonstrated compliance. As in all packages, but particularly important in Tri-wall packaging, the shipper shall ensure that the content load is in the center of the box or evenly distributed along the bottom.
(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.	A sign saying "Do Not Use As A Lifting Device," "Not A Lifting Device," etc. is not adequate to prevent the use of the unauthorized lifting devices. The procedures for use of the packaging should also state the intended use of any attachment points for other purposes (e.g., "For lifting the lid only--not entire packaging"). Designer, and perhaps tester and evaluator, to do and shipper responsibility to ensure.	None of the fiberboard packagings have lifting attachments; this requirement does not apply.

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 of being made inoperable for transport, or shall be designed with strength equivalent to that required for lifting attachments;		
(e) The external surfaces, as far as practicable, may easily decontaminated;	Plywood, although not normally thought of as easily decontaminated, is acceptable. The intent is to promote surfaces that are relatively smooth and that minimize cracks and crevices in which surface contamination could reside. Consideration should be given to actions such as sanding or painting surfaces. Designer to do and shipper responsibility to ensure.	All the packagings evaluated meet the intent of this requirement. If contamination is a significant potential problem, covering, painting, or similar surface preparation should be completed.
(f) The outer layer of packaging will avoid, as far as practicable, pockets or crevices where water might collect; and	This is not intended to eliminate 55-gal drums as Specification 7A packaging. The intent is for packaging design personnel to consider this aspect. Avoid designing a packaging that provides cavities to collect water, which could spill during transport or handling or could promote rusting and general deterioration of the packaging, possibly in locations difficult to detect. Designer to do and shipper responsibility to ensure.	All the packagings evaluated meet the intent of the requirement.
(g) Each feature that is added to the package at the time of transport, and that is not part of the package, will not reduce the safety of the	For example, a canvas cover placed over a package for protection against the rain must not adversely affect heat transfer requirements. Shipper responsibility to ensure.	This is a shipper responsibility because the regulation addresses items added to the packaging that was already evaluated.

package.		

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Table B-5. UF_6 Cylinders--Compliance With General Design Requirements (49 CFR 173.411).		
Regulatory requirement	**Guidance for application**	**Packaging category--UF_6 cylinders**
Except for a package that contains a limited quantity or excepted instrument or article under §§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;	This does not necessarily mean handles are required. The intent is to maintain a package size and geometry that allow conformance to paragraph (a). For example, a package 4 ft × 6 ft × 4 ft cannot be easily handled by hand. For such a package, other handling methods would be designed. A package with sharp edges or components may not be easily handled manually. Also, package stability is required during transport. A round-shaped package, a top-heavy package, or any similar package that would not maintain its initial orientation and load position under conditions incidental to routine transportation would not meet these requirements. Tie-downs are required for the packagings mentioned in this paragraph, and exclusive use shipments or documented special provisions with the carrier are required. Designer to do and shipper responsibility to ensure.	All cylinders evaluated meet the intent of this requirement. The experience data base demonstrates the stability of these packages in transport and their ease of handling.
(b) A package with a gross	This does not necessarily mean that handles are required. As in the previous comment on	This applies only to the **1S**, 2S, and 5A cylinders. As stated

weight exceeding 10 kilograms (22 pounds) and up to 50 kilograms (110 pounds) has a means for manual handling;	paragraph (a), physical size, geometry, and exterior surface design should be conducive to manual handling. Excluded are:	above, a vast experience base demonstrates compliance.
	- Large, awkward packages or odd-shaped packages with no reasonable way to lift, hold, or move by hand;	
	- Surfaces with sharp edges or points which make handling difficult.	
	Designer to do and shipper responsibility to ensure.	
(c) A package with a gross weight of 50 kilograms (110 pounds) or more can safely be handled by mechanical means;	Thought should be given to how the packages will be handled; and they should be designed accordingly. If skids are used, the balance stability of the package on the forklift must be considered. One must also ensure that, when lifted by a forklift, the bottom structure can support the weight without significant distortion or loss of containment integrity. If hooks/lifting devices are used, they must meet 49 CFR 173.411(d). In most cases, this is for the shipper to evaluate, particularly the requirements that failure "would not impair the ability of the package to meet all other requirements." Designer to do and shipper responsibility to ensure.	For the cylinders other than 1S, 2S, and 5A, a variety of mechanical systems are provided and have been used effectively and reliably for years. See Appendix C, Table C-9.
(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	A sign saying "Do Not Use As A Lifting Device," "Not A Lifting Device," etc. is not adequate to prevent the use of the unauthorized lifting devices. The procedures for use of the packaging should also state the intended use of any attachment points for other purposes (e.g., "For lifting the lid only--not entire packaging"). Designer, and perhaps tester and evaluator, to do and shipper responsibility to ensure.	All cylinders meet this requirement, as demonstrated in Appendix C, Table C-9.

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 of being made inoperable for transport, or shall be designed with strength equivalent to that required for lifting attachments;		
(e) The external surfaces, as far as practicable, may easily decontaminated;	Plywood, although not normally thought of as easily decontaminated, is acceptable. The intent is to promote surfaces that are relatively smooth and that minimize cracks and crevices in which surface contamination could reside. Consideration should be given to actions such as sanding or painting surfaces. Designer to do and shipper responsibility to ensure.	The metal and painted metal surfaces have demonstrated, through experience, compliance with this requirement.
(f) The outer layer of packaging will avoid, as far as practicable, pockets or crevices where water might collect; and	This is not intended to eliminate 55-gal drums as Specification 7A packaging. The intent is for packaging design personnel to consider this aspect. Avoid designing a packaging that provides cavities to collect water, which could spill during transport or handling or could promote rusting and general deterioration of the packaging, possibly in locations difficult to detect. Designer to do and shipper responsibility to ensure.	These packages meet the intent of the requirement as shown in Section 6.0 in Figures 6-1 through 6-13.
(g) Each feature that is added to the package at the time of transport, and that is not part of the package, will not reduce	For example, a canvas cover placed over a package for protection against the rain must not adversely affect heat transfer requirements. Shipper responsibility to ensure.	No features are added other than those described in operating procedures, and these are evaluated by the shipper.

the safety of the package.		

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Table B-6. Liquid and Gas Packagings--Compliance With General Design Requirements (49 CFR 173.411).		
Regulatory requirements	**Guidance for application**	**Packaging category--liquid and gas packagings**
Except for a package that contains a limited quantity or excepted instrument or article under §§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;	This does not necessarily mean handles are required. The intent is to maintain a package size and geometry that allow conformance to paragraph (a). For example, a package 1.2 m x 1.8 m x 1.2 m (4 ft × 6 ft × 4 ft) cannot be easily handled by hand. For such a package, other handling methods would be designed. A package with sharp edges or components may not be easily handled manually. Also, package stability is required during transport. A round-shaped package, a top-heavy package, or any similar package that would not maintain its initial orientation and load position under conditions incidental to routine transportation would not meet these requirements. Tie-downs are required for the packagings mentioned in this paragraph, and exclusive use shipments or documented special provisions with the carrier are required. Designer to do and shipper responsibility to ensure.	All packagings meet the intent of this requirement per analysis of the figures and as demonstrated by actual experience. In all cases, the shipper should avoid loading a top-heavy package and should be aware of the need for tie-downs for any such packages.
(b) A package with a gross	This does not necessarily mean that handles are required. As in the previous comment on	All the packagings evaluated meet the intent of this

weight exceeding 10 kilograms (22 pounds) and up to 50 kilograms (110 pounds) has a means for manual handling;	paragraph (a), physical size, geometry, and exterior surface design should be conducive to manual handling. Excluded are:	requirement when used in the 10-kg (22-lb) to 50-kg (110-lb) range.
	- Large, awkward packages or odd-shaped packages with no reasonable way to lift, hold, or move by hand;	
	- Surfaces with sharp edges or points which make handling difficult.	
	Designer to do and shipper responsibility to ensure.	
(c) A package with a gross weight of 50 kilograms (110 pounds) or more can safely be handled by mechanical means;	Thought should be given to how the packages will be handled; and they should be designed accordingly. If skids are used, the balance stability of the package on the forklift must be considered. One must also ensure that, when lifted by a forklift, the bottom structure can support the weight without significant distortion or loss of containment integrity. If hooks/lifting devices are used, they must meet 49 CFR 173.411(d). In most cases, this is for the shipper to evaluate, particularly the requirements that failure "would not impair the ability of the package to meet all other requirements." Designer to do and shipper responsibility to ensure.	**The three packagings that fit these criteria are the (1) Oak Ridge National Laboratory (ORNL) Returnable Shielded Shipping Container, (2) J. L. Sheppard Gas Cylinder No. 4, and (3) WHC Grout Sample Packaging**. These packages have an outer box or drum designed for routine handling with hand/mechanical devices. Experience has demonstrated packaging compliance with this requirement.
(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	A sign saying "Do Not Use As A Lifting Device," "Not A Lifting Device," etc. is not adequate to prevent the use of the unauthorized lifting devices. The procedures for use of the packaging should also state the intended use of any attachment points for other purposes (e.g., "For lifting the lid only--not entire packaging"). Designer, and perhaps tester and evaluator, to do and shipper responsibility to ensure.	**The only two packages with a lifting attachment are ORNL's returnable plastic box and EG&G Mound's commercial tritium packaging**. Tests at ORNL demonstrated compliance with this requirement, and failure of the handle would not impair the ability of the packaging to meet the containment integrity requirements. Tests at MLM demonstrated compliance with this requirement. Tests were conducted at five times the maximum gross weight with no apparent effect.

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 of being made inoperable for transport, or shall be designed with strength equivalent to that required for lifting attachments;		
(e) The external surfaces, as far as practicable, may be easily decontaminated;	Plywood, although not normally thought of as easily decontaminated, is acceptable. The intent is to promote surfaces that are relatively smooth and that minimize cracks and crevices in which surface contamination could reside. Consideration should be given to actions such as sanding or painting surfaces. Designer to do and shipper responsibility to ensure.	The variety of surfaces meet the intent of this requirement.
(f) The outer layer of packaging will avoid, as far as practicable, pockets or crevices where water might collect; and	This is not intended to eliminate 55-gal drums as Specification 7A packaging. The intent is for packaging design personnel to consider this aspect. Avoid designing a packaging that provides cavities to collect water, which could spill during transport or handling or could promote rusting and general deterioration of the packaging, possibly in locations difficult to detect. Designer to do and shipper responsibility to ensure.	These packages meet the intent of this requirement by analysis of the figures in Section 7.0.
(g) Each feature that is added to the package at the time of transport, and that is not part	For example, a canvas cover placed over a package for protection against the rain must not adversely affect heat transfer requirements. Shipper responsibility to ensure.	This is a shipper responsibility because the regulation addresses items added to the packaging that was already evaluated.

of the package, will not reduce the safety of the package.		

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Table B-7. Miscellaneous Packagings--Compliance With General Design Requirements (49 CFR 173.411).

Regulatory requirement	**Guidance for application**	**Packaging category--miscellaneous packagings**
Except for a package that contains a limited quantity or excepted instrument or article under §§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;	This does not necessarily mean handles are required. The intent is to maintain a package size and geometry that allow conformance to paragraph (a). For example, a package 4 ft × 6 ft × 4 ft cannot be easily handled by hand. For such a package, other handling methods would be designed. A package with sharp edges or components may not be easily handled manually. Also, package stability is required during transport. A round-shaped package, a top-heavy package, or any similar package that would not maintain its initial orientation and load position under conditions incidental to routine transportation would not meet these requirements. Tie-downs are required for the packagings mentioned in this paragraph, and exclusive use shipments or documented special provisions with the carrier are required. Designer to do and shipper responsibility to ensure.	All the packagings meet the intent of this requirement per analysis of the figures and as demonstrated by actual experience. In all cases, the shipper should avoid loading a top-heavy package and should be aware of the need for tie-downs for any such packages.
(b) A package with a gross weight exceeding 10 kilograms	This does not necessarily mean that handles are required. As in the previous comment on paragraph (a), physical size, geometry, and exterior surface design should be conducive to manual handling. Excluded are:	**Only the Lawrence Livermore National Laboratory (LLNL) shielded container fits this criterion because it has a handle**.

(22 pounds) and up to 50 kilograms (110 pounds) has a means for manual handling;		
	- Large, awkward packages or odd-shaped packages with no reasonable way to lift, hold, or move by hand;	
	- Surfaces with sharp edges or points which make handling difficult.	
	Designer to do and shipper responsibility to ensure.	
(c) A package with a gross weight of 50 kilograms (110 pounds) or more can safely be handled by mechanical means;	Thought should be given to how the packages will be handled; and they should be designed accordingly. If skids are used, the balance stability of the package on the forklift must be considered. One must also ensure that, when lifted by a forklift, the bottom structure can support the weight without significant distortion or loss of containment integrity. If hooks/lifting devices are used, they must meet 49 CFR 173.411(d). In most cases, this is for the shipper to evaluate, particularly the requirements that failure "would not impair the ability of the package to meet all other requirements." Designer to do and shipper responsibility to ensure.	The miscellaneous packagings exceeding 110 lb all have means for mechanical handling, and experience has demonstrated compliance.
(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	A sign saying "Do Not Use As A Lifting Device," "Not A Lifting Device," etc. is not adequate to prevent the use of the unauthorized lifting devices. The procedures for use of the packaging should also state the intended use of any attachment points for other purposes (e.g., "For lifting the lid only--not entire packaging"). Designer, and perhaps tester and evaluator, to do and shipper responsibility to ensure.	**On the ORNL Transuranic (TRU) package**, the outer metal skin will fail prior to the handle, but this would not compromise the overall ability to comply with this requirement. A similar analysis demonstrated that the handles of the **Federal Emergency Management Agency (FEMA) package** also comply with the three-times-the-gross-weight requirement, and failure of the lid handles would not reduce the ability of the packaging to comply with this requirement. Because the packaging for **Special Form Neutron Source** does not provide containment, failure of the lifting lugs would not affect the ability of the packaging to meet any other requirement.

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 of being made inoperable for transport, or shall be designed with strength equivalent to that required for lifting attachments;		
(e) The external surfaces, as far as practicable, may easily be decontaminated;	Plywood, although not normally thought of as easily decontaminated, is acceptable. The intent is to promote surfaces that are relatively smooth and that minimize cracks and crevices in which surface contamination could reside. Consideration should be given to actions such as sanding or painting surfaces. Designer to do and shipper responsibility to ensure.	The external surfaces are all metal and comply with this requirement, with the exception of the following: **The INEL, Mark III Concrete Container** has an exterior concrete body and lid that are painted and meets this requirement. **The INEL, ARROW-PAK Packaging** is made from high-density polyethylene material (M-8000 Marlex resin) and meets this requirement.
(f) The outer layer of packaging will avoid, as far as practicable, pockets or crevices where water might collect; and	This is not intended to eliminate 55-gal drums as Specification 7A packaging. The intent is for packaging design personnel to consider this aspect. Avoid designing a packaging that provides cavities to collect water, which could spill during transport or handling, or could promote rusting and general deterioration of the packaging, possibly in locations difficult to detect. Designer to do and shipper responsibility to ensure.	Compliance is obvious by analysis of the figures. **Exceptions** include the **Sandia National Laboratory (SNL) drum**, which complies with the intent per the column on the left. **The INEL, Mark III Concrete Container** design allows for water to collect around the lifting ring area of the lid; however, due to the construction and integrity of the packaging design, the intent of this requirement is met. The **ARROW-PAK Packaging's** fusion joint area allows for a

		slight exterior seam along the beaded edge. The cylindrical design promotes draining. Due to the construction and integrity of the packaging design, the intent of this requirement is met.
(g) Each feature that is added to the package at the time of transport, and that is not part of the package, will not reduce the safety of the package.	For example, a canvas cover placed over a package for protection against the rain must not adversely affect heat transfer requirements. Shipper responsibility to ensure.	This is a shipper responsibility because the regulation addresses items added to the packaging that was already evaluated.

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Table C-1. Steel Drums--Compliance with Additional Design Requirements for Type A Packages (49 CFR 173.412).		
Regulatory requirement	**Action required/by whom**	**Packaging category--steel drums**
In addition to meeting the general design requirements prescribed in §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);	Designer to do and shipper responsibility to ensure.	As shown in the figures and as given in the packaging descriptions in Section 2.0, all packagings meet this requirement.
(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	For this requirement, the package designer may need to be skilled and creative. This is especially true for packages such as fiberboard cartons and wooden boxes. A padlock is not effective as a security seal. It is not possible with most types of padlocks to ascertain if they have been illicitly opened. One acceptable approach toward meeting this requirement is serially numbered lead-wire seals, or, in the case of fiberboard packages, a tape of sufficient adhesive strength to damage the fiberboard upon removal. Designer to do and shipper responsibility to ensure.	There are acceptable approaches to compliance for all evaluated packagings. It is the shipper's responsibility to ensure compliance with this requirement.

vehicles, the cargo compartment may be sealed instead of the individual packages;		
(c) As far as practicable, the external surfaces are free from protrusions and are designed so that they can be easily decontaminated;	The intent is to minimize the number of protrusions by consideration during design and/or as a result of any modifications to the packaging. Designer to do and shipper responsibility to ensure.	All evaluated packagings meet this requirement.
(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;	This does not mean any of the tests must necessarily be performed at the temperature extremes. [Note: 49 CFR 173.461(b)] the regulations allow the assumption that the packaging is in equilibrium at 38 °C prior to testing. One must evaluate the packaging components with respect to behavior at the temperature extremes under conditions incidental to transportation (i.e., the jiggles, bounces, and bumps normally encountered in transportation). Gaskets and packaging components need to be evaluated to determine if they will become excessively brittle at -40F. This may be accomplished by actual testing, referring to property of material tables, obtaining data from manufacturers, etc. The shipper must consider such things as freezing of liquid contents and evaluate the effect to ensure continued containment integrity. The shipper must also consider the buildup of pressure at elevated temperatures and ensure continued containment. Designer, tester, and evaluator to do and shipper responsibility to ensure.	Metals used in these drums will not become excessively brittle at -40 °C and all gaskets used also meet this requirement. None of these packagings are authorized for liquids, so freezing of contents is not a concern. Temperatures of +70 °C will not result in any significant decrease in containment integrity.
(e) It is able to withstand the effects of any acceleration, vibration, or vibration resonance that may arise during normal transportation,	Typically, one uses actual experience as a guide. If experience is not available, one normally uses a comparison to a similar packaging with an experience profile. If this isn't possible, vibration testing can be performed. The purpose of this section is to prevent the loosening of nuts, bolts, and containment devices under conditions incident to routine transportation. Designer, tester, and evaluator to do and shipper responsibility to	Experience has consistently demonstrated that these packagings or similar designs comply with this requirement. The shipper must ensure the application of quality assurance necessary to achieve this requirement.

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;	ensure.	
(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 §173.469, may be considered as a component of the containment system;	Screw-type closures can qualify. Friction fit normally does not qualify. Security clips on cans could be acceptable. However, one cannot depend on friction alone. Designer, tester, and evaluator to do and shipper responsibility to ensure.	All packagings evaluated meet this requirement, as shown on the figures or in the packaging descriptions in Section 2.0.
(g) The materials of the packaging and any components or structures are physically and chemically compatible with each other and with the	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

contents, taking into account the behavior of each under irradiation;		
(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;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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 is defined as the components intended to retain the radioactive contents during transportation. Thus, one starts by identifying the containment system. The radioactive contents must be completely retained in the containment system if the package is subjected to reduced pressure. A filtered packaging is possible as long as it can be demonstrated that the filtered package will retain the contents and that the filter is not susceptible to damage from any other tests. Caution should be exercised to ensure that the contents and internal packaging components (e.g., plastic boxes, etc.) will not effectively seal the filter during normal use. In cases where a pressure differential will not build up because of the free-flow through a filter, the requirement of demonstrating the retention of contents must still be met. For a package that breathes (does not hold 11.2 psi), such as a wooden box, one must demonstrate that, even with breathing, the contents will be retained. Otherwise, a separate inner containment capable of meeting the reduced pressure requirement is required. Designer, tester, and evaluator to do and shipper responsibility to ensure.	This analysis requires a more detailed description to provide adequate information. See Table C-2.
(j) Each valve through which the radioactive contents could otherwise	Designer to do and shipper responsibility to ensure.	None of these packagings have valves.

escape is protected against damage and unauthorized operation and, except for a pressure relief device, has an enclosure to retain any leakage;		
(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 shield shall be securely closed or, by way of packaging design, ensure against escape of a containment component. One example is a package with Celotex* on top of a lead shield with a press-fit lid in which closure of the Celotex holds the lid in place. The shipper must make sure that under the tests prescribed in 49 CFR 173.465, there will be no rearrangement of the original containment/shield orientation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	None of these packagings have shielding as described.
(l) Failure of any tiedown attachment on the packaging under excessive load will not impair the ability of the package to meet other requirements of this subpart;	Designer, tester, and evaluator to do and shipper responsibility to ensure.	None of these packagings have tie-down attachments as described.
(m) When subjected to the tests specified in §173.465 or evaluated against these tests by any of the methods authorized by §173.461(a), the packaging will prevent:		
(1) Loss or	Designer, tester, and evaluator to do; shipper	Shipper responsibility to ensure.

dispersal of the radioactive contents; and	responsibility to ensure.	
(2) Any significant increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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 §173.466 or evaluated against these tests by any of the methods authorized by §173.461(a);	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

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	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(o) Each package designed for compressed or uncompressed	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

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 §173.461(a).		

*Celotex is a trademark of the Celotex Corporation.

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Table C-2. Steel Drums--"Reduced Pressure" Tests Summary.

Steel drums in order of presentation in Section 2.0	Test results on standard production packagings without RTV		Test results with RTV adhesive sealant (requires 24-h cure before testing)		Contents	Comments
	No. Tested	Result	No. Tested	Result		
DOT-6C 5-gal	0		2	2 pass	Vermiculite with flour and fluorescein on top	Containers without RTV were not tested because they were not expected to pass based on previous test results.
DOT-6C 10-gal	0		2	2 pass	Vermiculite with flour and fluorescein on top	Containers without RTV were not tested because they were not expected to pass based on previous test results.
DOT-17C 5-gal	1	1 fail	2	2 pass	Vermiculite with flour and fluorescein on top	After one failed without RTV, the next two were tested with RTV.
DOT-17C 30-gal	None tested due to limited DOE contractor use. Evaluation based on testing/analysis of DOT-17H 30-gal packaging, a drum of less expected structural strength (i.e., 18-gauge sheet steel vs. 16-gauge steel sheet, etc.)					
DOT-17C 35-gal	1	1 fail	5	5 pass	Vermiculite with flour and fluorescein on top	RTV required.
DOT-17C	5	5 pass	0	NA	Empty	
55-gal[a]	1	1 fail (see comments)		NA	Flour and fluorescein	Upon inspection, a manufacturing defect in the gasket was noted. Drums from same supplier tested again and all passed.
	5	5 pass	0	NA	Vermiculite with flour and fluorescein	
	3 LLNL galvanized drums	3 pass	0	NA	Vermiculite with flour and fluorescein	
DOT-17C 55-gal with pressure relief devices	5 HF	5 pass	0	NA	Flour and fluorescein	This test with no vent clips was to demonstrate the integrity of a standard production drum without

						RTV.
- Vent clip	5 HF	5 pass	0	NA	Vermiculite with flour and fluorescein	At 11.2 psig, air readily escaped, but no fluorescein was detected during or after these tests.
- Filter	3 RFP	3 pass	0	NA	Vermiculite with flour and fluorescein	The opening on the filter filter was covered on the inside and 11.2 psi pressure was applied to test the drums and the filter housing. As previously stated, all passed.
- Filter (same drums as above)	3 RFP	3 pass	0	NA	Vermiculite with flour and fluorescein	At 11.2 psig, air readily escaped, but no fluorescein was detected during or after these tests.
DOT-17C 55-gal with 90-mil HDPE liner	No tests were required because the 17C 55-gal drums had already been tested and had met this requirement.					
DOT-17H 30-gal	5 LANL	5 fail	0	NA	Empty	
	3 LANL	3 fail	0	NA	Flour and fluorescein	
	3 LANL	3 pass	0	NA	Flour and fluroescein	
	3 RFP	3 fail	0	NA	Empty	
	1 RFP	1 pass	0	NA	Empty	
	3 RFP	3 fail	0	NA	Vermiculite with flour and fluroescein	
DOT-17H 55-gal[b]	7 Mound	7 fail	0	NA	Empty	Both empty and full tests were performed to demonstrate that not only were the drums leaking, but they were leaking particles detectable with UV light.
	2 Mound	2 pass	0	NA	Empty	
	5 Mound	5 fail	0	NA	Vermiculite with flour	
	0	NA	10 Mound	10 pass		
	2 RFP	2 fail	0	NA	Empty	
	0	NA	2 RFP	2 pass	Vermiculite with flour and fluorescein	
	2 LLNL	2 fail	0	NA	Empty	
	3 LLNL	3 fail	0	NA	Vermiculite with flour and fluorescein	
	0	NA	2 LLNL	2 pass	Empty	
Military Specification Containers						
MS-24347-1[c], 0.25-gal	3	3 pass			Flour, flourescein, sand, and lead	
MS-24347-7, 1.25-gal	3	3 pass			Same as above	
MS-24684-1, 0.25-gal	3	3 pass			Same as above	

MS-27684-2, 4-gal	2	3 pass			Same as above	
MS-27684-3, 6-gal	3	3 pass			Same as above	
MS-27684-6, 8-gal	3	3 pass			Same as above	
MS-27684-8, 12-gal	3	3 pass			Same as above	
MS-27683-7, 30-gal	3	3 pass			Same as above	
MS-27683-13, 45-gal	3	3 pass			Same as above	
MS-27683-21, 85-gal	1	1 pass	3	3 pass		The 85-gal packaging was the only one requiring RTV.
	2	2 fail	0	NA		
Packaging Specialties Square Steel Drums						
Style 1A	6	5 pass 1 fail			Water - to within 2 to 3 in. of full	The single failure was a result of a manufacturing process defect, which was corrected.
Style 1B	5	5 pass			Same as above	
Style 2	5	5 pass			Same as above	
Style 3	5	5 pass			Same as above	

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[a]Twenty-one DOT-17C 55-gal drums from three different DOE contractors were tested and demonstrated compliance with this requirement. Of the 14 tested with RTV, 14 passed.

[b]Thirty-five DOT-17H 55-gal drums were tested. Of the 21 tested (from three different DOE contractors) without RTV, 19 failed and 2 passed.

[c]Drum assembly number.

DOE = U.S. Department of Energy
DOT = U.S. Department of Transportation
HDPE = High-density polyethylene
HF = Hanford, Richland, Washington
LLNL = Lawrence Livermore National Laboratory
Mound = Mound Laboratory
NA = Not applicable
RFP = Rocky Flats Plant
RTV = Room temperature vulcanizing
UV = Ultraviolet.

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Table C-3. Steel Boxes--Compliance With Additional Design Requirements for Type A Packages (49 CFR 173.412).		
Regulatory requirement	**Action required/by whom**	**Packaging category--steel boxes**
In addition to meeting the general design requirements prescribed in §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);	Designer to do and shipper responsibility to ensure.	As shown in the figures and as given in the packaging descriptions in Section 3.0, all packagings meet this requirement.
(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	For this requirement, the package designer may need to be skilled and creative. This is especially true for packages such as fiberboard cartons and wooden boxes. A padlock is not effective as a security seal. It is not possible with most types of padlocks to ascertain if they have been illicitly opened. One acceptable approach toward meeting this requirement is serially numbered lead-wire seals, or, in the case of fiberboard packages, a tape of sufficient adhesive strength to damage the fiberboard upon removal. Designer to do and shipper responsibility to ensure.	There are acceptable approaches to compliance for all evaluated packagings. It is the shipper's responsibility to ensure compliance with this requirement.

compartment may be sealed instead of the individual packages;		
(c) As far as practicable, the external surfaces are free from protrusions and are designed so that they can be easily decontaminated;	The intent is to minimize the number and nature of protrusions by consideration during design and/or as a result of any modifications to the packaging. Designer to do and shipper responsibility to ensure.	All evaluated packagings meet this requirement.
(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;	This does not mean any of the tests must necessarily be performed at the temperature extremes. [Note: 49 CFR 173.461(b)] the regulations allow the assumption that the packaging is in equilibrium at 38 °C prior to testing. One must evaluate the packaging components with respect to behavior at the temperature extremes under conditions incidental to transportation (i.e., the jiggles, bounces, and bumps normally encountered in transportation). Gaskets and packaging components need to be evaluated to determine if they will become excessively brittle at -40 °C. This may be accomplished by actual testing, referring to property of material tables, obtaining data from manufacturers, etc. The shipper must consider such things as freezing of liquid contents and evaluate the effect to ensure continued containment integrity. The shipper must also consider the buildup of pressure at elevated temperatures and ensure continued containment. Designer, tester, and evaluator to do and shipper responsibility to ensure.	Metals used in these boxes will not become excessively brittle at -40° C and all gaskets used also meet this requirement. None of these packagings are authorized for liquids, so freezing of contents is not a concern. Temperatures of +70° C will not result in any significant decrease in containment integrity.
(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	Typically, one uses actual experience as a guide. If experience is not available, one normally uses a comparison to a similar packaging with an experience profile. If this isn't possible, vibration testing can be performed. The purpose of this section is to prevent the loosening of nuts, bolts, and containment devices under conditions incident to routine transportation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	Experience has consistently demonstrated that these packagings or similar designs comply with this requirement. The shipper must ensure the application of quality assurance necessary to achieve this requirement.

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;		
(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 §173.469, may be considered as a component of the containment system;	Screw-type closures can qualify. Friction fit normally does not qualify. Security clips on cans could be acceptable. However, one cannot depend on friction alone. Designer, tester, and evaluator to do and shipper responsibility to ensure.	All packagings evaluated meet this requirement, as shown in the figures or in the packaging descriptions in Section 3.0.
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

behavior of each under irradiation;		
(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;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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 is defined as the components intended to retain the radioactive contents during transportation. Thus, one starts by identifying the containment system. The radioactive contents must be completely retained in the containment system if the package is subjected to reduced pressure. A filtered packaging is possible as long as it can be demonstrated that the filtered package will retain the contents and that the filter is not susceptible to damage from any other tests. Caution should be exercised to ensure that the contents and internal packaging components (e.g., plastic boxes, etc.) will not effectively seal the filter during normal use. In cases where a pressure differential will not build up because of the free-flow through a filter, the requirement of demonstrating the retention of contents must still be met. For a package that breathes (does not hold 11.2 psi), such as a wooden box, one must demonstrate that, even with breathing, the contents will be retained. Otherwise, a separate inner containment capable of meeting the reduced pressure requirement is required. Designer, tester, and evaluator to do and shipper responsibility to ensure.	This analysis requires a more detailed description to provide adequate information. See Table C-4.
(j) Each valve through which the radioactive contents could otherwise escape is protected	Designer to do and shipper responsibility to ensure. None of these packagings have valves.	None of these packagings have valves.

against damage and unauthorized operation and, except for a pressure relief device, has an enclosure to retain any leakage;		
(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 shield shall be securely closed or, by way of packaging design, ensure against escape of a containment component. One example is a package with cellotex on top of a lead shield with a press-fit lid in which closure of the cellotex holds the lid in place. the shipper must make sure that under the tests prescribed in 49 CFR 173.465, there will be no rearrangement of the original containment/shield orientation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	None of these packagings have shielding as described.
(l) Failure of any tie-down attachment on the packaging under excessive load will not impair the ability of the package to meet other requirements of this subpart.	Designer, tester, and evaluator to do and shipper responsibility to ensure.	None of these packagings have tie-down attachments as described.
(m) When subjected to the tests specified in §173.465 or evaluated against these tests by any of the methods authorized by §173.461(a), the packaging will prevent:		
(1) Loss or dispersal of the radioactive	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

contents; and		
(2) Any significant increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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 §173.466 or evaluated against these tests by any of the methods authorized by §173.461(a);	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

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	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(o) Each package designed for compressed or uncompressed gases other than tritium or	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

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 §173.461(a).		

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Table C-4. Steel Boxes--"Reduced Pressure" Tests Summary.				
Steel boxes in order of presentation in Section 3.0	**Size/model no.**	**Test methodology**	**Test results**	**Comments**
Capital Industries	S-0510-0823	Pressurized with water to 11.2 psi	Pass	No leakage of water and pressure held for 5 min.
	V-0510-0823	N/A	N/A	Vented/filtered, so this test is not applicable.
	S-0450-0846	N/A	Pass	Engineering analysis by comparison to S-0510-0823 above.
	S-0730-0846	N/A	Pass	Engineering analysis comparison to S-0730-1006 below.
	S-0240-0906	N/A	Pass	Engineering analysis by comparison to S-0510-0823 above.
	S-0480-0906	N/A	Pass	Engineering analysis by comparison to S-0510-0823 above.
	S-0730-1006	Pressurized with water to 11.2 psi	Pass	No leakage of water and pressure held for 5 min.
	S-0480-1376	N/A	Pass	Engineering analysis by comparison to S-0730-1006 above.
	S-0840-1440	Pressurized with water to 11.2 psi	Pass	No leakage of water and pressure held for 5 min.
Container Products Corp.	B-96-5 S/L FD	N/A	N/A	Vented/filtered, so test is not applicable.
	B-96-5 S/L RA	Pressurized with air to 11.2 psi	Pass	No leakage of air and pressure held for 2 min.

	B-96-5-RA-B	Pressurized with air to 11.2 psi	Pass	No leakage of air and pressure held for 2 min.
NOTE: All the remaining Container Products Corp. models are vented/filtered; therefore, this test is not applicable.				
RoGar Chemical & Nuclear Services Inc.	R-1	N/A	Pass	Engineering analysis by comparison to R-3 below.
	R-2	N/A	Pass	Engineering analysis by comparison to R-3 below.
	R-3	Pressurized with nitrogen to 11.2 psi	Pass	No leakage of nitrogen and pressure held for 5 min.
	R-4	N/A	Pass	Engineering analysis by comparison to R-3 above.
RFP	Style 1	Each style (1-4) pressurized with nitrogen nitrogen to slightly above 12 psi	Pass	No leakage of nitrogen and pressure held for 5 min.
	Style 2		Pass	
	Style 3		Pass	
	Style 4		Pass	
ANL-E	M-4 Bin	Pressurized with water to 11.5 psig	Pass	No leakage of water and pressure held for more than 5 min.
ANL-W	Steel box	N/A	N/A	Certified only for Form No. 3 material; thus, test not meaningful. Box is not designed with a gasket seal intended to retain Form No. 1 or Form No. 2 contents.
WIPP	TRUPACT II Standard Waste Box	N/A	N/A	Because these packagings are filtered, a pressure differential of this magnitude could not be achieved. [Docket 89-07-7A]
ORNL	Low-level box	Pressure elevation to 11.5 psig - 10 min.	Pass	Test conducted on nonvented version only. [Docket 89-04-7A]
ANL-E = Argonne National Laboratory - East ANL-W = Argonne National Laboratory - West ORNL = Oak Ridge National Laboratory RFP = Rocky Flats Plant WIPP = Waste Isolation Pilot Plant.				

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Table C-5. Wooden Boxes--Compliance With Additional Design Requirements for Type A Packages (49 CFR 173.412).		
Regulatory requirement	**Action required/by whom**	**Packaging category--wooden boxes**
In addition to meeting the general design requirements prescribed in §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);	Designer to do and shipper responsibility to ensure.	As shown in the figures and as given in the packaging descriptions in Section 4.0, all packagings meet this requirement.
(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	For this requirement, the package designer may need to be skilled and creative. This is especially true for packages such as fiberboard cartons and wooden boxes. A padlock is not effective as a security seal. It is not possible with most types of padlocks to ascertain if they have been illicitly opened. One acceptable approach toward meeting this requirement is serially numbered lead-wire seals, or, in the case of fiberboard packages, a tape of sufficient adhesive strength to damage the fiberboard upon removal. Designer to do and shipper responsibility to ensure.	There are acceptable approaches to compliance for all evaluated packagings. It is the shipper's responsibility to ensure compliance with this requirement.

vehicles, the cargo compartment may be sealed instead of the individual packages;		
(c) As far as practicable, the external surfaces are free from protrusions and are designed so that they can be easily decontaminated;	The intent is to minimize the number of protrusions by consideration during design and/or as a result of any modifications to the packaging. Designer to do and shipper responsibility to ensure.	All evaluated packagings meet this requirement.
(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;	This does not mean any of the tests must necessarily be performed at the temperature extremes. [Note: 49 CFR 173.461(b)] the regulations allow the assumption that the packaging is in equilibrium at 38 °C prior to testing. One must evaluate the packaging components with respect to behavior at the temperature extremes under conditions incidental to transportation (i.e., the jiggles, bounces, and bumps normally encountered in transportation). Gaskets and packaging components need to be evaluated to determine if they will become excessively brittle at -40 °C. This may be accomplished by actual testing, referring to property of material tables, obtaining data from manufacturers, etc. The shipper must also consider the buildup of pressure at elevated temperatures and ensure continued containment. Designer, tester, and evaluator to do and shipper responsibility to ensure.	The materials, (wood, caulking, metal strips, nails, gaskets, etc.) would not become excessively brittle at -40 °C and all gaskets used met this requirement. None of these packagings are authorized for liquids, so freezing of contents is not a concern. Temperatures of +70 °C would not result in any significant decrease in integrity either, as shown in property of materials tables.
(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	Typically, one uses actual experience as a guide. If experience is not available, one normally uses a comparison to a similar packaging with an experience profile. If this isn't possible, vibration testing can be performed. The purpose of this section is to prevent the loosening of nuts, bolts, and containment devices under conditions incident to routine transportation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	Experience has consistently demonstrated that these packagings or similar designs comply with this requirement. The shipper must ensure the application of quality assurance necessary to achieve this requirement.

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;		
(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 §173.469, may be considered as a component of the containment system;	Screw-type closures can qualify. Friction fit normally does not qualify. Security clips on cans could be acceptable. However, one cannot depend on friction alone. Designer, tester, and evaluator to do and shipper responsibility to ensure.	All packagings evaluated meet this requirement, as shown in the figures or in the packaging descriptions in Section 4.0.
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

each under irradiation;		
(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;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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 is defined as the components intended to retain the radioactive contents during transportation. Thus, one starts by identifying the containment system. The radioactive contents must be completely retained in the containment system if the package is subjected to reduced pressure. A filtered packaging is possible as long as it can be demonstrated that the filtered package will retain the contents and that the filter is not susceptible to damage from any other tests. Caution should be exercised to ensure that the contents and internal package will retain the contents and that the filter is not susceptible to damage from any other tests. Caution should be exercised to ensure that the contents and packaging components (e.g., plastic boxes, etc.) will not effectively seal the filter during normal use. In cases where a pressure differential will not build up because of the free-flow through a filter, the requirement of demonstrating the retention of contents must still be met. For a package that breathes (does not hold 11.2 psi), such as a wooden box, one must demonstrate that, even with breathing, the contents will be retained. Otherwise, a separate inner containment capable of meeting the reduced pressure requirement is required. Designer, tester, and evaluator to do and shipper responsibility to ensure.	Based on the testing discussed in Table C-6, these packagings all meet this requirement for Form No. 2 and No. 3 materials. The containment system in each case is the wooden box itself. Obviously, the box is not expected to be air-leak tight with a significant pressure differential applied. Thirteen separate boxes were subjected to this test. The contents in all cases were flour, fluorescein, and sand. In each case, the box did not hold pressure, as expected. Typically, boxes started leaking air at less than 1 psi. As the pressure increased, leak-paths increased until they began leaking all over (at the seams, around nails, etc.) at 9 psi. In each case, no sand was released, so these packagings passed for Form No. 2 and No. 3 materials (which is what they were evaluated for). In all cases, fluorescein was detected, but again, this simply means the packaging cannot be authorized for Form No. 1 materials. This does not present a problem since the boxes were never intended for use with Form No. 1 materials, and each evaluation states that Form No. 1 materials are "Not Authorized without separate containment tested to Type A requirements with appropriate documentation."
(j) Each valve through which	Designer to do and shipper responsibility to ensure.	None of these packagings have valves.

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;		
(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 shield shall be securely closed or, by way of packaging design, ensure against escape of a containment component. One example is a package with cellotex on top of a lead shield with a press-fit lid in which closure of the cellotex holds the lid in place. The shipper must make sure that under the tests prescribed in 49 CFR 173.465, there will be no rearrangement of the original containment/shield orientation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	None of these packagings have shielding as described.
(l) Failure of any tie-down attachment on the packaging under excessive load will not impair the ability of the package to meet other requirements of this subpart;	Designer, tester, and evaluator to do and shipper responsibility to ensure.	None of these packagings have tie-down attachments as described.
(m) When subjected to the tests specified in §173.465 or evaluated against these tests by any of the methods authorized by §173.461(a), the		

packaging will prevent:		
(1) Loss or dispersal of the radioactive contents; and	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Any significant increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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 §173.466 or evaluated against these tests by any of the methods authorized by §173.461(a);	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

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	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(o) Each package	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

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 §173.461(a).		

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Table C-6. Wooden Boxes--"Reduced Pressure" Tests Summary.				
Type of wooden box/principal user	**Model/size**	**Test analysis**	**Results**	**Comments**
ANL-W	7A-217 7A-375 7A-670 7A-880 7A-995 7A-1315	These packagings are authorized only for Form No. 3 materials. Test results discussed in this section demonstrate that Form No. 3 materials would not be released.	Pass	Authorized only for Form No. 3 materials.
LLNL	Flush panel 4 ft × 4 ft × 7 ft	Test data on similar packagings as discussed below demonstrate that Form No. 2 and No. 3 materials would not be released as a result of this test.	Pass	Authorized only for Form No. 2 and No. 3 materials.
Mound Configuration A	MA-1 MA-2 MA-3	Test data on similar packagings as discussed in this table demonstrate that Form No. 2 and No. 3 materials would not be released as a result of this test.	Pass	Authorized only for Form No. 2 and No. 3 materials.
Mound Configuration B	MB-1 MB-2 MB-3 MB-4 MB-5 MB-6	Tests were conducted on MB-1, 2, 3, 4, and 5 with flour, fluorescein, and sand as contents. The package was pressurized to between 9 and 11.2 psi, and an equilibrium (escape vs. input) was achieved and held for 1-2 min. Air leaked out almost immediately. Fluorescein was detected in all cases, but in no instance was sand detected.	Pass	There was no release of Form No. 2 (or No. 3 by extrapolation) contents. Thus, these packagings are authorized for Form No. 2 and No. 3 materials.
Mound Configuration C	MC-1 MC-2	Tests data on similar packagings as discussed in this	Pass	Authorized only for Form No. 2 and

		table demonstrate that Form No. 2 and No. 3 materials would not be released as a result of this test.		No. 3 materials.
	MC-3			
	MC-4			
	MC-5			
Mound Configuration D	MD-1	Tests were conducted on MD-1, 2, 3, 4, 5, and 6 with flour, fluorescein, and sand as contents. The package was pressurized to between 9 and 11.2 psi, and an equilibrium (escape vs. input) was achieved and held for 1-2 min. Air leaked out almost immediately. Fluorescein was detected in all cases, but in no instance was sand detected.	Pass	There was no release of Form No. 2 (or No. 3 by extrapolation) contents. Thus, these packagings are authorized for Form No. 2 and No. 3 materials.
	MD-2			
	MD-3			
	MD-4			
	MD-5			
	MD-6			
Mound Configuration E	ME-1	Tests were conducted on all three models with flour, fluorescein, and sand as contents. The package was pressurized to between 9 and 11.2 psi, and an equilibrium (escape vs. input) was achieved and held for 1-2 min. Air leaked out almost immediately. Fluorescein was detected in all cases, but in no instance was sand detected.	Pass	There was no release of Form No. 2 (or No. 3 by extrapolation) contents. Thus, these packagings are authorized for Form No. 2 and No. 3 materials.
	ME-2			In summary, 13 of the Mound series boxes were tested and passed for Form No. 2 and No. 3 materials. These tests demonstrate that all the boxes in this section would meet this requirement for Form No. 2 and No. 3 materials.
	ME-3			
NLO Family of Boxes	G-4214	These packagings are authorized only for Form No. 3 materials. The test results discussed in this section demonstrate that Form No. 3 materials would not be released.	Pass	Authorized only for Form No. 3 materials.
	G-4245			
	G-4255			
	G-4273			
	G-4292			
Y-12 Series B	B-1 through B-8	These packagings are authorized only for Form No. 3	Pass	Authorized only for Form No. 3

		materials. Test results discussed in this section demonstrate that Form No. 3 materials would not be released.		materials.
Y-12 Picture Frames	PF-1 through PF-8, PF-10	These packagings are authorized only for Form No. 3 materials. Test results discussed in this section demonstrate that Form No. 3 materials would not be released. (Docket 89-12-7A)	Pass	Authorized only for Form No. 3 materials.
RFP RA Series	Configuration 1 Configuration 2	These packagings are authorized only for Form No. 3 materials. Test results discussed in this section demonstrate that Form No. 3 materials would not be released.	Pass	Authorized only for Form No. 3 materials.
WMCO Banded Wooden Boxes	G-4214 G-4245 G-4255 G-4273-5 G-4273-6	These packagings are authorized only for Form No. 3 materials. The test results discussed in this section demonstrate that Form No. 3 materials would not be released.	Pass	Authorized only for Form 3 materials. (Docket 89-09-7A)
ORNL Y-12 C-Series	C-1 C-2 C-3	These packagings are authorized only for Form 3 materials. The test results discussed in this section demonstrate that Form 3 materials not be released.	Pass	Authorized only for Form 3 materials. (Docket 89-01-7A)

ANL-W = Argonne National Laboratory - West
LLNL = Lawrence Livermore National Laboratory
Mound = Mound Laboratory
NLO = National Lead Corporation
ORNL = Oak Ridge National Laboratory
RFP = Rocky Flats Plant
WMCO = Westinghouse Materials Company of Ohio.

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Table C-7. Fiberboard Containers--Compliance With Additional Design Requirements for Type A Packages (49 CFR 173.412).		
Regulatory requirement	**Action required/by whom**	**Packaging category--fiberboard containers**
In addition to meeting the general design requirements prescribed in §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);	Designer to do and shipper responsibility to ensure.	As shown in the figures and as given in the packaging descriptions in Section 5.0, all packagings meet this requirement.
(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	For this requirement, the package designer may need to be skilled and creative. This is especially true for packages such as fiberboard cartons and wooden boxes. A padlock is not effective as a security seal. It is not possible with most types of padlocks to ascertain if they have been illicitly opened. One acceptable approach toward meeting this requirement is serially numbered lead-wire seals, or, in the case of fiberboard packages, a tape of sufficient adhesive strength to damage the fiberboard upon removal. Designer to do and shipper responsibility to ensure.	There are acceptable approaches to compliance for all evaluated packagings. It is the shipper's responsibility to ensure compliance with this requirement.

vehicles, the cargo compartment may be sealed instead of the individual packages;		
(c) As far as practicable, the external surfaces are free from protrusions and are designed so that they can be easily decontaminated;	The intent is to minimize the number of protrusions by consideration during design and/or as a result of any modifications to the packaging. Designer to do and shipper responsibility to ensure.	All evaluated packagings meet this requirement.
(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;	This does not mean any of the tests must necessarily be performed at the temperature extremes. [Note: 49 CFR 173.461(b)] the regulations allow the assumption that the packaging is in equilibrium at 38 °C prior to testing. One must evaluate the packaging components with respect to behavior at the temperature extremes under conditions incidental to transportation (i.e., the jiggles, bounces, and bumps normally encountered in transportation). Gaskets and packaging components need to be evaluated to determine if they will become excessively brittle at -40 °C. This may be accomplished by actual testing, referring to property of material tables, obtaining data from manufacturers, etc. The shipper must also consider such things as freezing of liquid contents and evaluate the effect to ensure continued containment integrity. The shipper must also consider the buildup of pressure at elevated temperatures and ensure continued containment. Designer, tester, and evaluator to do and shipper responsibility to ensure.	The materials (fiberboard, metal strips, nails, gaskets, etc.) would not become excessively brittle at -40 °C and all gaskets used met this requirement. None of these packagings are authorized for liquids, so this requirement is not applicable. Temperatures of +70 °C would not result in any significant decrease in integrity, as shown in property of materials tables.
(e) It is able to withstand the effects of any acceleration, vibration, or vibration resonance that may arise during normal transportation,	Typically, one uses actual experience as a guide. If experience is not available, one normally uses a comparison to a similar packaging with an experience profile. If this isn't possible, vibration testing can be performed. The purpose of this section is to prevent the loosening of nuts, bolts, and containment devices under conditions incident to routine transportation. Designer, tester, and evaluator to do and shipper responsibility to	Experience has consistently demonstrated that these packagings or similar designs comply with this requirement. The shipper must ensure the application of quality assurance necessary to achieve this requirement.

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;	ensure.	
(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 §173.469, may be considered as a component of the containment system;	Screw-type closures can qualify. Friction fit normally does not qualify. Security clips on cans could be acceptable. However, one cannot depend on friction alone. Designer, tester, and evaluator to do and shipper responsibility to ensure.	All packagings evaluated meet this requirement, as shown in the figures or in the packaging descriptions in Section 5.0.
(g) The materials of the packaging and any components or structures are physically and chemically compatible with each other and with the	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

contents, taking into account the behavior of each under irradiation;		
(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;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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 is defined as the components intended to retain the radioactive contents during transportation. Thus, one starts by identifying the containment system. The radioactive contents must be completely retained in the containment system if the package is subjected to reduced pressure. A filtered packaging is possible as long as it can be demonstrated that the filtered package will retain the contents and that the filter is not susceptible to damage from any other tests. Caution should be exercised to ensure that the contents and internal packaging components (e.g., plastic boxes, etc.) will not effectively seal the filter during normal use. In cases where a pressure differential will not build up because of the free-flow through a filter, the requirement of demonstrating the retention of contents must still be met. For a package that breathes (does not hold 11.2 psi), such as a wooden box, one must demonstrate that, even with breathing, the contents will be retained. Otherwise, a separate inner containment capable of meeting the reduced pressure requirement is required. Designer, tester, and evaluator to do and shipper responsibility to ensure.	Except for LLNL's package, this test was not conducted on any of the fiberboard packagings since they obviously are not leak tight. With the exception of the LLNL package previously mentioned, these packagings are authorized only for Form No. 3 materials. Since Form No. 3 materials by definition have no dispersible contamination, a movement of air from inside the package to the outside would have no adverse consequences. Thus, all these packagings authorized for only Form No. 3 material would meet this requirement. For the one exception, the LLNL packaging, two separate inner metal containers (No. 10 cans), were tested in a bell jar assembly and passed. The metal inner container (containment system) was immersed in a beaker of water inside a bell jar for approximately 5 min., and the pressure inside the bell jar was reduced to 3.6 psi. The water was checked for bubbles and, in both cases, none were detected. Thus, the metal inner container (No. 10 can) passed this test by itself.
(j) Each valve through which the radioactive	Designer to do and shipper responsibility to ensure.	None of these packagings have valves.

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;		
(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 shield shall be securely closed or, by way of packaging design, ensure against escape of a containment component. One example is a package with cellotex on top of a lead shield with a press-fit lid in which closure of the cellotex holds the lid in place. The shipper must make sure that under the tests prescribed in 49 CFR 173.465, there will be no rearrangement of the original containment/shield orientation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	None of these packagings have shielding as described.
(l) Failure of any tie-down attachment on the packaging under excessive load will not impair the ability of the package to meet other requirements of this subpart.	Designer, tester, and evaluator to do and shipper responsibility to ensure.	None of these packagings have tie-down attachments as described.
(m) When subjected to the tests specified in §173.465 or evaluated against these tests by any of the methods authorized by §173.461(a), the packaging will		

prevent:		
(1) Loss or dispersal of the radioactive contents; and	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Any significant increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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 §173.466 or evaluated against these tests by any of the methods authorized by §173.461(a);	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

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	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(o) Each package designed for	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

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 §173.461(a).		

LLNL = Lawrence Livermore National Laboratory.

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Table C-8. UF_6 Cylinders--Compliance With Additional Design Requirements for Type A Packages (49 CFR 173.412).

Regulatory requirement	**Action required/by whom**	**Packaging category-- UF_6 cylinders**
In addition to meeting the general design requirements prescribed in §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);	Designer to do and shipper responsibility to ensure.	As shown in the figures and as given in the packaging descriptions in Section 6.0, all packagings meet this requirement.
(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	For this requirement, the package designer may need to be skilled and creative. This is especially true for packages such as fiberboard cartons and wooden boxes. A padlock is not effective as a security seal. It is not possible with most types of padlocks to ascertain if they have been illicitly opened. One acceptable approach toward meeting this requirement is serially numbered lead-wire seals, or, in the case of fiberboard packages, a tape of sufficient adhesive strength to damage the fiberboard upon removal. Designer to do and shipper responsibility to ensure.	There are acceptable approaches to compliance for all evaluated packagings. It is the shipper's responsibility to ensure compliance with this requirement.

closed transport vehicles, the cargo compartment may be sealed instead of the individual packages;		
(c) As far as practicable, the external surfaces are free from protrusions and are designed so that they can be easily decontaminated;	The intent is to minimize the number of protrusions by consideration during design and/or as a result of any modifications to the packaging. Designer to do and shipper responsibility to ensure.	All evaluated packages meet this requirement.
(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;	This does not mean any of the tests must necessarily be performed at the temperature extremes. [Note: 49 CFR 173.461(b)] the regulations allow the assumption that the packaging is in equilibrium at 38 °C prior to testing. One must evaluate the packaging components with respect to behavior at the temperature extremes under conditions incidental to transportation (i.e., the jiggles, bounces, and bumps normally encountered in transportation). Gaskets and packaging components need to be evaluated to determine if they will become excessively brittle at -40 °C. This may be accomplished by actual testing, referring to property of material tables, obtaining data from manufacturers, etc. The shipper must also consider such things as freezing of liquid contents and evaluate the effect to ensure continued containment integrity. The shipper must also consider the buildup of pressure at elevated temperatures and ensure continued containment. Designer, tester, and evaluator to do and shipper responsibility to ensure.	Metals used in these cylinders will not become excessively brittle at -40 °C and all gaskets used also meet this requirement. None of these packagings are authorized for liquids, so freezing of contents is not a concern. Temperatures of +70 °C will not result in any significant decrease in containment integrity, as shown in property of materials tables.
(e) It is able to withstand the effects of any acceleration, vibration, or vibration resonance that may arise during normal	Typically, one uses actual experience as a guide. If experience is not available, one normally uses a comparison to a similar packaging with an experience profile. If this isn't possible, vibration testing can be performed. The purpose of this section is to prevent the loosening of nuts, bolts, and containment devices under conditions incident to routine transportation. Designer, tester, and	Experience has consistently demonstrated that these packagings or similar designs comply with this requirement. The shipper must ensure the application of quality assurance necessary to achieve this requirement.

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;	evaluator to do and shipper responsibility to ensure.	
(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 §173.469, may be considered as a component of the containment system;	Screw-type closures can qualify. Friction fit normally does not qualify. Security clips on cans could be acceptable. However, one cannot depend on friction alone. Designer, tester, and evaluator to do and shipper responsibility to ensure.	All packagings evaluated meet this requirement, as shown in the figures or in the packaging descriptions in Section 6.0.
(g) The materials of the packaging and any components or structures are physically and chemically compatible with each other and	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

with the contents, taking into account the behavior of each under irradiation;		
(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;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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 is defined as the components intended to retain the radioactive contents during transportation. Thus, one starts by identifying the containment system. The radioactive contents must be completely retained in the containment system if the package is subjected to reduced pressure. A filtered packaging is possible as long as it can be demonstrated that the filtered package will retain the contents and that the filter is not susceptible to damage from any other tests. Caution should be exercised to ensure that the contents and internal packaging components (e.g., plastic boxes, etc.) will not effectively seal the filter during normal use. In cases where a pressure differential will not build up because of the free-flow through a filter, the requirement of demonstrating the retention of contents must still be met. For a package that breathes (does not hold 11.2 psi), such as a wooden box, one must demonstrate that, even with breathing, the contents will be retained. Otherwise, a separate inner containment capable of meeting the reduced pressure requirement is required. Designer, tester, and evaluator to do and shipper responsibility to ensure.	All cylinders are designed to withstand pressures far in excess of 11.2 psi. The minimum service pressure for any of these cylinders is 100 psig and extends up to 200 psig for nine of the cylinders.
(j) Each valve through which the radioactive contents could	Designer to do and shipper responsibility to ensure.	Each valve is protected against damage, sealed against unauthorized operation, and capped to retain any leakage.

otherwise escape is protected against damage and unauthorized operation and, except for a pressure relief device, has an enclosure to retain any leakage;		
(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 shield shall be securely closed or, by way of packaging design, ensure against escape of a containment component. One example is a package with cellotex on top of a lead shield with a press-fit lid in which closure of the cellotex holds the lid in place. The shipper must make sure that under the tests prescribed in 49 CFR 173.465, there will be no rearrangement of the original containment/shield orientation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	None of these packagings have shielding as described.
(l) Failure of any tie-down attachment on the packaging under excessive load will not impair the ability of the package to meet other requirements of this subpart;	Designer, tester, and evaluator to do and shipper responsibility to ensure.	Only one configuration (48-in. cylinder) uses/incorporates tie-down attachments. Table C-9 shows the calculated safety factors and the failure mode analyses. In all cases, it was demonstrated that the lug would fail, not the cylinder. Thus, the integrity of the cylinder would not be impaired.
(m) When subjected to the tests specified in §173.465 or evaluated against these tests by any of the methods authorized by §173.461(a), the packaging will prevent:		

(1) Loss or dispersal of the radioactive contents; and	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Any significant increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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 §173.466 or evaluated against these tests by any of the methods authorized by §173.461(a);	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

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	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(o) Each package designed for compressed or	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

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 §173.461(a).		

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Table C-9. Calculated Safety Factor for UF_6 Cylinders.			
Cylinder	**Weight (lb)**	**Calculated Safety Factor**	**Result**
48X	25,530	12	Pass
48Y	32,760	10	Pass
48G	30,600	10	Pass
48H	31,190	10	Pass
48HX	31,190	10	Pass

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Table C-10. Liquid and Gas Packagings--Compliance With Additional Design Requirements for Type A Packages (49 CFR 173.412).		
Regulatory requirement	**Action required/by whom**	**Packaging category--liquid and gas packagings**
In addition to meeting the general design requirements prescribed in §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);	Designer to do and shipper responsibility to ensure.	As shown in the figures and as given in the packaging descriptions in Section 7.0, all packagings meet this requirement.
(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	For this requirement, the package designer may need to be skilled and creative. This is especially true for packages such as fiberboard cartons and wooden boxes. A padlock is not effective as a security seal. It is not possible with most types of padlocks to ascertain if they have been illicitly opened. One acceptable approach toward meeting this requirement is serially numbered lead-wire seals, or, in the case of fiberboard packages, a tape of sufficient adhesive strength to damage the fiberboard upon removal. Designer to do and shipper responsibility to ensure.	There are acceptable approaches to compliance for all evaluated packagings. It is the shipper's responsibility to ensure compliance with this requirement.

vehicles, the cargo compartment may be sealed instead of the individual packages;		
(c) As far as practicable, the external surfaces are free from protrusions and are designed so that they can be easily decontaminated;	The intent is to minimize the number of protrusions by consideration during design and/or as a result of any modifications to the packaging. Designer to do and shipper responsibility to ensure.	All evaluated packagings meet this requirement.
(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;	This does not mean any of the tests must necessarily be performed at the temperature extremes. [Note: 49 CFR 173.461(b)] the regulations allow the assumption that the packaging is in equilibrium at 38 °C prior to testing. One must evaluate the packaging components with respect to behavior at the temperature extremes under conditions incidental to transportation (i.e., the jiggles, bounces, and bumps normally encountered in transportation). Gaskets and packaging components need to be evaluated to determine if they will become excessively brittle at -40 °C. This may be accomplished by actual testing, referring to property of material tables, obtaining data from manufacturers, etc. The shipper must consider such things as freezing of liquid contents and evaluate the effect to ensure continued containment integrity. The shipper must also consider the buildup of pressure at elevated temperatures and ensure continued containment. Designer, tester, and evaluator to do and shipper responsibility to ensure.	The materials (wood, caulking, metal strips, nails, gaskets, etc.) would not become excessively brittle at -40 °C. Temperatures of +70 °C would not result in any significant decrease in integrity either, as shown in property of materials tables. The shipper must ensure that, if the contents freeze, no rupture of the container will occur. In addition, the shipper must evaluate the potential for pressure buildup at elevated temperatures.
(e) It is able to withstand the effects of any acceleration, vibration, or vibration resonance that may arise during normal transportation,	Typically, one uses actual experience as a guide. If experience is not available, one normally uses a comparison to a similar packaging with an experience profile. If this isn't possible, vibration testing can be performed. The purpose of this section is to prevent the loosening of nuts, bolts, and containment devices under conditions incident to routine transportation. Designer, tester, and evaluator to do and shipper responsibility to	Experience has consistently demonstrated that these packagings or similar designs comply with this requirement. The shipper must ensure the application of quality assurance necessary to achieve this requirement.

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;	ensure.	
(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 §173.469, may be considered as a component of the containment system;	Screw-type closures can qualify. Friction fit normally does not qualify. Security clips on cans could be acceptable. However, one cannot depend on friction alone. Designer, tester, and evaluator to do and shipper responsibility to ensure.	All packagings evaluated meet this requirement, as shown in the figures or in the packaging descriptions in Section 7.0.
(g) The materials of the packaging and any components or structures are physically and chemically compatible with each other and with the	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

contents, taking into account the behavior of each under irradiation;		
(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;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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 is defined as the components intended to retain the radioactive contents during transportation. Thus, one starts by identifying the containment system. The radioactive contents must be completely retained in the containment system if the package is subjected to reduced pressure. A filtered packaging is possible as long as it can be demonstrated that the filtered package will retain the contents and that the filter is not susceptible to damage from any other tests. Caution should be exercised to ensure that the contents and internal packaging components (e.g., plastic boxes, etc.) will not effectively seal the filter during normal use. In cases where a pressure differential will not build up because of the free-flow through a filter, the requirement of demonstrating the retention of contents must still be met. For a package that breathes (does not hold 11.2 psi), such as a wooden box, one must demonstrate that, even with breathing, the contents will be retained. Otherwise, a separate inner containment capable of meeting the reduced pressure requirement is required. Designer, tester, and evaluator to do and shipper responsibility to ensure.	This analysis requires a more detailed discussion to provide adequate information. See Table C-11.
(j) Each valve through which the radioactive contents could otherwise	Designer to do and shipper responsibility to ensure.	Five packagings in this category have valves as described below: (1) **LLNL Gas Cylinders**: These cylinders are packaged in a 17H 114-L (30-gal) steel drum, which provides

escape is protected against damage and unauthorized operation and, except for a pressure relief device, has an enclosure to retain any leakage;		the physical protection and protects against unauthorized operation. The 17H 114-L (30-gal) drum also provides an enclosure to retain any leakage. More positively, each valve outlet is capped to retain any leakage. (2) **ORNL Gas Cylinders**: Each cylinder has a threaded protective cap and is sealed against unauthorized operation. The threaded caps also retain any leakage. (3) **EG&G Mound Commercial Tritium Cylinders**: The inner valves meet this requirement. (4) **WHC Grout Sample Packaging**: The 417-L (110-gal) overpack provides protection against damage and unauthorized operation of the secondary container valve. Unauthorized operation of the valve also is prevented by use of safety wire. (5) **EG&G Mound Lewis Gas Packaging**: The VCR cap provides the required enclosure. The valves are protected by the metal drum and polyurethane cushioning.
(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 shield shall be securely closed or, by way of packaging design, ensure against escape of a containment component. One example is a package with cellotex on top of a lead shield with a press-fit lid in which closure of the cellotex holds the lid in place. The shipper must make sure that under the tests prescribed in 49 CFR 173.465, there will be no rearrangement of the original containment/shield orientation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	The packagings meeting this criterion are discussed in Table C-12.
(l) Failure of any tie-down attachment on the packaging under excessive load will not impair the ability of the	Designer, tester, and evaluator to do and shipper responsibility to ensure.	None of the packagings have tie-down attachments as described.

package to meet other requirements of this subpart;		
(m) When subjected to the tests specified in §173.465 or evaluated against these tests by any of the methods authorized by §173.461(a), the packaging will prevent:		
(1) Loss or dispersal of the radioactive contents; and	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Any significant increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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 §173.466 or evaluated against these tests by any of the methods authorized by §173.461(a);	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

(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	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) Have a containment system composed of primary inner and secondary outer containment	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

components designed to assure retention of the liquid contents within the secondary outer components in the event that the primary inner components leak; and		
(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 §173.461(a).	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
LLNL = Lawrence Livermore National Laboratory ORNL = Oak Ridge National Laboratory.		

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Table C-11. Liquid and Gas Packagings--"Reduced Pressure" Tests Summary.				
Packaging/Principal User	**Model/Size**	**Containment System**	**Test/Analysis**	**Results**
Lovelace	MS-24347-7	Glass bottle with screw cap	Two of the glass bottles with caps screwed on by hand were inverted in a beaker of water, and a vacuum was drawn (3.6 psi). After 5 min. there was no evidence of leakage (bubbles in the water). Also, the metal drum itself passed the reduced pressure test, so the tests on the bottles would not have been required.	Pass
LANL	Fiberboard box with inner lead container	Inner lead container with screw-top cap and O-ring seal	The inner lead container was inverted in a beaker of water, and a vacuum was drawn (3.6 psi). After 5 min., there was no evidence of leakage (bubbles in the water).	Pass
LLNL	3A-1800 3E-1800	Steel drum Gas cylinders	Each of the cylinders was pressurized before being sent to Mound. The pressure was measured in each one upon receipt and averaged approximately 92 psig per cylinder. These data and the fact that the surface pressure was ambient (1 atm) indicate compliance with the 11.2 psi requirements.	Pass
ORNL	Fiberboard box for liquids and solids	Glass bottles with plastic screw-top caps: 15 mL - 6 tested 25 mL - 6 tested	Four to six bottles of each size were inverted in a glass beaker of water in a bell jar. The pressure was reduced (vacuum drawn) to 3.6 psig and held for 5 min. There was no leakage (bubbles in the	Pass

		50 mL - 5 tested 100 mL - 4 tested	water) in any case.	
ORNL	Fiberboard box for gases	Glass ampules: 2 cc - 4 tested 5 cc - 4 tested 10 cc - 4 tested 20 cc - 4 tested	Four ampules of each size were immersed in water in glass beaker in a bell jar. The pressure was reduced (vacuum drawn) to 3.6 psig and held for 5 min. There was no leakage (bubbles in the water) in any case.	Pass
ORNL	Fiberboard box for liquids and solids	Glass bottles with plastic screw-top caps	Four to six bottles of each size were inverted in a glass beaker of water in a bell jar. The pressure was reduced (vacuum drawn) to 3.6 psig and held for 5 min.	Pass
ORNL	Aluminum clad wood box (returnable)	Glass bottles with plastic screw-top caps	Four to six bottles of each size were inverted in a glass beaker of water in a bell jar. The pressure was reduced (vacuum drawn) to 3.6 psig and held for 5 min. There was no leakage (bubbles in the water) in any case.	Pass
ORNL	Gas cylinders in returnable plastic boxes	Gas cylinders as listed in Figures 7-9, 7-10, and 7-11	Each of these cylinders is designed for and tested at pressures well above 11.2 psi.	Pass
LANL	LANL-2	Combination outer steel drum with inner shielded container (pig)	Qualified based on previous testing of DOT-17C 55-gal steel drums.	Pass
HF	WHC Liquid Sample Packaging	Combination outer steel drum with inner polyethylene bottle	RTV silicone rubber sealant was applied to the drum gasket for the test. [Docket 90-14-7A]	Pass
Rocky Flats	RF Container Model LWS-1	Containment plus twice the absorbent required	10 vials containing 5 ml of RC-77 Fluorescent Penetrant each. [Docket 91-25-7A]	Pass
EG&G Mound Applied Technology	EG&G Mound Commercial Tritium Packaging	Gas cylinders as listed in Figure 7-18	These cylinders were tested at pressure differentials well above the required 77.2 kPa (11.2 psi). Note: All shipments will be at less than 1 atm.	Pass
WHC	WHC Grout	Combination inner	Inner shielded canister filled	Pass

	Sample Packaging	shielded canister with outer steel container	with water in a bell jar. The pressure was reduced (vacuum drawn) to 24.1 kPA (3.5 psia) and held for 15 min. There was no leakage. Outer steel container filled with water. The pressure was increased to 77.2 kPa (11.2 psig) for 15 min and then to 345 kPA (50 psig) for another 15 min. There was no leakage.	
EG&G Mound Applied Technology	EG&G Mound Lewis Gas Packaging	Gas cylinders as listed in Figure 7-20	In this packaging, the containment system is defined as the stainless steel inner cylinder. This cylinder is rated for up to 310 kPa (45 psi) at 93 °C (200 °F), thus meeting the requirement. In addition, the test cylinder was subjected to the reduced pressure test per 173.412 (i) and passed.	Pass
WHC	Hedgehog Container			
	1-L version:	Primary: PVC-coated glass bottle with Teflon-lined, phenolic lid. Secondary: SafeSend container.	The SafeSend[a] container is the reduced pressure containment boundary. The SafeSend container was manufacturer-tested by the 3M Company to an internal pressure of 100 kPa (14.5 psig) with no adverse effects.	Pass
	30-, 125-, and 250-mL versions:	Primary: Type 304 ss assembly(ies). Secondary: SafeSend container.	The SafeSend container is the reduced pressure containment boundary. In addition to the above-noted testing conducted by the 3M Company, the ss pig assemblies for the 30-mL and 250-mL versions underwent a reduced external pressure test. A vacuum of 20.68 kPa (3.0 psia) was drawn and held for 15 minutes (a pressure differential of 11.49 psi was achieved) with no leakage of simulated contents. The 125-mL version was not tested but was evaluated to pass this test due to it similarity in design	Pass

			with the 30-mL and 250-mL versions.	
	1-L Liquid Shipper	Primary: Narrow-mouth, Teflon[b] FEP bottle with a Tefzel[c] ETFE lid. Secondary: SafeSend[c] container.	The SafeSend container is the reduced pressure containment boundary. The SafeSend container was manufacturer-tested by the 3M Company to an internal pressure of 100 kPa (14.5 psi) with no adverse effects. [Docket 95-41-7A]	Pass

[a]SafeSend is a trademark of 3M Company.
[b]Teflon is a trademark of E.I. du Pont de Nemours & Company.
[c]Tefzel is a trademark of E.I. du Pont de Nemours & Company.
ETFE = ethylene-tetrafluorethylene
FEP = fluorinated ethylene propylene
HF = Hanford, Richland, Washington
LANL = Los Alamos National Laboratory
LLNL = Lawrence Livermore National Laboratory
Mound = Mound Laboratory
ORNL = Oak Ridge National Laboratory
WHC = Westinghouse Hanford Company.

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Table C-12. Packages Meeting 49 CFR 173.412(k) Criterion.

Packaging	Containment System	Analysis	Results
LANL fiberboard box with inner lead shielded containers	Inner lead container [5.08-cm (2-in.) outside diameter] with screw-cap and O-ring seal	The inner container is held in place by a lid with three bolts. Thus the outer shield is securely closed. There was no rearrangement during the tests specified in 49 CFR 173.465.	Pass
ORNL fiberboard boxes with shielded inner containers	Glass ampule or bottle with screw cap and a sealed metal can	The packaging components are firmly held in place by the sealed metal can.	Pass
ORNL aluminum clad wood box	Glass bottle and the 2R containers	The 2R container is held in place by the bolt closure lid of the stainless-steel-clad lead carrier.	Pass
ORNL gas cylinder	The cylinder itself	The lead shielding, when used, fills the void between the inner and outer wall and prevents escape.	Pass
LANL-2 drum with inner container	The inner container	The tubing, valves and shielding are securely held in place by the upper and lower shell, which is bolted in place.	Pass
WHC Grout Sample Packaging	Inner shielded canister; outer steel container	The inner shielded canister is held in place by the outer steel container, which is secured by means of a bayonet cover and two locking screws.	Pass
WHC Hedgehog Container	1-L version:	1-L version uses no shielding material. The bottle is held within the SafeSend container. The SafeSend container has a self-locking mechanism located on the lid that engages to the proper torque when the lid is screwed on. The SafeSend retains the primary containment.	Pass
	Primary: PVC-coated glass bottle with Teflon[a]-lined phenolic lid.		
	Secondary: SafeSend[b] container.		
	30-, 125-, 250-mL versions:	The ss assemblies are held together with 8-32 screws. There is an O-ring in the base and lid of	Pass

	Primary: Type 304 stainless steel assembly(ies).	each assembly. The assemblies act as both shielding and containment. The assemblies, when serving as a shield, retain the inner container shield. The SafeSend container has a self-locking mechanism located on the lid that engages to the proper torque when the lid is screwed on. The SafeSend retains the shielding and primary containment.	
	Secondary: SafeSend container.		

[a]Teflon is a trademark of E. I. du Pont de Nemours & Company.
[b]SafeSend is a trademark of 3M Company.
LANL = Los Alamos National Laboratory
ORNL = Oak Ridge National Laboratory
WHC = Westinghouse Hanford Company.

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Table C-13. Miscellaneous Packagings--Compliance With Additional Design Requirements for Type A Packages (49 CFR 173.412).

Regulatory requirements	**Action required/by whom**	**Package category--miscellaneous packagings**
In addition to meeting the general design requirements prescribed in §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);	Designer to do and shipper responsibility to ensure.	As shown in the figures and as given in the packaging descriptions in Section 8.0, all packagings meet this requirement.
(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	For this requirement, the package designer may need to be skilled and creative. This is especially true for packages such as fiberboard cartons and wooden boxes. A padlock is not effective as a security seal. It is not possible with most types of padlocks to ascertain if they have been illicitly opened. One acceptable approach toward meeting this requirement is serially numbered lead-wire seals, or, in the case of fiberboard packages, a tape of sufficient adhesive strength to damage the fiberboard upon removal. Designer to do and shipper responsibility to ensure.	There are acceptable approaches to compliance for all evaluated packagings. It is the shipper's responsibility to ensure compliance with this requirement.

vehicles, the cargo compartment may be sealed instead of the individual packages;		
(c) As far as practicable, the external surfaces are free from protrusions and are designed so that they can be easily decontaminated;	The intent is to minimize the number of protrusions by consideration during design and/or as a result of any modifications to the packaging. Designer to do and shipper responsibility to ensure.	All evaluated packagings meet this requirement.
(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;	This does not mean any of the tests must necessarily be performed at the temperature extremes. [Note: 49 CFR 173.461(b)] the regulations allow the assumption that the packaging is in equilibrium at 38 °C (100 °F) prior to testing. One must evaluate the packaging components with respect to behavior at the temperature extremes under conditions incidental to transportation (i.e., the jiggles, bounces, and bumps normally encountered in transportation). Gaskets and packaging components need to be evaluated to determine if they will become excessively brittle at -40 °C (-40 °F). This may be accomplished by actual testing, referring to property of material tables, obtaining data from manufacturers, etc. The shipper must also consider the buildup of pressure at elevated temperatures and evaluate the effect to ensure continued containment. Integrity. The shipper must also consider the buildup of pressure at elevated temperatures and ensure continued containment. Designer, tester, and evaluator to do and shipper responsibility to ensure.	The materials (wood, caulking, metal strips, nails, gaskets, etc.) would not become excessively brittle at -40 °C (-40 °F). Temperatures at +70 °C (+158 °F) would not result in any significant decrease in containment integrity, as shown in property of material tables.
(e) It is able to withstand the effects of any acceleration, vibration, or vibration resonance that may arise during normal	Typically, one uses actual experience as a guide. If experience is not available, one normally uses a comparison to a similar packaging with an experience profile. If this isn't possible, vibration testing can be performed. The purpose of this section is to prevent the loosening of nuts, bolts, and containment devices under conditions incident to routine transportation. Designer, tester, and	Experience has consistently demonstrated that these packagings or similar designs comply with this requirement. The shipper must ensure the application of quality assurance necessary to achieve this requirement.

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;	evaluator to do and shipper responsibility to ensure.	
(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 §173.469, may be considered as a component of the containment system;	Screw-type closures can qualify. Friction fit normally does not qualify. Security clips on cans could be acceptable. However, one cannot depend on friction alone. Designer, tester, and evaluator to do and shipper responsibility to ensure.	All packagings evaluated meet this requirement, as shown in the figures or in the packaging descriptions in Section 8.0.
(g) The materials of the packaging and any components or structures are physically and chemically compatible with each other and	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

with the contents, taking into account the behavior of each under irradiation;		
(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;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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 is defined as the components intended to retain the radioactive contents during transportation. Thus, one starts by identifying the containment system. The radioactive contents must be completely retained in the containment system if the package is subjected to reduced pressure. A filtered packaging is possible as long as it can be demonstrated that the filtered package will retain the contents and that the filter is not susceptible to damage from any other tests. Caution should be exercised to ensure that the contents and internal packaging components (e.g., plastic boxes, etc.) will not effectively seal the filter during normal use. In cases where a pressure differential will not build up because of the free-flow through a filter, the requirement of demonstrating the retention of contents must still be met. For a package that breathes [does not hold 77.2 kPa (11.2 psi)], such as a wooden box, one must demonstrate that, even with breathing, the contents will be retained. Otherwise, a separate inner containment capable of meeting the reduced pressure requirement is required. Designer, tester, and evaluator to do and shipper responsibility to ensure.	See Table C-14.
(j) Each valve through which the radioactive contents could	Designer to do and shipper responsibility to ensure.	The only packaging meeting this criterion are as follows: **SNL Tritium Waste Package**. The 17H 114-L (30-gal) drum provides the

otherwise escape is protected against damage and unauthorized operation and, except for a pressure relief device, has an enclosure to retain any leakage;		physical protection against unauthorized operation. The asphalt which surrounds the entire inner packaging and the 17H steel drum will retain any contents. **INEL Mark III Concrete Container**. Two valves exist on the lower body of the container. Both valves are cast in the concrete within one layer of welded wire fabric for protection from damage. The valves are sealed after loading of the packaging. Leakage would be retained in plugged lines.
(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 shield shall be securely closed or, by way of packaging design, ensure against escape of a containment component. One example is a package with cellotex on top of a lead shield with a press-fit lid in which closure of the cellotex holds the lid in place. The shipper must make sure that under the tests prescribed in 49 CFR 173.465, there will be no rearrangement of the original containment/shield orientation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	The only packaging meeting this criterion is the **LLNL (Spec. 55) container**. The packaging/shield is one piece, so it is obviously the containment system also. Since the containment system and the radiation shield are all the same, they cannot escape/separate.
(l) Failure of any tie-down attachment on the packaging under excessive load will not impair the ability of the package to meet other requirements of this subpart.	Designer, tester, and evaluator to do and shipper responsibility to ensure.	The only packaging in this category that has a tie-down attachment as described is the **INEL Mark III Concrete Container**. Tie-down points are located on the four upper corners of the body and lid. The lifting ring hardware has a safety factor of 5. Should a failure occur, the lid and body consist of substantial concrete, welded wire fabric, liner material, and a gasket, and will prevent release of hazardous material.
(m) When subjected to the tests specified in §173.465 or evaluated against these tests by any of the methods authorized by §173.461(a), the packaging will		

prevent:		
(1) Loss or dispersal of the radioactive contents; and	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Any significant increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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 §173.466 or evaluated against these tests by any of the methods authorized by §173.461(a);	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

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	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(o) Each package designed for	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.

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 §173.461(a).		

LLNL = Lawrence Livermore National Laboratory
SNL = Sandia National Laboratory.

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Table C-14. Miscellaneous Packagings Containment System Analysis.				
Packaging/Principal User	**Model/Size**	**Containment System**	**Test/Analysis**	**Results**
LLNL	Spec 55	There is only one packaging component, so this obviously is the containment.	The cavity of this packaging was filled with a water-fluorescein solution. The package was inverted in a bell jar and subjected to a reduced pressure of 3.6 psi for 5 min. Upon completion of the test there was no visible loss of contents and no loss found with a black light.	Pass
ORNL	ORNL-TRU	Because the contents are restricted to Special Form [49CFR 173.403(z)], Form [49CFR 173.403(z)], this provides the containment system.	This test has little meaning since there is no loose contamination available for dispersion or transfer. This test was not conducted, but obviously would meet the criterion, if tested, of "No Loss of Contents."	Pass
FEMA	FEMA Source Overpack	Because the contents are restricted to Special Form [49CFR 173.403(z)], Form [49CFR 173.403(z)], this provides the containment system.	This test has little meaning since there is no loose contamination available for dispersion or transfer. This test was not conducted, but obviously would meet the criterion, if tested, of "No Loss of Contents."	Pass
LLNL	SNL Tritium Waste Package	Modified DOT 5C-304 15-gal stainless steel drum.	The inner container was subjected to a hydrostatic pressure of 80 psi for 5 min., with no leakage.	Pass
LANL	LANL-1 Aluminum Packaging	Form No. 3 Material (self-contained)	The material form of the contents would prevent dispersal when the package was exposed to the reduced pressure	Pass

			conditions. Testing was not needed.	
WIPP	RH-TRU Canister	Steel Cylinder, Welded Construction, NucFil[a] Filter	The NucFil filter would prevent pressure differentials. Testing was not needed. [Docket 89-03-7A]	Pass
Grand Junction	Special Form Neutron Source	Special Form Material	The authorized contents are restricted to special form material. Testing was not needed. [Docket 91-26-7A]	Pass
WIPP	TRUPACT II Ten-Drum Overpack	Cylindrical body; lid; capscrews; carbon filters; pipe plugs	Because this packaging has multiple filters, a pressure differential of this magnitude could not be achieved. This packaging was tested with 10 filters installed. An analysis showed that if the contents of the TDOP have the potential to generate flammable gas, then nine filters are sufficient to maintain the flammable gas concentration. The analysis also showed that if the contents of the TDOP do not have the potential for flammable gas generation, a minimum of one filter may be installed and the unused filter ports sealed with pipe plugs. [Docket 90-16-7A]	Pass
INEL	MARK III Concrete Container	Concrete body and lid; polyethylene liner; polyethylene foam gasket; six coil bolts and washers; a lid vent plug; four bottom drain plugs; and two valves	A containment boundary verification was performed by conducting a hydrostatic pressure test using the polyethylene foam gasket material. Test unit 33-TU-04 was filled with water and pressurized to 77.22 kPa (11.2 psig) and held for 15 min.	Pass
INEL	ARROW-PAK	Cylindrical tube and two dome-shaped end caps, permanently fused together	A containment boundary verification was performed by conducting a hydrostatic pressure test on test unit 40-TU-03. This test unit was filled with water and fluorescein, then pressurized with compressed nitrogen gas to 80.66 kPa (11.7 psig), and held for 15 min. [Docket 95-40-7A]	Pass

[a]NucFil is a trademark of Nuclear Filter Technology, Inc.
DOT = U.S. Department of Transportation
FEMA = Federal Emergency Management Agency
INEL = Idaho National Engineering Laboratory
LANL = Los Alamos National Laboratory
LLNL = Lawrence Livermore National Laboratory
ORNL = Oak Ridge National Laboratory
RH = Remotely handled
SNL = Sandia National Laboratory
TRU = Transuranic
TRUPACT = Transuranic package transporter
WHC = Westinghouse Hanford Company
WIPP = Waste Isolation Pilot Plant.

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Table D-1.a. Water Spray Test Results for Steel Drums.	
STEEL DRUMS	
Specific packaging	**Test/Analysis Results**
DOT-6C, 5-gal	By comparison, this drum would meet this requirement.
DOT-6C, 10-gal	By comparison, this drum would meet this requirement.
DOT-17C, 5-gal	By comparison, this drum would meet this requirement.
DOT-17C, 30-gal	By comparison, this drum would meet this requirement.
DOT-17C, 35-gal	Three loaded and three empty drums were tested and passed.
DOT-17C 55-gal	Three drums were subjected to this test and passed (Configuration RF-1).
DOT-17C, 55-gal w/pressure relief device	Three lids with the Nucfil[a] filters were subjected to the water spray test and no water passed through the filter (Configurations HF-1 and RF-2).
DOT-17C, 55-gal w/HDPE liner	The same data shown for the 17C 55-gal drum would apply here (Configurations HF-2, LL-1, MD-1 and RF-3).
DOT-17C, 55-gal w/HDPE vented liner	One test unit package was subjected to the test conditions and passed (Configurations RF-4 through RF-8). [Dockets 89-13-7A and 90-18-7A]
DOT-17H, 30-gal	Three drums were subjected to this test and passed (Configuration OR-1).
DOT-17H, 30-gal w/filter	One test unit package was subjected to the test conditions and passed (Configurations AW-1 and FM-1). [Dockets 90-17-7A and 90-20-7A]
DOT-17H, 55-gal	Three drums were subjected to this test and passed.

MS-24347-1[b]	By comparison, this drum would meet this requirement.
MS-24347-7[b]	Two drums were subjected to this test and passed.
MS-27684-1[b]	By comparison, this drum would meet this requirement.
MS-27684-2[b]	By comparison, this drum would meet this requirement.
MS-27684-3[b]	Three drums were subjected to this test and passed.
MS-27684-6[b]	By comparison, this drum would meet this requirement.
MS-27684-8[b]	Three drums were subjected to this test and passed.
MS-27683-7[b]	Three drums were subjected to this test and passed.
MS-27683-13[b]	By comparison, this drum would meet this requirement.
MS-24683-21[b]	Three drums were subjected to this test and passed.
See Table D-1.b. Water Spray Test Results for Steel Drums (Packaging Specialties).	

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Table D-1.b. Water Spray Test Results for Steel Drums.				
PACKAGING SPECIALTIES, SQUARE STEEL DRUMS				
Specific packaging	**No. tested**	**Contents**	**Results**	**Comments**
Style 1A	1	Flour and fluorescein	Pass	The drum was opened upon completion of the test and the 2-hr waiting period. An inspection demonstrated that there had been no inleakage of water.
	2	Cement in a plastic liner inside the steel drum Flour and fluorescein were placed between the plastic liner and the wall of the steel drum.	Pass	One drum was dropped (angle) on both the top and the bottom (same drum). The drum passed the drop test with no effect apparent from the water spray test. A second drum was dropped flat on its side and again it passed the drop test with no effect from the water spray test.
Style 1B	1	Empty	Pass	The drum was opened upon completion of the test and the 2-hr waiting period. An inspection demonstrated that there had been no inleakage of water.
	2	Flour and fluorescein on top and bottom Sand and metal weights as required for weight Plastic cover between sand and flour, top and bottom	Pass	One drum was dropped (angle) on both the top and the bottom (same drum). The drum passed the drop test with no effect apparent from the water spray test. A second drum was dropped flat on its side and again it passed the drop test with no effect from the water spray test.
Style 2	1	Empty	Pass	The drum was opened upon completion of the test and the 2-hr waiting period. An inspection demonstrated that there had been no inleakage of water.
	2	Flour and fluorescein on top and bottom	Pass	One drum was dropped (angle) on both the top and the bottom (same

		Sand and metal weights as required for weight		drum). The drum passed the drop test with no effect apparent from the water spray test. A second drum was dropped flat on its side and again it passed the drop test with no effect from the water spray test.
		Plastic cover between sand and flour, top and bottom		
Style 3	1	Empty	Pass	The drum was opened upon completion of the test and the 2-hr waiting period. An inspection demonstrated that there had been no inleakage of water.
	2	Flour and fluorescein on top and bottom	Pass	One drum was dropped (angle) on both the top and bottom (same drum). The drum passed the drop test. A second drum was dropped flat on its side and again it passed the drop test with no effect from the water spray test.
		Sand and metal weights as required for weight		
		Plastic cover between sand and flour, top and bottom		

[a]Nucfil is a trademark of Nuclear Filter Technology, Inc.
[b]Drum assembly numbers.
AW = Argonne National Laboratory - West
DOT = U.S. Department of Transportation
FM = Feed Materials Production Center
HDPE = High-density polyethylene
HF = Hanford, Richland, Washington
LL = Lawrence Livermore National Laboratory
MD = Mound Laboratory
MS = Military specification
OR = Oak Ridge National Laboratory
RF = Rocky Flats.

See Table D-1.a. Water Spray Test Results for Steel Drums.

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Table D-2. Water Spray Test Results for Steel Boxes.

Specific packaging	Test Analysis Results
All • Capital Industries • Container Products Corp. • RoGar Chemical and Nuclear Services • Rocky Flat SAND Boxes • Argonne M-4 Steel Bin	All these boxes pass by analysis of materials, methods of construction, years of experience (exposure to a variety of weather conditions, including heavy rains), and air-leak or water-leak tests that have demonstrated the boxes to be leak tight. The tests referenced are the reduced pressure tests (Appendix C). The filters (for filtered boxes) have been tested and demonstrated to be water-leak resistant also.
TRUPACT-II - SWB	The water spray test was conducted on the SWB Steel Box prior to each of the Type A tests. In all cases the packagings passed the performance requirements. In addition, the box was tested empty to evaluate the potential inleakage of water. Test Unit No. 1 was tested and then opened and inspected for the presence of water. None was found.
ANL-W/7A-960	Because this package does not have a gasket, one has to assume there could be an inleakage of water, however slight. To protect against the possibility of exposure to water, the contents must be enclosed in plastic or equally water resistant materials, or the shipper must ensure that, if the contents were exposed to such water, there would be no transfer of radioactive materials to the liquid. See Section 3.6.3, Restrictions/Specifications. A preferred method (since the introduction of any water into a radioactive material shipping container is highly undesirable) is to use a gasket. Thus, all of the steel boxes except the ANL-W 7A-960 meet this requirement without any restrictions or specifications, and the ANL-W 7A-960 meets this requirement when used as prescribed in Section 3.6.3.

ORNL Low-Level Waste Container	Package 7V-90-0002 was subjected to the water spray test conditions for 1 hr with no adverse affects. There were no cracks or crevices where water could collect, which would cause damage to the package. No inleakage was observed. No other packages were water sprayed, since water will have no adverse affects on the metal packaging. [Docket 89-04-7A]

ANL-W = Argonne National Laboratory - West
ORNL = Oak Ridge National Laboratory
SWB = Standard waste box.

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Table D-3. Water Spray Test Results for ANL and LLNL Wooden Boxes.	
Specific packaging	**Test Analysis Results**
ANL-W Family of Boxes	By comparison, these boxes would meet this requirement.
LLNL FLUSH Panel Box	By comparison, these boxes would meet this requirement.
ANL-W = Argonne National Laboratory - West LLNL = Lawrence Livermore National Laboratory.	

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Table D-4. Water Spray Test Results for Mound Wooden Boxes.

Configuration (Dimensions in Inches)	**1st Test As Built**	**2nd Test RTV Used to Seal Seams on Inside**	**3rd Test Water Sealant Applied to Boxes[a]**
Mound Configuration A 8 × 8 × 36	Pass - No indication of water	Fail[b]	Pass
Mound Configuration B 12 × 12 × 36	Pass - No indication of water	Pass	Pass
Mound Configuration C 12 × 12 × 36	Fail - Water absorbed on paper	Fail	Pass
Mound Configuration D 12 × 15 1/2 × 48	Fail - Water absorbed on paper	Fail	Pass
Mound Configuration E 21 × 21 × 22 1/2	Fail - Water absorbed on paper	Fail	Pass

[a]GEOCEL, brushable sealant, 1 coat. GEOCEL is a trademark of GEOCEL Limited, Inc.
[b]Water detected on paper.
Mound = Mound Laboratory.

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Table D-5. Water Spray Test Results for Wooden Boxes.

Specific packaging	Test/analysis results
NLO Family of Boxes	By comparison, these boxes would meet this requirement.
Y-12 B Series B-1 through B-8	Each of these packagings was subjected to the water spray test for 1 hr, allowed to sit for 2 hr, and then subjected to the drop test. There was no evidence of a decrease in containment integrity as a result of this test. Considering the materials and methods of construction, all of the other wooden boxes would also meet this requirement.
Y-12 Picture Frame Boxes PF-1 through PF-8, and PF-10	By comparison, these boxes would meet this requirement.
Rocky Flats RA Series of Boxes	By comparison, these boxes would meet this requirement.
ORNL Y-12	A test unit of each model (C-1, C-2, and C-3) was subjected to the test conditions and passed. [Docket 89-01-7A]
C-Series	Two of the boxes were tested for 1 hr without painting (as received from Y-12). In both cases significant water was detected within the boxes after the test (determined by comparing weights before and after the test). The boxes were painted (two separate coats of exterior grade paint) and the tests were conducted again. This time there was no free liquid detected, although the bottom portions of the walls were noticeably damp. This amount of water is no reason to cause these boxes to fail this test. A third coat was placed on the boxes to see if that made any difference. The tests were redone, but the results were the same, a slight dampness of the bottom portion of the wall. Each box was also tested prior to the other Type A tests and in no case did this test have an effect on the ability of the package to meet the performance requirements. [Docket 90-19-7A]
WMCO Family of Boxes	Water spray tests were conducted on all boxes and varying degrees of water inleakage were noted in all boxes. There was no evidence that the water spray test decreased the containment integrity of the boxes when the drop test was performed. [Docket 89-09-7A]

NLO = National Lead Corporation
ORNL = Oak Ridge National Laboratory
WMCO = Westinghouse Materials Company of Ohio.

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Table D-6. Water Spray Test Results for Fiberboard Containers.

Specific packaging	Test/analysis results
Fiberboard Boxes 12B-65 Fiberboard Box LLNL Fiberboard Box Tri-Wall	Each of these packagings was subjected to this test prior to each of the three tests: free drop, compression, and penetration. As a result of the water spray, the addition of triple-wall support was required in many of the containers so that these packagings could withstand the compression test. This test also demonstrated the need for water-resistent tape as required in the Restrictions/Specifications sections. As one would expect, the boxes were softened considerably; however, this didn't seem to make much difference in the drop or penetration tests.
Fiberboard Drums	Since one has to assume an inleakage of water, each shipper must address this potential inleakage of water and ensure there is no transport of radioactive materials out of the packaging by the methods discussed in Section D1.6 or their equivalent.

LLNL = Lawrence Livermore National Laboratory.

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Table D-7. Water Spray Test Results for UF_6 Cylinders.	
Specific packaging	**Test/analysis results**
Models	
1S 2S 5A 8A 12A 12B 30A 30B 48G 48H 48HX 48X 48Y	The factors to be considered in evaluating compliance as mentioned previously were as follows: (1) The effect the water spray would have on the ability of the UF_6 cylinders to meet the other Specification 7A performance requirements (2) The potential for inleakage of water with the subsequent potential for transport of the radioactive contents out of the packagings. The materials and method of construction make it obvious that a water spray (rain) would not have any significant effect on the structural integrity. This is well-substantiated by years of shipping thousands of these packagings through a wide variety of weather conditions. The potential for inleakage of water is not credible because these cylinders have welded seams and threaded valves that are gas-leak tight. Thus, these packagings meet this requirement.
Modified	
5A 5B	One test unit was subjected to the water spray test conditions for 1 hr with no adverse effects. There were no cracks or crevices where water could collect which would cause damage to the package. No other packages were water sprayed, because water will not have any adverse effects on the metal packaging. [Docket 89-08-7A].

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Table D-8. Water Spray Test Results for Liquid and Gas Packagings.	
Specific packaging	**Test/analysis results**
Steel drum MS 24327-7	This test was not conducted on this packaging because the outer packaging component is a steel drum, and compliance is demonstrated as described in Tables D-1.a and D-1.b.
LANL-12B-62 Fiberboard Box	The test was conducted prior to each of the three tests: 9-m (30-ft) drop, compression, and penetration. The packaging successfully passes these three tests, which demonstrates the lack of significant effect with respect to structural aspects. Also, because the 5.08-cm (2-in.) inner container is air-leak tight, there is no potential for inleakage of water. Thus, this packaging meets this requirement.
LLNL Steel Drums with Gas Cylinders	The compliance of the outer packaging, DOT-17H 114-L (30-gal) steel drum, has already been demonstrated, as described in Tables D-1.a and D-1.b.
ORNL liquids and solids	The water spray test was performed prior to each test, and the packaging successfully met all requirements. Because there is a sealed metal inner container, there is no potential for further inleakage of water.
Disposable Container with Shielding (liquids, solids, or gases)	The water spray test was performed prior to each test, and the packaging successfully met all requirements. Because there is a sealed metal inner container, there is no potential for further inleakage of water.
Wooden Box (returnable, shielded)	The water spray test was performed prior to each test, and the packaging successfully met all requirements. The sealed inner metal containers preclude any potential for further inleakage.
Gas Cylinder (returnable - Hoke)	The water spray test was performed prior to each test, and the packaging successfully met all requirements. The plastic box used as an overpack typically precludes any significant effect from the water spray. Considering that the inner cylinders are gas-leak tight, there is no potential for further inleakage of water.
Gas Cylinder (returnable - J. L. Shephard)	Considering the materials and method of construction and the fact that these cylinders are gas-leak tight, there is no potential for inleakage of water.
EG&G Mound Applied Technologies	This test was conducted on each of the packagings prior to conducting the drop, penetration, and compression tests. There was no apparent effect on the packaging. Tests also were conducted on two empty packagings to ensure that there would be no

Commercial Tritium Packaging (10, 50, 150, 300 and 500 cc)	inleakage of water. The result was no inleakage of water.
WHC Grout Sample Packaging	The water spray test was performed immediately prior to the compression test. No water spray was applied to the package prior to any further testing, as the strength of the steel drum will not be affected by the application of water. (See discussions in Introduction, D1.2 Packaging Category--Steel Drums, and Table of Requirements, D-1 Water Spray Test.
EG&G Mound Lewis Gas Packaging	This test was conducted on each packaging before conducting the DOT-7A performance tests. Results: Pass. This test had no significant effect on the packaging.
	This test also was conducted on an empty packaging (metal drum) to ensure that there would be no inleakage of water. Results: Pass. Upon completion of the test, the drum was opened and it was confirmed that there had been no inleakage of water.
WHC Hedgehog Container	This test was conducted on an empty packaging (39-TU-02) before conducting the DOT-7A performance tests and after the vibration standards test. Water collected on the top exterior of the Hardigg Case[a] as it would normally sit during transportation. There was no in-leakage of water. There was no damage to the exterior or interior of the packaging. Results: Pass.
WHC 1-L Liquid Shipper	This test was conducted on test units 41-TU-11 and 41-TU-17. Water pooled in the top of the SafeSend[b] lid around the handhold area; however, there was no inleakage of water. There was no damage to the exterior or interior of the packaging. No further water spray tests were conducted as this test had no negative effect on the performance of the packaging. Results: Pass.

[a]Hardigg Case is a trademark of Hardigg Industries, Inc.
[b]SafeSend is a trademark of the 3M Company.
DOT = U.S. Department of Transportation
LANL = Los Alamos National Laboratory
LLNL = Lawrence Livermore National Laboratory
MS = Military specification
ORNL = Oak Ridge National Laboratory
WHC = Westinghouse Hanford Company.

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Table D-9. Water Spray Test Results for Miscellaneous Packagings.	
Specific packaging	**Test/analysis results**
LLNL Spec 55	This test was not conducted because, considering the materials and methods of construction, it is obvious that this test would not adversely affect the ability of the package to meet the additional Specification 7A requirements. In addition, because the package was demonstrated to be water-leak tight even after the 4-ft drop, there is no potental for inleakage of water.
ORNL TRU Shipping Container	This test was not conducted because, considering the material and methods of construction, it is obvious that this test would not adversely affect the ability of the package to meet the additional Specification 7A requirements. In addition, because the inner (source) containment has to meet the Special Form [173.412(z)] criteria, the inleakage of water would not result in a potential transport of radioactive material from the package.
FEMA Source Overpack	This test was not conducted because, considering the materials and methods of construction, it is obvious that this test would not adversely affect the ability of the package to meet the additional Specification 7A requirements. In addition, because the inner (source) containment has to meet the Special Form [173.412(z)] criteria, the inleakage of water would not result in a potential transport of radioactive material from the package.
SNL Tritium Waste Package	The compliance of the outer packaging, DOT-17H 30-gal steel drums, has already been demonstrated and discussed in Tables D-1.a and D-1.b.
LANL Aluminum Packaging (LANL-1)	This test was not conducted because, considering the materials and methods of construction, it is obvious that this test would not adversely affect the ability of the package to meet the additional Specification 7A requirements. In addition, there would be no inleakage of water expected.
WIPP RH-TRU Canister	Test Unit Package LA02 was subjected to the water spray test conditions for 1 hr with no adverse affects. Result: Pass. [Docket 89-03-7A].
Packaging for Special Form Neutron Source	Test Unit 26-TU-1 was subjected to the water spray test conditions for 1 hr with no adverse affects. Pass. [Docket 91-26-7A].
TRUPACT II Ten-	Test Package 130408 was subjected to the water spray test conditions for 1 hr with no inleakage or entrapment of water (tested on 7/27/90). The water spray test was not

Drum Overpack	conducted on test units that underwent testing on 10/28/93 as it was determined that design modifications made on the TRUPACT II Ten-Drum Overpack would not have any negative effect. Result: Pass. [Docket 90-16-7A].
INEL Mark III Concrete Container	This test was conducted on test units 33-TU-02 and 33-TU-05 and included the top wooden impact limiter. Water collected within the lid pockets where the lifting rings attach; there were no adverse effects. Results: Pass. [Docket 92-33-7A].
INEL ARROW-PAK Packaging	This test was conducted on test unit 40-TU-03 with no adverse effects. Results: Pass. [Docket 95-40-7A].

FEMA = Federal Emergency Management Agency
INEL = Idaho National Engineering Laboratory
LANL = Los Alamos National Laboratory
LLNL = Lawrence Livermore National Laboratory
ORNL = Oak Ridge National Laboratory
RH = Remotely handled
SNL = Sandia National Laboratory
TRU = Transuranic
TRUPACT = Transuranic package transporter
WIPP = Waste Isolation Pilot Plant.

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Table D-10.a. Free Drop Test Results for Steel Drums.

				45° Top[b]		45° Bottom[c]		Side[d,e]	
Specific packaging	**Weight[a] (lb)**	**Contents**	**RTV/liner**	**No. tested**	**Results**	**No. tested**	**Results**	**No. tested**	**Results**
DOT-6C (5-gal)	80	F/F/S/Pb[f]	RTV	2	2 pass	2	2 pass	1	1 pass
DOT-6C (10-gal)	160	F/F/S/Pb	RTV	2	2 pass	2	2 pass	1	1 pass
DOT-17C (5-gal)	100	F/F/S/Pb	RTV	1	1 pass	1	1 pass	1	1 pass
DOT-17C (30-gal)	400 (Form 1) 500 (Form 2)		None	Tests were not done on the 17C (30-gal). This evaluation is based on testing of the 17H (30-gal) drum, which has structural integrity equal to the 17C drum.					
DOT-17C (55-gal) (Config. RF-1)	900 (Form 1)	F/F/S/Pb	Liner[g]	5	5 pass	5	5 pass	7	7 pass
	1,000 (Form 2)	S/Pb[h]	None	5	5 pass	5	5 pass	6	6 pass
				Flat on top and bottom					
DOT-17C (55-gal) (Config. RF-1)	900	F/F/S/Pb	--	3	3 pass	3	3 pass	--	--
DOT-17C (55-gal) with Pressure Relief Device									
- Vent Clip (Config. HF-1)	900	F/F/S/Pb	Liner	4	4 pass	2	2 pass	2	2 pass
	1,000	S[i]	None	--	--	--	--	--	--
DOT-17C (55-gal) with									

Pressure Relief Device - Filter (Config. RF-2)	900 F/F/S/Pb	None	3	3 pass	--	--	3	3 pass
				Flat on top				
DOT-17C (55-gal) - Filter Installed (Config. RF-2)	900 F/F/S/Pb	None	3	3 pass	--	--	--	--

					45° Top[b]		**45° Bottom[c]**		**Side[d,e]**
Specific packaging	**Weight[a] (lb)**	**Contents**	**RTV/liner**	**No. tested**	**Results**	**No. tested**	**Results**	**No. tested**	**Results**
DOT-17C (55-gal) with 90-mil HDPE Liners (Configs. HF-2, LL-1, MD-1, RF-3)	900	F/F/S/Pb	HDPE liner	5	5 pass	5	5 pass	5	5 pass
	900	F/F/S/Pb	HDPE liner	5	5 pass	5	5 pass	5	5 pass
	900	F/F/S/Pb	HDPE liner	2	2 pass	2	2 pass	3	3 pass

See Table D-10.b. Free Drop Test Results for Steel Drums.
See Table D-10.c. Free Drop Test Results for Steel Drums.
See Table D-10.d. Free Drop Test Results for Steel Drums.
See Table D-10.e. Free Drop Test Results for Steel Drums.

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Table D-10.b. Free Drop Test Results for Steel Drums.

Specific packaging	Weight[a] (lb)	Contents	RTV/liner	Orientation	No. tested	Results
DOT-17C (55-gal) HDPE Liner (Configs. RF-4, RF-5 thru RF-8) [Dockets 89-13-7A, 90-18-7A]	950	F/F/S/Pb	HDPE liner	CG over bolt	1	1 pass
				Flat on bottom	1	1 pass
	1,025	S/Pb	HDPE liner	CG over bolt	1	1 pass
				Flat on bottom	1	1 pass
	935	F/F/S/Pb	HDPE liner	Side flat on bolt	1	1 pass
				CG over bottom rim	1	1 pass
				Flat on top	1	1 pass
	1,050	S/Pb	HDPE liner	Side flat on bolt	1	1 pass
				CG over bottom rim	1	1 pass
				Flat on top		
DOT-17C (UN1A2) (55-gal) NucFil*-013 Filtered drum, open Type IV HDPE 110-mil liner, 3.5-mil polyethylene bag (Config. LL-2) [Docket 94-37-7A]	900	F/F/S/Pb	HDPE liner	Side flat on bolt	1	1 pass
				CG at bolt location	1	1 pass
	1,000	S/Pb	HDPE liner	Side flat on bolt	1	1 pass
				CG at bolt location	1	1 pass
DOT-17C (30-gal) Filtered drum with bag liner (Configs. AW-1, FM-1) [Dockets 90-17-7A, 90-20-	900	F/F/S[j]	Bag liner	Flat on top	1	1 pass
				Flat on bottom	1	1 pass
				CG over top	1	1 pass
				CG over bottom	1	1 pass
	420	F/F/S	Bag liner	CG over top on bolt	1	1 pass
				CG over bottom	1	1 pass

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See Table D-10.a. Free Drop Test Results for Steel Drums.
See Table D-10.c. Free Drop Test Results for Steel Drums.
See Table D-10.d. Free Drop Test Results for Steel Drums.
See Table D-10.e. Free Drop Test Results for Steel Drums.

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Table D-10.c. Free Drop Test Results for Steel Drums.

				45° Top[b]		45° Bottom[c]		Side[d,e]	
Specific packaging	**Weight[a] (lb)**	**Contents**	**RTV/liner**	**No. tested**	**Results**	**No. tested**	**Results**	**No. tested**	**Results**
DOT-17H (30-gal) (Config. OR-1)	400	F/F/S/Pb	RTV	2	2 pass	1	1 pass	2	2 pass
	400	F/F/S/Pb	4-mil	2	2 pass	2	2 pass	2	2 pass
	400	F/F/S/Pb	None	1	1 pass	1	1 pass	1	1 pass
	500	S/Pb	None	2	2 pass	1	2 pass	2	2 pass
DOT-17H (55-gal)	1,000	S/Pb	None	8	8 pass	8	8 pass	4	4 pass
				Flat on Top and Bottom					
DOT-17H (55-gal)	1,000	S/Pb	None	5	5 pass	5	5 pass	--	--
DOT-17H	900	F/F/S/Pb	4-mil	5	5 pass	5	5 pass	--	--
	900	F/F/S/Pb	None	6	6 pass	--	--	7	2 pass 5 fail
	900	F/F/S/Pb	4-mil	8	8 pass	2	2 pass	11	11 pass
	900	F/F/S/Pb	RTV	5	5 pass	5	5 pass	5	5 pass
MS-24347-1 (0.25-gal)**	10	F/F/S/Pb	None	2	2 fail	--	--	3	2 pass 1 fail
	10	F/F/S/Pb	4-mil	2	2 pass	--	--	2	2 pass
MS-24347-7 (1.25-gal)**	35	F/F/S/Pb	None	1	1 fail	--	--	1	1 fail
		F/F/S/Pb	4-mil	3	3 pass	--	--	3	3 pass
MS-27684-1 (3-gal)**	60	F/F/S/Pb	4-mil	3	3 pass	--	--	1	1 pass
		S/Pb		--	--	--	--	1	1 pass
MS-27684-2 (4-gal)**	110	F/F/S/Pb	None	4	4 pass	4	4 pass	4	4 pass
MS-27684-2	110	F/F/S/Pb	None	4	4 pass	4	4 pass	--	--

(4-gal)**								
MS-27684-3 (6-gal)**	80 F/F/S/Pb	4-mil	3	3 pass	k	--	1	1 pass
	S/Pb	None	--	--	k	--	1	1 pass
MS-27684-6 (8-gal)**	80 F/F/S/Pb	None	3	3 pass	k	--	2	2 pass
MS-27684-8 (12-gal)**	200 F/F/S/Pb	4-mil	2	2 pass	k	--	1	1 pass
	200 S/Pb	None	1	1 pass	k	--	1	1 pass
MS-27683-13 (30-gal)**	400 F/F/S/Pb	4-mil	2	2 pass	k	--	1	1 pass
	400 S/Pb	None	1	1 pass	k	--	1	1 pass
MS-27683-13 (45-gal)**	500 F/F/S/Pb	4-mil Liner	3	3 pass	k	--	2	2 pass
	F/F/S/Pb	None	--	--	k	--	1	1 pass
MS-27683-21 (85-gal)**	800 F/F/S/Pb	RTV	2	2 pass	k	--	2	2 pass

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See Table D-10.a. Free Drop Test Results for Steel Drums.
See Table D-10.b. Free Drop Test Results for Steel Drums.
See Table D-10.d. Free Drop Test Results for Steel Drums.
See Table D-10.e. Free Drop Test Results for Steel Drums.

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Table D-10.d. Free Drop Test Results for Steel Drums.

Test unit	Authorized gross weight (lb)	Weight (lb)	Test[l] contents	RTV/liner	No. tested	Orientation[m]	Results	Comments
DOT-17C (35-gal)	400	>400	S/F/F	RTV	5	Top Edge	5 pass	The only result was a minor dent at the point of impact. The largest dent was 1 1/8 in. during the drop test on the top edge.
DOT-17C (35-gal)	400	>400	S/F/F	RTV	5	Bottom Edge	5 pass	The only result was a minor dent at the point of impact. The largest dent was 1/2 in.
DOT-17C (35-gal)	400	>400	S/F/F	RTV	3	Flat on Side	3 pass	The only result was a minor dent at the point of impact. The largest dent was 3/4 in. at the top of one drum.
DOT-17C (35-	400	>400	S/F/F	RTV	1	Flat on Top and Bottom	1 pass	There was no effect.

gal)

See Table D-10.a. Free Drop Test Results for Steel Drums.
See Table D-10.b. Free Drop Test Results for Steel Drums.
See Table D-10.c. Free Drop Test Results for Steel Drums.
See Table D-10.e. Free Drop Test Results for Steel Drums.

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Table D-10.e. Free Drop Test Results for Steel Drums.

Specific packaging	No. tested	Results	Contents and weight	Drop orientation	Comments
PACKAGING SPECIALTIES SQUARE STEEL DRUMS					
Style 1A[n,o]	1	1 pass	Concrete matrix with pieces of steel F/F[p] between liner and bottom of drum F/F on top of concrete (1,370 lb)	Flat on top of the drum	Monitoring for fluorescein in each case below demonstrated "no release of contents." Decreased height ~5/16 in.
	1	1 pass	Same as above (1,370 lb--same drum)	Flat on bottom	Overall height did not change
	1	1 pass	Same as above (1,368 lb)	Flat on side edge closest to bung	1/4-in. dent, top and bottom
	1	1 pass	Same as above (1,366 lb)	Flat on side closest to bung	Rolling hoops dented 1/4 in.
	1	1 pass	Same as above (1,380 lb)	Flat on side with weld seam	Rolling hoops dented 1/4 in.
			ANGLE DROPS		
	1	1 pass	Same as above (1,356 lb)	Top corner near bung	Dent of 3 in.
	1	1 pass	Same as above (1,360 lb--same drum)	Bottom corner at weld seam	Dent of 1 3/4 in.
	1	1 pass	Same as above (1,360 lb)	Top corner at bung	Dent of 4 in.
	1	1 pass	Same as above (1,360 lb)	Bottom corner closest to weld seam	Dent of 1 3/4 in.
	1	1 pass	Same as above (1,380 lb)	Flat on top long edge nearest weld seam	Dent of 2 1/4 in.

	1	1 pass	Same as above (1,380 lb)	Flat on long edge of bottom nearest weld seam	Dent of 1 in.
	1	1 pass	Same as above (1,372 lb)	Top corner nearest weld seam	Dent of 3 1/4 in.
	1	1 pass	Same as above (1,372 lb)	Bottom corner nearest weld seam	Dent of 1 7/8 in.
	1	1 pass	Same as above (1,364 lb)	Top corner at weld seam	Dent of 3 1/2 in.
	1	1 pass	Same as above (1,364 lb)	Flat on bottom edge containing weld seam	Dent of 1 in.
Style 1B	1	1 pass	Sand and steel weight F/F on top and bottom (1,394 lb)	Top corner nearest bung	Dent of 3 1/2 in.
	1	1 pass	Same as above (1,394 lb)	Bottom corner nearest weld seam	Dent of 4 in.
	1	1 pass	Same as above (1,356 lb)	Top corner nearest bung	Dent of 3 in.
	1	1 pass	Same as above (1,356 lb)	Bottom corner nearest weld seam	Dent of 3 1/2 in.
	1	1 pass	Same as above (1,392 lb)	Top corner nearest bung	Dent of 3 1/4 in.
	1	1 pass	Same as above (1,392 lb)	Bottom corner opposite the weld seam	Dent of 3 1/2 in.
	1	1 pass	Same as above (1,390 lb)	Top corner nearest weld seam	Dent of 3 7/8 in.
	1	1 pass	Same as above (1,390 lb)	Bottom corner opposite the weld seam	Dent of 3 3/8 in.
	1	1 pass	Same as above (1,352 lb)	Flat on long edge nearest bung	Dent of 1 3/4 in.
	1	1 pass	Same as above (1,352 lb)	Flat on long edge nearest weld seam (bottom)	Dent of 2 in.
	1	1 pass	Cement with F/F[q] (1,384 lb)	Top corner nearest bung at top and bottom of drum[q]	Dent of 3 1/4 in.
	1	1 pass	Same as above (1,384 lb)	Bottom corner nearest weld seam	Dent of 2 1/4 in.
	1	1 pass	Same as above (1,368 lb)	Top corner nearest bung	Dent of 3 1/8 in.
	1	1 pass	Same as above (1,368 lb)	Bottom corner nearest weld seam	Dent of 1 7/8 in.
			SIDE DROPS		
	1	1 pass	Same as above (1,354 lb)	Flat on side - long edge nearest bung	Dent of 1 in. - top Dent of 1 in. - bottom
	1	1 pass	Same as above (1,382 lb)	Flat on side nearest bung	Dent of 0 in. - top Dent of 1/8 in. - bottom

	1	1 pass	Same as above (1,354 lb)	Flat on side with weld (nearest bung)	Dent of 0 in. - top Dent of 1/8 in. - bottom
	1	1 pass	Same as above (1,366 lb)	Flat on top	No effect
	1	1 pass	Same as above (1,366 lb)	Flat on bottom	No effect
Style 2	1	1 pass	Sand and steel weights F/F top and bottom (1,414 lb)	Top corner at lugs	Dent of 3 3/4 in.
	1	1 pass	Same as above (1,414 lb)	Bottom corner nearest weld seam	Dent of 3 5/8 in.
	1	1 pass	Same as above (1,354 lb)	Top corner nearest lugs and weld seam	Dent of 3 1/4 in.
	1	1 pass	Same drum (1,354 lb)	Bottom corner nearest weld seam	Dent of 3 1/4 in.
	1	1 pass	Same as above (1,352 lb)	Top corner nearest lugs	Dent of 3 1/2 in.
	1	1 pass	Same drum (1,352 lb)	Flat on long edge of bottom nearest weld seam	Dent of 1 1/2 in.
	1	1 pass	Same as above (1,356 lb)	Top corner nearest bung	Dent of 3 1/2 in.
	1	1 pass	Same drum (1,356 lb)	Bottom corner opposite welded seam	Dent of 3 1/4 in.
	1	1 pass	Same as above (1,354 lb)	Flat on long edge nearest lugs and weld seam	Dent of 1 1/2 in.
	1	1 pass	Same drum	Bottom corner nearest weld seams	Dent of 3 1/8 in.
	1	1 pass	Same as above (1,382 lb)	Top corner nearest lugs and weld seam	Dent of 3 in.
	1	1 pass	Same drum	Bottom corner nearest weld	Dent of 3 3/4 in.
	1	1 pass	Same as above (1,374 lb)	Top corner nearest bung and weld seam	Dent of 3 in.
	1	1 pass	Same drum	Bottom corner nearest weld seam	Dent of 3 1/4 in.
	1	1 pass	Cement with F/F at top and bottom (1,390 lb)	Top corner nearest lugs and weld seam	Dent of 1 7/8 in.
	1	1 pass	Same drum	Bottom corner nearest weld seam	Dent of 2 in.
	1	1 pass	Same as above (1,386 lb)	Top corner nearest bung	Dent of 3 in.
	1	1 pass	Same drum	Bottom corner nearest weld seam	Dent of 2 in.
			SIDE DROPS		
	1	1 pass	Sand and steel weights F/F top and bottom (1,356 lb)	Flat on long edge nearest lugs	Dent of 3/4 in. - top Dent of 3/4 in. -

					bottom
	1	1 pass	Same as above (1,358 lb)	Flat on side nearest bung	Dent of 0 in. - top Dent of 3/16 in. - bottom
	1	1 pass	Same as above (1,358 lb)	Flat on side nearest lugs, bung and weld seam	Dent of 0 in. - top Dent of 1/8 in. - bottom
			END DROP		
	1	1 pass	Same as above (1,352 lb)	Flat on top and bottom ends	No significant effect
Style 3	1	1 pass	Sand and steel weights F/F at top and bottom (1,386 lb)	Top corner nearest bung	Dent of 3 3/4 in.
	1	1 pass	Same as above	Bottom corner nearest weld seam	Dent of 4 in.
	1	1 pass	Same as above (1,386 lb)	Top corner nearest bung	Dent of 3 5/8 in.
	1	1 pass	Same as above	Bottom corner nearest weld seam	Dent of 4 1/2 in.
	1	1 pass	Same as above (1,358 lb)	Top corner nearest weld seam	Dent of 3 in.
	1	1 pass	Same as above (1,386 lb)	Top corner nearest weld seam	Dent of 3 1/2 in.
	1	1 pass	Same drum	Bottom corner opposite weld seam	Dent of 4 in.
	1	1 pass	Same as above (1,378 lb)	Flat on top long edge nearest bung and weld seam	Dent of 1 1/4 in.
	1	1 pass	Same drum	Flat on bottom long edge nearest weld seam	Dent of 1 1/2 in.
	1	1 pass	Cement with F/F at top and bottom (1,408 lb)	Top corner nearest bung and weld seam	Dent of 2 in. Dent of 2 in.
	1	1 pass	Same drum	Bottom corner nearest weld seam	Dent of 2 in.
	1	1 pass	Same as above (1,418 lb)	Top corner nearest weld seam	Dent of 2 in.
	1	1 pass	Same drum	Bottom corner nearest weld seam	Dent of 2 1/8 in.
			SIDE DROPS WITH SAND AND STEEL		
	1	1 pass	Sand and steel weights	Flat on long edge nearest to bung	Dent of 1 3/8 in. - top
			F/F at top and bottom (1,362 lb)		Dent of 1 3/8 in. - bottom
	1	1 pass	Same as above (1,388 lb)	Flat on side with weld seam	Dent of 1/2 in. - top Dent of

				3/8 in. - bottom
1	1 pass	Same as above (1,394 lb)	Flat on side with weld seam and nearest bung	Dent of 1/2 in. - top Dent of 3/8 in. - bottom
		END DROP WITH SAND AND STEEL		
1	1 pass	Same as above (1,380 lb)	Flat on top and bottom	No effect

[a]This is the authorized gross weight. In each case, the actual test weights exceeded this value.

[b]Approximately a 45° angle with the package impacting on the bolt of the bolt closure ring.

[c]Approximately a 45° angle with the package impacting on the bottom chime.

[d]Oriented so that the bolt is at the point of impact.

[e]4-ft drops flat on the top and flat on the bottom were conducted on the DOT-17H and DOT-17C 55-gal steel drums, but were not deemed necessary for other drums because of the almost total lack of effect.

[f]Flour, fluorescein, sand, and lead, as required to achieve desired weight.

[g]4-mil polyethylene bag, not the 90-mil high-density polyethylene (HDPE) liner discussed later.

[h]Sand and lead, as required to achieve desired weight.

[i]Sand, as required to achieve desired weight.

[j]Flour, fluorescein, and sand, as required to achieve desired weight.

[k]No tests were conducted because these were one-piece structures with no seals or chimes to test.

[l]Sand, flour, fluorescein and weights as needed.

[m]The top and bottom edge drops were done at about a 45° angle. The bolt was oriented at the point of impact during the side drops.

[n]After all the tests on Style 1A packagings, a hole was drilled at the point of impact to ensure the presence of F/F between the liner and the drum.

[o]After all the tests on Style 1A packagings, the bung on the top was removed to verify the presence of F/F.

[p]Flour and fluorescein mixture.

[q]Plastic sheet (4 mil) was used to separate F/F from the concrete.
*NucFil is a trademark of Nuclear Filter Technology, Inc.
**Drum assembly numbers.
AW = Argonne National Laboratory - West
DOT = U.S. Department of Transportation
FM = Feed Materials Production Center
HDPE = high-density polyethelene
HF = Hanford, Richland, Washington
LL = Lawrence Livermore National Laboratory
MD = Mound Laboratory
MS = Military specification
OR = Oak Ridge National Laboratory
RF = Rocky Flats Site
RTV = room temperature vulcanizing
-- = Not applicable.

See Table D-10.a. Free Drop Test Results for Steel Drums.
See Table D-10.b. Free Drop Test Results for Steel Drums.
See Table D-10.c. Free Drop Test Results for Steel Drums.

See Table D-10.d. Free Drop Test Results for Steel Drums.

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Table D-11.a. Free Drop Test Results for Steel Boxes.[a]

Specific packaging	Weight (lb)	Contents	Results	Comments
Capital Industries				
S-0510-0823	7,000	F/F/S[b]	Pass	Angle drop on top corner. No loss of contents or significant change in package geometry. Authorized for Form No. 1, No. 2, and No. 3 materials.
V-0510-0823	7,000	F/F/S	Pass	Angle drop on top corner. No loss of contents or significant change in package geometry. Authorized for Form No. 1, No. 2, and No. 3 materials.
S-0840-1440	22,700	F/F/S	Pass	Angle drop on top corner. No loss of contents or significant change in package geometry. Authorized for Form No. 1, No. 2, and No. 3 materials.
S-0730-1006	10,400	F/F/S	Pass	Angle drop on top corner. No loss of contents or significant change in package geometry. Authorized for Form No. 1, No. 2, and No. 3 materials.
S-0730-00846	8,700	Not tested	Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials) to packaging S-0730-1006, which was tested and evaluated. All materials and methods of construction were equal to or better than the evaluated packaging, and the authorized gross weight was 1,700 lb less than that for the evaluated packaging. Authorized for Form No. 1, No. 2, and No. 3 materials.
S-0480-0906	6,120	Not tested	Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials) to packaging S-0510-0823, which was tested and evaluated. All materials and methods

				of construction were equal to or better than the evaluated packaging, and the authorized gross weight was 820 lb less than that for the evaluated packaging. Authorized for Form No. 1, No. 2, and No. 3 materials.
S-0450-0846	5,240	Not tested	Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials) to packaging S-0510-0823, which was tested and evaluated. All materials and methods of construction were equal to or better than the evaluated packaging, and the authorized gross weight was 1,760 lb less than that for the evaluated packaging. Authorized for Form No. 1, No. 2, and No. 3 materials.
S-0240-0906	3,672	Not tested	Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials) to packaging S-0510-0823, which was tested and evaluated. All materials and methods of construction were equal to or better than the evaluated packaging, and the authorized gross weight was 3,328 lb less than that for the evaluated packaging. Authorized for Form No. 1, No. 2, and No. 3 materials.
S-0480-1376	9,295	Not tested	Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials) to packaging S-0730-1006, which was tested and evaluated. All materials and methods of construction were equal to or better than the evaluated packaging, and the authorized gross weight was 1,105 lb less than that for the evaluated packaging. Authorized for Form No. 1, No. 2, and No. 3 materials.
Container Products Corp.				
B-12-44-4-S/L FD; Drawing No. 01-3100-1-00, Rev. B	4,625	F/F/S	Pass	Angle drop on top corner. Authorized for Form No. 1, No. 2, and No. 3 materials.
B-25-4-S/L FD; Drawing No. 01-2800-1-00, Rev. C	4,820	Not tested	Pass	Evaluated by analysis and comparison to tests of B-96-5 S/L FD, which has identical lid seal characteristics. In addition, this package was tested using just

				sand with no loss of contents. Authorized for Form No. 1, No. 2, and No. 3 materials.
B-52-4-S/L FD Drawing No. 04-1000-1-00, Rev. F	4,775	Not tested	Pass	Evaluated by analysis and comparison to tests of B-96-5 S/L FD, which has identical lid seal characteristics. In addition, this package was tested using just sand with no loss of contents. Authorized for Form No. 1, No. 2, and No. 3 materials.
B-82-6-S/L FD; Drawing No. 01-2300-1-00, Rev. D	6,775	Not tested	Pass	Evaluated by analysis and comparison to tests of B-96-5 S/L FD, which has identical lid seal characteristics. In addition, this package was tested using just sand with no loss of contents. Authorized for Form No. 1, No. 2, and No. 3 materials.
B-87-6-S/L FD; Drawing No. 04-1300-1-00, Rev. B	6,970	Not tested	Pass	Evaluated by analysis and comparison to tests of B-96-5 S/L FD, which has identical lid seal characteristics. Authorized for Form No. 1, No. 2, and No. 3 materials.
B-96-6-S/L FD; Drawing No. 04-1200-1-00, Rev. O	7,000	Not tested	Pass	Evaluated by analysis and comparison to tests of B-96-8 S/L FD, which has identical lid seal design. By analysis, the six side drive clips are comparable to the eight side drive clips for the B-96-8 S/L FD considering the difference of 2,000 lb in authorized gross weight. Authorized for Form No. 1, No. 2, and No. 3 materials.
B-96-8-S/L FD; Drawing No. 04-1200-2-00, Rev. O	9,100	F/F/S	Pass	Angle drop on top corner. Authorized for Form No. 1, No. 2, and No. 3 materials.
B-96-5-S/L FD; Drawing No. 01-2101-1-00, Rev. O	6,050	F/F/S	Pass	Angle drop on top corner. Authorized for Form No. 1, No. 2, and No. 3 materials.
B-96-5-S/L RA; Drawing No. 01-1901-1-00, Rev. O	6,800	Not tested	Pass	Identical to B-96-5-S/L FD (except for strength members added to meet reduced pressure test), which was tested and passed. Authorized for Form No. 1, No. 2, and No. 3 materials.
B-96-5-RA B; Drawing No. 01-2201-1-01, Rev. O	6,500	Not tested	Pass	Identical to B-96-5-S/L FD (except there is no filter), which was tested and passed. Authorized for Form No. 1, No. 2, and No. 3 materials.
467-C-S/L FD; Drawing No. 01-3700-1-00, Rev.	4,000	Not tested	Pass	Evaluated by analysis and comparison to tests of B-96-5 S/L FD, which has identical lid seal characteristics. In

C				addition, tests have been completed using just sand with no loss of contents. Authorized for Form No. 1, No. 2, and No. 3 materials.
B-96-5 FD B; Drawing No. 01-2301-1-01, Rev. 0	6,500	F/F/S	Pass	Angle drop on top corner. Authorized for Form No. 1, No. 2, and No. 3 materials.
RoGar Chemical and Nuclear Services				
Model R-1	7,750	Not tested	Pass	Evaluated by analysis and comparison (lids, lid reinforcing angle, bolt size, bolt spacing, container flange, materials of construction, etc.) to Model R-3. All materials and methods of construction were equal to or better than the test packaging, the dimensions were substantially less, and the authorized gross weight was 170 lb less than that for the test packaging.
Model R-2	7,820	Not tested	Pass	Evaluated by analysis and comparison (lids, lid reinforcing angle, bolt size, bolt spacing, container flange, materials of construction, etc.) to Model R-3. All materials and methods of construction were equal to or better than the test packaging, the dimensions were substantially less, and the authorized gross weight was 100 lb less than that for the test packaging.
Model R-3	7,920	F/F/S	Pass	This package was dropped 4 ft on a top (lid) corner. There was no loss of contents or significant change in package geometry. Authorized for Form No. 1, No. 2, and No. 3 materials.
Model R-4	7,920	Not tested	Pass	Evaluated by analysis and comparison (lids, lid reinforcing angle, bolt size, bolt spacing, container flange, materials of construction, etc.) to Model R-3. All materials and methods of construction were equal to or better than the test packaging, the dimensions were substantially less, and the gross weight remained the same.
Rocky Flats SAND Box				
Style 1	7,000	Gravel and water	Pass	A number of tests were conducted at different orientations (45° on top, 45° on bottom, etc.) for each packaging. After

				each test, the packagings were successfully air-leak tested to 0.5 psi. The use of water and gravel was more conservative than the use of flour and fluorescein to simulate the contents. Authorized for Form No. 1, No. 2, and No. 3 materials.
Style 2	6,000	Gravel and water	Pass	A number of tests were conducted at different orientations (45° on top, 45° on bottom, etc.) for each packaging. After each test, the packagings were successfully air-leak tested to 0.5 psi. The use of water and gravel was more conservative than the use of flour and fluorescein to simulate the contents. Authorized for Form No. 1, No. 2, and No. 3 materials.
Style 3	6,000	Gravel and water	Pass	A number of tests were conducted at different orientations (45° on top, 45° on bottom, etc.) for each packaging. After each test, the packagings were successfully air-leak tested to 0.5 psi. The use of water and gravel was more conservative than the use of flour and fluorescein to simulate the contents. Authorized for Form No. 1, No. 2 and No. 3 materials.
Style 4	6,000	Gravel and water	Pass	A number of tests were conducted at different orientations (45° on top, 45° on bottom, etc.) for each packaging. After each test, the packagings were successfully air-leak tested to 0.5 psi. The use of water and gravel was more conservative than the use of flour and fluorescein to simulate the contents. Authorized for Form No. 1, No. 2 and No. 3 materials.
Argonne M-4 Bin	3,000[c]	Four 55-gal drums filled with sand, two 5-gal pails, and approx. 300 lb of loose sand.	Pass	Dropped on one of the bottom corners. Previous analysis had shown this orientation to be most vulnerable to damage. After the drop the bin was filled with 24 in. of water, 18 in. above the damage area. The bin was leak-tight. Authorized for Forms No. 1, No. 2, and No. 3 materials.
ANL-W				
7A-960	960	Solid pieces of lead	Pass	Dropped on top corner of lid. There was no loss of contents and no significant pathways created by which contents could escape. Authorized only for Form No. 3 materials.
ORNL Low-Level Waste Container [Docket 89-04-7A]				

Vented	8,150	Misc. Debris F/F/S	Pass	Test unit package no. 7V-90-0003 was subjected to four different 4-ft drop tests in different orientations and passed.
Nonvented	10,230	Misc. Debris F/F/S	Pass	Test unit package no. 7NV-90-0003 was subjected to three different 4-ft drop tests in different orientations and passed.
See Table D-11.b. Free Drop Test Results for Steel Boxes.[a]				

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Table D-11.b. Free Drop Test Results for Steel Boxes.[a]

FOUR-FT FREE DROP TEST RESULTS FOR TRUPACT-II STANDARD WASTE BOX (SWB)[d]

Test unit	Authorized gross weight (lb)	Test weight (lb)	Contents	Form	No. tested	Orientation	Results	Comments
TU-1A	4,000	4,040	F/F/S	1 & 2	1	Top corner	1 pass	The only result was a minor dent at the point of impact. The largest dent was 1/2 in. during the drop test on the bottom corner.
TU-1B	4,000	4,100	F/F/S	1 & 2	2[e]	Bottom corner	2 pass	Dent of 4 in.
TU-2	4,000	4,092	Debris[f]	3 & 4	1	Flat on end	1 pass	The only results were minor dents on the end surface.
TU-3B	4,000	4,100	Four loaded steel drums[g]	5	1	Top corner	1 pass	The only results were minor dents at the point of impact due to the drums.
TU-3B(1B)[h]	4,000	4,100	Four loaded steel drums[g]	5	1	Top corner	1 pass	Same as above.

[a]General Comments: The primary drop orientation was inverting the box (lid down) with a corner as the point of impact. When filters were used, they were typically placed in an end, and the corner chosen for the

impact point was the corner closest to the filter location.

[b]Flour, fluorescein, and sand.

[c]The authorized gross weight is 3,000 lb; however, the actual gross weight for testing was 3,215 lb.

[d]General Comments: These drops were conducted on top corners, bottom corners, and flat on the end of the box. In each case there was no loss of contents and the box is authorized for the contents as specified in this table. The water spray test was conducted prior to the free drop test for TU-1, and the packaging was allowed to set for 2 hr prior to the drop test.

[e]Same packaging was dropped twice.

[f]Debris represents motors, pipes, steel plates, concrete blocks, etc. which would represent Form No. 3. To provide Form No. 1 contents, F/F was added. The pass/fail criteria then becomes no release of F/F.

[g]F/F was placed on top of the drums.

[h]Test Unit 1B was emptied and refilled with Form No. 5 contents.
ANL-W = Argonne National Laboratory - West
ORNL = Oak Ridge National Laboratory.

See Table D-11.a. Free Drop Test Results for Steel Boxes.[a]

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Table D-12. Free Drop Test Results for ANL and LLNL Wooden Boxes.

Specific packaging	Weight (lb)	Contents	Results	Comments
ANL-W				
7A-217	217	Solid materials simulating Form No. 3 materials were used for all tests.	Pass	Packagings were dropped on a top corner, which included the lid. In all cases the packaging met the requirements for Form No. 3 materials. Authorized only for Form No. 3 materials.
7A-375	375			
7A-880	880			
7A-995	995			
7A-1315	1,315			
7A-670	670	55-gal drum filled with soil placed inside the wooden box.	Pass	Packaging was dropped on a top corner, which included the lid. In all cases, the packaging met the requirement for Form No. 3 materials. Authorized only for Form No. 3 materials.
LLNL				
Flush Panel	2,500	Drysorb 75% by weight; Microsel-E 25% by weight	Pass	Packaging was dropped on a top corner, which included the lid. There was no release of contents and the packaging was authorized for Form No. 2 and No. 3 materials.

ANL-W = Argonne National Laboratory - West
LLNL = Lawrence Livermore National Laboratory.

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Table D-13.a. Free Drop Test Results for Wooden Boxes.[a]

Specific packaging	Weight (lb)	Contents	No. tested	Results	Comments
Mound Wooden Boxes - Configuration A					
MA-1	40	S/Pb[b]	2	2 pass	Authorized only for Form No. 2 and No. 3 materials
MA-2	100	S/Pb	2	2 pass	
MA-3	100	S/Pb	1	1 pass	
		F/F/S/Pb[c]	1	1 pass	
MA-4	100	S/Pb	1	1 pass	
		F/F/S/Pb	1	1 pass	
Mound Wooden Boxes - Configuration B					
MB-1	150	F/F/S/Pb	2	2 pass	Authorized only for Form No. 2 and No. 3 materials
MB-2	150	F/F/S/Pb	2	2 pass	
MB-3	200	F/F/S/Pb	2	2 pass	
MB-4	150	F/F/S/Pb	2	2 pass	
MB-5	150	F/F/S/Pb	2	2 pass	
MB-6	200	F/F/S/Pb	1	1 pass	
Mound Wooden Boxes - Configuration C					
MC-1	150	F/F/S/Pb	1	1 pass	Authorized only for Form No. 2 and No. 3 materials
		S	1	1 pass	
MC-2	300	F/F/S/Pb	1	1 pass	
		S/Pb	1	1 pass	
MC-3	250	F/F/S/Pb	1	1 pass	
		S/Pb	1	1 pass	
MC-4	100	F/F/S/Pb	1	1 pass	

		S	1	1 pass	
MC-5	150	F/F/S	1	1 pass	
Mound Wooden Boxes - Configuration D					
MD-1	200	F/F/S/Pb	2	2 pass	Authorized only for Form No. 2 and No. 3 materials
MD-2	300	F/F/S/Pb	1	1 pass	
MD-3	250	F/F/S	2	2 pass	
MD-4	250	F/F/S	2	2 pass	
MD-5	200	F/F/S/Pb	2	2 pass	
MD-6	200	F/F/S/Pb	2	2 pass	
Mound Wooden Boxes - Configuration E					
ME-1	150	S	1	1 pass	Authorized only for Form No. 2 and No. 3 materials
ME-2	150	S	2	2 pass	
ME-3	150	F/F/S	1	1 pass	
Y-12 B-Series Wooden Boxes					
B-1	400	S/Pb	2	2 pass	Authorized only for Form No. 3 materials
B-2	400	S/Pb	2	2 pass	
B-3	400	S/Pb	2	2 pass	
B-4	400	S/Pb	2	2 pass	
B-5	400	S/Pb	2	2 pass	
B-6	400	S/Pb	2	2 pass	
B-7	400	S/Pb	2	2 pass	
B-8	400	S/Pb	2	2 pass	
Y-12 Picture Frame Wooden Boxes					
PF-1	500	S/Pb	1	1 pass	Authorized only for Form No. 3 materials
PF-2	750	Pb	2	2 pass	
PF-3	1,000	Pb	2	2 pass	
PF-4	500	Pb	2	2 pass	
PF-5	750	S/Pb	2	2 pass	
PF-6	1,000	Pb	2	2 pass	
PF-7	750	Pb	2	2 pass	

PF-8	1,000	Pb	2	2 pass	
PF-10	2,500	S/Pb	1	1 pass	
Rocky Flats RA Series					
Configuration 1	900	Solid material	1	1 pass	Authorized only for Form No. 3 materials
Configuration 2	1,250	Solid material	1	1 pass	
ORNL Y-12 Series					**Docket 89-01-7A**
C-1	1,190	Concrete block	1	1 pass	Authorized only for Form No. 3 materials
	1,181	Concrete cyl.	1	1 pass	Authorized only for Form No. 3 materials
C-2	1,804	Concrete block	1	1 pass	Authorized only for Form No. 3 materials
	1,735	Concrete cyl. and lead	1	1 pass	Authorized only for Form No. 3 materials
C-3	2,326	Concrete block	1	1 pass	Authorized only for Form No. 3 materials
	2,260	Concrete cyl. and lead	1	1 pass	Authorized only for Form No. 3 materials
Note: Drop information for the ORNL Y-12 Series containers is continued in Table D-13.b. **See Table D-13.b. Free Drop Test Results for Wooden Boxes**.[a]					

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Table D-13.b. Free Drop Test Results for Wooden Boxes.[a]

Specific packaging	Weight (lb)	Contents	No. tested	Orientation	Results	Comments
ORNL Y-12 Series (cont.)						
C-280 (1) (3/8-in. bands)	>280	S/Pb	1	Top corner	Pass	Authorized only for Form No. 3 materials
C-280 (2) (3/8-in. bands)	>280	S/Pb	1	Bottom corner	Pass	Authorized only for Form No. 3 materials
C-400 (1) (3/4-in. bands)	>400	S/Pb	1	Top corner	Pass	Authorized only for Form No. 3 materials
C-400 (2) (3/4-in. bands)	>400	S/Pb	1	Bottom corner	Pass	Authorized only for Form No. 3 materials
C-600 (2) (3/4-in. bands)	606	S/Pb	1	Bottom corner	Pass	Authorized only for Form No. 3 materials
C-600 (2) (3/4-in. bands)	606	S/Pb	1	Top corner	Pass	Authorized only for Form No. 3 materials
C-600 (1) (3/4-in. bands)	608	S/Pb	1	Top corner	Pass	Authorized only for Form No. 3 materials
C-600 (1) (3/4-in. bands)	608	S/Pb	1	Bottom corner	Pass	Authorized only for Form No. 3 materials
C-1000 (1) (3/4-in. bands)	1,004	S/Pb	1	Top corner	Pass	Authorized only for Form No. 3 materials
C-1000 (1) (3/4-in. bands)	1,004	S/Pb	1	Bottom corner	Pass	Authorized only for Form No. 3 materials

C-1000 (2) (3/4-in. bands)	1,008	S/Pb	1	Top corner	Pass	Authorized only for Form No. 3 materials
C-1000 (2) (3/4-in. bands)	1,008	S/Pb	1	Bottom corner	Pass	Authorized only for Form No. 3 materials

[a]General Comments: All drops were conducted on a top corner of the lid. There was no loss of contents and the packagings were authorized for Form No. 2 and No. 3 materials.

[b]Sand and lead.

[c]Flour, fluorescein, sand, and lead.
ORNL = Oak Ridge National Laboratory.

See Table D-13.a. Free Drop Test Results for Wooden Boxes.[a] (3 pages)

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Table D-14. Free Drop Test Results for NLO Family of Banded Wooden Boxes.[a]

Specific packaging	Weight (lb)	Results	Orientation	Comments
G-4214	1,805	Pass	All drops were conducted on a top corner of lid. In several instances these packagings survived drops of 30 ft (7.5 times the prescribed distance) with no release of contents.	Authorized only for Form No. 3 materials.
G-4245	250	Pass		
G-4255	1,500	Pass		
G-4273	3,250	Pass		
G-4292	852	Pass		
WMCO Banded Wooden Boxes				
G-4214-1A	1,264	Pass	Drop on top corner of lid and opposite bottom corner. Both at ~45°	Authorized only for Form No. 3 materials. [Docket 89-09-7A]
G-4214-1B	1,256	Pass	Drop on top corner of lid at 45° and flat on opposite end	
G-4245-3A	225	Pass	Drop on top corner of lid and opposite bottom corner. Both at ~45°	
G-4245-3B	201	Pass	Drop on top corner of lid at 45° and flat on opposite end	
G-4255-4A	1,448	Pass	Drop on lid top corner at 45°	
G-4255-4B	1,474	Pass	Drop on bottom corner at 45°	
G-4273-5A	3,035	Pass	Drop on lid top corner at 45°	
G-4273-5B	2,960	Pass	Drop on bottom corner at 45°	
G-4273-6A	3,646	Pass	Drop on bottom corner at 45°	
G-4273-6B	3,649	Pass	Drop on top corner at 45°	

G-4292-2A	1,334	Pass	Drop on lid top corner at 45°	
G-4292-2B	1,331	Pass	Drop on bottom corner at 45°	
[a]General Comments: All drops were conducted on a top corner of the lid. There was no loss of contents and the packagings were authorized for Form No. 3 materials. WMCO = Westinghouse Materials Company of Ohio.				

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Table D-15. Free Drop Test Results for Fiberboard Boxes.[a]

Specific packaging	Weight (lb)	Contents	No. tested	Results	Comments
12B-65 Fiberboard Boxes					
1	65	Pb[b]	2	2 pass	Authorized only for Form No. 3 materials.
2	65	Pb	3	3 pass	
3	65	Pb	1	1 pass	
4	65	S[c]	2	2 pass	
5	65	S	2	2 pass	Authorized only for Form No. 3 materials.
6	65	S	1	1 pass	
7	65	S	2	2 pass	
8	65	S	2	2 pass	
9	65	S	2	2 pass	
10	65	S	2	2 pass	
11	65	S	1	1 pass	
12	65	S	2	2 pass	
13	65	S	2	2 pass	
LLNL 12B-10 with inner metal can[d]	10	Inner metal can filled with rocks	3	3 pass	Authorized for Form No. 1, No. 2, and No. 3 materials. Inner can was air-leak tested after each test.
Tri-Wall Fiberboard Box	350	Sand in plastic bags	2	2 pass	Authorized only for Form No. 3 materials.

[a]General Comments: All drops were conducted on a top corner of the lid. There was no loss of contents and the packagings were authorized for Form No. 3 materials.
[b]Lead
[c]Sand
[d]The inner metal can was removed after each test and leak checked in a bell jar under water.
LLNL = Lawrence Livermore National Laboratory.

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Table D-16. Free Drop Test Results for DOT-21C Fiberboard Drums.

Specific packaging	Weight kg (lb)	Contents	45° Top		45° Bottom		Side		Comments
			No. tested	Results	No. tested	Results	No. tested	Results	
1	52.21 (115)	F/F/S[a]	1	1 pass	1	1 pass	1	1 pass	Authorized only for Form No. 3 materials.[c]
2	52.21 (115)	F/F/S/Pb[b]	1	1 pass	1	1 pass	1	1 pass	
3	52.21 (115)	F/F/S	1	1 pass	1	1 pass	1	1 pass	
4	52.21 (115)	F/F/S/Pb	1	1 pass	1	1 pass	1	1 pass	
5	52.21 (115)	F/F/S	1	1 pass	1	1 pass	1	1 pass	
6	52.21 (115)	F/F/S	1	1 pass	1	1 pass	1	1 pass	

[a]Flour, fluorescein, and sand.

[b]Flour, fluorescein, sand, and lead.

[c]Even though these packagings passed the drop test without release of the flour and fluorescein, they were authorized only for Form No. 3 materials because their performance in the penetration test was sporadic.

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Table D-17. Free Drop Test Results for UF_6 Cylinders.				
Specific packaging	**Weight kg (lb)**		**Orientation**	**Comments**
1S	0.9	(2)	This category of packagings was evaluated based on numerous drop tests conducted on Models 5A, 8A, 12B, 30B, and 48X cylinders. These tests included the 1.2-m (4-ft) drop (side and angle), the much more severe 9-m (30-ft) drop (side and angle), and the 1.2-m (4-ft) drop onto the bar (puncture test). In all of these tests, there was no loss of contents. When analyses were performed, data such as materials of construction, dimensions, authorized gross weight, and effects of testing were used to verify that the cylinders not tested meet the Specification 7A requirements.	These packagings are authorized for Form No. 1, No. 2, and No. 3 materials (recognizing that Form No. 2 and No. 3 are not really appropriate).
2S	4.3	(9.5)		
5A	50	(110)		
8A	170	(375)		
12A	293	(645)		
12B	295	(650)		
30A	2,883	(6,350)		
30B	2,915	(6,420)		
48G	13,892	(30,600)		
48H	13,688	(30,150)		
48HX	13,688	(30,150)		
48X	11,591	(25,530)		
48Y	14,873	(32,760)		
Modified				
5A	50	(110)	Four test units were subjected to 1.2-m (4-ft) drop tests with different orientations with no adverse affects.	Docket 89-08-7A
5B				

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Table D-18.a. Additional Free Drop Test Results for Liquid and Gas Packagings.

Specific packaging	Weight kg (lb)	Contents	Results/Comments
Steel Drum MS-24347-7	2.7 (6)	Water	Top (45°): No. tested - 3; Results - 3 pass Flat on Top: No. tested - 1; Results - 1 pass Bottom (45°): No. tested - 3; Results - 3 pass Side: No. tested - 2; Results - 2 pass Three 9-m (30-ft) drops were done consecutively on the same package. The inner containment vessel (glass bottle) was removed and inverted for 10 min to determine if there had been any loss of contents. After nine 9-m (30-ft) drops, there was no evidence of leakage, and the package was evaluated as meeting all requirements.
LANL 12B-62 Fiberboard Box	28 (62)	Water	One 9-m (30-ft) drop was done on this packaging. The impact point was a top corner (package was inverted). After completion of the test, the inner containment vessel (glass ampule) was removed and inverted for 10 min to determine if there had been any loss of contents. There was no loss of contents. In addition, after an additional 9-m (30-ft) drop, the 5.08-cm- (2-in-) diameter inner shield container with the threaded cap and O-ring seal was air-leak tested and passed. Thus, this packaging meets all requirements with any appropriate inner containment.
LANL Steel Drums with Gas Cylinders			A 9-m (30-ft) drop test was conducted on both configurations. After each drop test, it was determined that there had been no loss of contents (by comparison of pre-test pressure to post-test pressure) from any of the seven test cylinders. Thus, there was no loss of contents, and this package meets all requirements.
3A 1800	31 (68)	Air	
3E 1800	27 (60)	Air	
LANL-2	225 (495)		Top (45°): No. tested - 3; Results - 3 pass Three 9-m (30-ft) drops were conducted using the same inner container (Fenton Hill Pig) and the same Celotex[a] disks placed in new 17C 208-L (55-gal) steel drums. The drops orientations were all on the top, at approximately a 45° angle and positioned so that the bolt of the bolt closure ring was at the point of impact.

Drop	Maximum	Effect on	Movement of

	No.	dent cm (in.)	lid	inner container	Results/Comments
	1	10.16 (4)	Separated on sides away from impact point	Minimal [<2.54 cm (<1 in.)]	After each drop test the inner container was removed, the cover taken off, and the container inverted over paper for at least 10 min, looking for evidence of leakage. None was found. All pass.
	2	12.06 (4.75)	Same as above	Same as above	
	3	10.16 (4)	Same as above	Same as above	
ORNL Fiberboard Box (Liquids and Solids)	15 (33)	Water	A 9-m (30-ft) drop test was conducted on this packaging. The impact was on the bottom edge of the cardboard box. There was no evidence of loss of contents, and this packaging meets all requirements.		
ORNL Fiberboard Box (Gases)	15 (33)	Water	A 9-m (30-ft) drop test was conducted on this packaging. The impact was on the bottom edge of the cardboard box. There was no evidence of loss of contents, and this packaging meets all requirements.		

Specific packaging	Weight kg (lb)	Contents	Results/Comments
ORNL Fiberboard Box (Liquids and Solids with Shielding)	15 (33)	Water	A 9-m (30-ft) drop test was conducted on this packaging. The impact was on the bottom edge of the cardboard box. There was no evidence of loss of contents, and this packaging meets all requirements.
ORNL Wooden Box (Returnable, Shielded)	96 (212)	Water	Two 9-m (30-ft) drops were conducted: one with the entire packaging assembly and one with just the stainless steel clad lead shield by itself (without the wooden box). The second drop indicated that this inner assembly could withstand the 9-m (30-ft) drop test by itself. After both tests, the glass inner container was removed and examined. There was no loss of contents (leakage of water), and this packaging meets all requirements.
ORNL Gas Cylinder Returnable (Hoke Cylinders)			
HOH-50	4.1 (9)		Nine-m (30-ft) drop tests were conducted on the 1,000-ml (34-oz) (not currently used) and 500-ml (17 oz) gas shipping cylinders. The test packages were dropped with the valve cover down. There was no loss of contents, and these packagings meet this requirement. These two tests subjected the packaging to maximum stress, so, after consideration of material of construction, thickness of materials, package weights, etc., the analysis demonstrated that all listed packagings meet all requirements.
HOXe-50	6.8 (15)		
HOKr-50	6.8 (15)		
HOH-150	5.0 (11)		
HOXe-1150	15.9 (35)		
HOKr-150	15.9 (35)		
HOH-300	5.5 (12)		
HOKr-300	16.3 (36)		

HOH-500	6.8 (15)		
HOKr-500	23 (50)		
ORNL Gas Cylinder Returnable (J. L. Shephard)			
Cylinder 1	11 (24)		A 9-m (30-ft) drop test was conducted on a J. L. Shephard Model 394-500-L gas shipping cylinder. The cylinder landed on its top. Helium leak testing before and after the testing demonstrated that there was no loss of contents, and this packaging meets this requirement. Because this packaging would be subject to the greatest stress, all smaller packagings also meet all requirements.
Cylinder 2	18 (40)		
Cylinder 3	27 (60)		
WHC Liquid Sample Packaging	21 (46.75)	Saturated salt water, colored water	The package was subjected to 9-m (30-ft) drops. Two drop orientations were used: (1) package oriented to strike on the side, and (2) package oriented with the center of gravity over top rim positioned to strike on the closure bolt area.
	20 (43.25)	Saturated salt water, colored water	The damage observed from the drop for orientation was (1) the side of the package flattened approximately 0.635 cm (0.25 in.) for orientation and (2) the rim and drum edge were pushed down 3.175 cm (1.25 in.). In both cases, the packaging passed the test.
SRP Process Water Sample Packaging	54 (118)	Water	The package was subjected to 1.2-m (4-ft) and 9-m (30-ft) drop tests with varying orientations. In all cases, the packaging passed the tests.
RF Container Model LWS-1	5.5 (12)	Fluorescent penetrant	The package was subjected to 1.2-m (4-ft) and 9-m (30-ft) drops. Three drop orientations were used: (1) package oriented with the center of gravity over top rim positioned to strike on the closure bolt area, (2) package oriented to drop directly onto the bottom, and (3) package oriented to drop flat on the side. The damage observed from the drop for orientation was (1) the rim being driven inward about 2.54 cm (1 in.), (2) the bottom rim was driven up even with the bottom of the drum, and (3) the side of the packaging was flattened along the height of the drum side and was pushed in about 2.54 cm (1 in.) from the original position. In all three cases, the packaging passed the test. The inner packaging moves within the space provided in the foam. The movement could influence the radiation readings.

See Table D-18.b. 9-m (30-ft) Additional Drop Test Results for Liquid and Gas Packagings.
See Table D-18.c. 9-m (30-ft) Free Drop Test Results for Liquid and Gas Packagings.

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Table D-18.b. Additional Drop Test Results for Liquid and Gas Packagings.

Specific Packaging	Weight kg (lb)	Contents	Results/Comments
EG&G Mound Applied Technologies Commercial Tritium Packaging			
	4.67 (10.29)	Air	See specific drop test information listed below. In one instance [500 cc (3.17 lb)], there was movement of th inner cylinder of 3.81 cm (1 1/2 in.), and the maximum dent in the outer packaging was 1.27 cm (1/2 in.). In all cases, the packaging passed the tests.
	4.84 (10.66)	Air	
	5.13 (11.29)	Air	
	5.37 (11.83)	Air	
	5.78 (12.72)	Air	

Packaging/cylinder	Number of drops	Orientation	Results	Comments
Case and 10 cc (0.74 lb)	1	End - top of cylinder	Pass	Package split about 5.08 cm (2 in.) from top front corner, 7.62-cm (3-in.) length [note final 500-cc (3.17-lb) drop test].
Case and 50 cc (1.11 lb)	2	45° on back top left cylinder	Pass	Pushed corner in 0.317 cm (1/8 in.)
	1	End drop on top of cylinder	Pass	No visible damage
	2	45° on front Right corner (whole)	Pass	No visible damage, but one latch came loose[b]
Case and 150 cc (1.74 lb)	1	45° on top back right corner	Pass	No visible damage, but one latch came loose
	2	45° on top back left corner	Pass	No visible damage
	3	Side at latches	Pass	No visible damage, but both latches came loose
	4	Flat on top	Pass	No visible damage, but both latches came loose
Case and 300 cc (2.28 lb)	1	Flat on top	Pass	Both latches came loose, but no other visible effect
	2	Side at hinge	Pass	No visible damage
Case and 500 cc (3.17 lb)	1	Flat on bottom	Pass	No visible damage, but one latch came loose

	2	45° on bottom front right corner	Pass	Pushed corner in 1.27 cm (1/2 in.)
	3	End at top of cylinder	Pass	No visible damage[c]

Specific Packaging	Weight kg (lb)	Contents	Results/Comments
WHC Grout Sample Packaging			
	178 (391)	Water, lead shot, fluorescent penetrant	Three drop orientations were used: (1) package oriented to drop flat on the bottom, (2) package oriented to drop flat on the top, (3) package oriented to drop flat on the side with bolt down. The damage observed from the drop for each orientation from 9 m (30 ft) was as follows: (1) overall height compressed from 109.22 cm (43 in.) to 106.997 cm (42 1/8 in.), (2) overall height compressed to 106.36 cm (41 7/8 in.), and (3) the side of the packaging was flattened along the height of the drum side and was pushed in about 3.969 cm (1 9/16 in.) from the original position. In all three cases, the packaging passed the test.
EG&G Mound Lewis Gas Packaging			
	9.49 (20.875)	Air	See specific test information listed below. There was no loss of contents after any of these test, and the packaging passed the test.

Packaging/cylinder	Number of drops	Orientation	Results	Comments
Package #1	1	45° angle on bolt closure	Pass[d]	Dent of approximately 2.54 cm (1 in.) at point of impact
Package #2	1	45° angle on bolt closure	Pass	Dent of approximately 2.858 cm (1 1/8 in.) at point of impact
Package #3	2	Flat on side (bolt at point of impact)	Pass	Dent of approximately 2.54 cm (1 in.) at point of impact

Specific Packaging	Weight kg (lb)	Contents	Results/Comments
WHC Hedgehog Container			
30 mL version	28.6 (63)	steel shot, water, and fluorescein	Although damage to the internal foam on the case lid resulted in crevices of varying depth and slight shifting of the foam pieces, there was no significant movement of the SafeSend[e] container within the cavity area of the Hardigg Case.[f] See specific test information listed below for both versions. Packaging passed test.
1-L version	18.1 (40)		

	Number of

	drops	Orientation	Results	Comments
39-TU-01 (30-mL)	1	Flat onto lid of packaging	Pass	Internal foam on the lid of the Hardigg Case received a crevice 1.19-cm (0.47-in.) and 1.42-cm (0.558-in.) deep from the impact of the top and bottom of SafeSend. The foam located in the internal cavity shifted outward, away from the cavity 1.10 cm (0.435 in.) and 1.89 cm (0.745 in.). No further damage.
39-TU-01 (30-mL)	1	Impact top corner of lid, latch side, CG (45° angle)	Pass	Although damage to the internal foam on the case lid resulted in crevices of varying depth, and slight shifting of the foam pieces, there was no significant movement of the SafeSend container within the cavity area of the Hardigg Case. The external, impacted corner of the Hardigg Case indented 3.81 to 3.96 cm (1.5 to 1.562 in.). The case pushed outward, near the indented area 1.27 cm (0.5 in.). Internal foam on the lid of the case received a crevice 1.46-cm (0.575-in.) and 1.35-cm (0.532-in.) deep from the impact of the top and bottom of the SafeSend. The maximum compressed area on the lid foam, from the impact of the SafeSend, measured 0.70 cm (0.275 in.). No further damage.
39-TU-01 (30-mL)	1	Flat onto top of packaging	Pass	Although damage to the internal foam on the case lid resulted in crevices of varying depth and slight shifting of the foam pieces, there was no significant movement of the SafeSend container within the cavity area of the Hardigg Case. The top, center foam piece of the Hardigg Case cavity shifted upward at each end, a distance o 0.64 cm (0.25 in.) and 1.27 cm (0.50 in.) on the left and right sides. The wooden spacer bent 0.16 cm (0.063 in.) around the top of and touching the SafeSend container. This spacer could not be used during further testing. No further damage resulted.
39-TU-01 (30-mL)	1	Flat onto bottom of packaging	Pass	The ABS load spacer was bent 0.54 cm (0.25 in.) in two locations around the bottom of the SafeSend container. No further damage resulted.

39-TU-03 (1-L)	1	Flat onto the lid of the packaging	Pass	No damage resulted. No leakage or discharge of contents from internal bottle.
39-TU-03 (1-L)	2	Flat onto top of packaging	Pass	Although damage to the internal foam on the case lid resulted in crevices of varying depth and slight shifting of the foam pieces, there was no significant movement of the SafeSend container within the cavity area of the Hardigg Case. During the first drop, a slight discharge of simulated contents was noted around the bottle lid (about eight drops). A few drops of water and fluorescein was indicated on the foam spacer closest to the lid. No damage resulted. There was no loss of material from the package. The SafeSend and internal bottle were changed out, and the packaging was dropped a second time at this orientation. Slight discharge (about five drops) was indicated around the bottle lid. A few drops of water and fluorescein were indicated on the foam spacer closest to the bottle lid. No damage resulted. There was no loss of material from the package.
39-TU-03 (1-L)	1	Flat onto bottom of packaging	Pass	Although damage to the internal foam on the case lid resulted in crevices of varying depth and slight shifting of the foam pieces, there was no significant movement of the SafeSend container within the cavity area of the Hardigg Case. No damage resulted. No leakage or discharge of contents from internal bottle.

See Table D-18.a. Additional Free Drop Test Results for Liquid and Gas Packagings.
See Table D-18.c. 9-m (30-ft) Free Drop Test Results for Liquid and Gas Packagings.

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Table D-18.c. Additional Free Drop Test Results for Liquid and Gas Packagings.

Specific Packaging	Weight g (lb)	Contents	Results/Comments
WHC 1-L Liquid Shipper			
	3830.5 (8.4)	Steel shot, water, and fluorescein	See specific drop test information listed below. [Docket 95-41-7A] Two different 1-L bottle types were initially tested. The narrow-mouthed Teflon[g] FEP bottle with Tefzel[h] ETFE lid performed successfully, and the packaging passed using this specific bottle type. The wide-mouthed FLPE bottle with a PP lid leaked as a result of drop testing in certain orientations. When this bottle was used in certain orientations, the SafeSend canister lid pushed outward a distance of 0.3175-cm (0.125-in), or the bottle leaked. This bottle is not to be used. **NOTE: 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.**

	Number of drops	Orientation	Results	Comments
WHC 1-L Liquid Shipper (cont.)				
41-TU-01	1	Flat onto lid of packaging	Pass	Narrow-mouthed bottle used. Slight amount of fluorescent dye evident within inner bottle lid threads. No shifting of contents, leakage, or damage noted.
41-TU-02	1	Impact top corner of lid at locking mechanism, CG (25° angle)	Pass	Narrow-mouthed bottle used. Minor damage occurred to the SafeSend. No shifting of contents or leakage noted.

41-TU-03	1	Flat onto bottom of packaging	Pass	Narrow-mouthed bottle used. Inner absorbent material on SafeSend lid pushed outward 2.54-cm (1.0-in), and inner bottle had indented slightly along the area impacted. No shifting of contents or leakage noted.
41-TU-04	1	Impact bottom corner of packaging, CG (25° angle)	Pass	Narrow-mouthed bottle used. Slight dimpling measuring 3.175-cm (1.25-in) across the base of the SafeSend, and inner bottle had indented slightly along the area impacted. No shifting of contents or leakage noted.
41-TU-05	1	Flat onto side of packaging at locking mechanism	Pass	Narrow-mouthed bottle used. Minor damage occurred to the SafeSend. Slight amount of fluorescent dye evident within inner bottle lid threads. No shifting of contents or leakage noted.
41-TU-06	1	Flat onto lid of packaging	Marginal	Wide-mouth bottle used. Due to shifting of the internal bottle, the SafeSend lid pushed outward a distance of 0.3175-cm (0.125-in). Compression of the SafeSend lid handhold area was noted. No leakage noted.
41-TU-07	1	Impact top corner of lid at locking mechanism, CG (25° angle)	Marginal	Wide-mouth bottle used. Due to shifting of the internal bottle, the SafeSend lid pushed outward a distance of 0.3175-cm (0.125-in). Compression of the SafeSend lid handhold area was noted. Slight amount of fluorescent dye noted in the inner bottle lid threads. No leakage noted.
41-TU-08	1	Flat onto bottom of packaging	Pass	Wide-mouth bottle used. Slight amount of fluorescent dye noted in the inner bottle lid threads. No shifting of contents, damage, or leakage noted.
41-TU-09	1	Impact bottom corner of packaging, CG (25° angle)	Pass	Wide-mouth bottle used. SafeSend sidewall dented 13.97-cm (5.50-in) across, and the base dented 11.43-cm (4.50-in) across. Slight amount of fluorescent dye noted in the inner bottle lid threads. No shifting of contents or leakage noted.
41-TU-10	1	Flat onto side of packaging at locking mechanism	Fail	Wide-mouthed bottle used. No shifting of contents or damage noted; however, inner bottle leaked.
41-TU-12	1	Flat onto side of packaging at locking mechanism	Bad Drop	Wide-mouthed bottle used. Packaging impacted at slight angle and not flat. The sidewall of the SafeSend dented 12.7-cm (5.0-in) across, and the base dented 12.06-cm (4.75-in) across. No shifting of contents or leakage.
41-TU-18	1	Flat onto side of packaging	Fail	Wide-mouthed bottle used. No shifting of

		at locking mechanism		contents or damage noted; however, inner bottle leaked.
41-TU-19	1	Flat onto side of packaging at locking mechanism	Pass	Narrow-mouthed bottle used. Slight amount of fluorescent dye noted in the inner bottle lid threads. No shifting of contents or leakage noted.

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[a]Celotex is a trademark of the Celotex Corporation.

[b]Package remained closed because a bolt is required on one side of the handle.

[c]At the end of the 500-cc (3.17-lb) package tests, the cylinder had moved 3.81 cm (1 1/2 in.).

[d]Determined by comparing the pressure after the test with the measured pressure before the test. In each case, the measurement was made for 20 minutes. In each instance there was no decrease in pressure or any other indication of a leak. Also, for package No. 3, after two 9-m (30-ft) drops had been made on the same packaging, the inner gas container was placed under water for 2 minutes and again no leakage was detected. This was in addition to the measurement of pressure before and after testing.

[e]SafeSend is a trademark of the 3M Company.

[f]Hardigg Case is a trademark of Hardigg Industries, Inc.

[g]Teflon is a trademark of E.I. du Pont de Nemours & Company.

[h]Tefzel is a trademark of E.I. du Pont de Nemours & Company.
ETFE = ethylene-tetrafluorethylene
FEP = fluorinated ethylene propylene
FLPE = fluorinated high-density
LANL = Los Alamos National Laboratory
MS = Military specification
ORNL = Oak Ridge National Laboratory
PP = fluorinated polypropylene
RF = Rocky Flats
SRP = Savannah River Plant
WHC = Westinghouse Hanford Company.

See Table D-18.a. Additional Free Drop Test Results for Liquid and Gas Packagings.
See Table D-18.b. 9-m (30-ft) Additional Drop Test Results for Liquid and Gas Packagings.

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Table D-19.a. Free Drop Test Results for Liquid and Gas Packagings.				
Specific Packaging	**Weight kg (lb)**	**Contents**	**Results/Comments**	
EG&G Mound Applied Technologies Commercial Tritium Packaging				
	4.67 (10.29)	Air	See specific drop test information listed below. No loss of contents.	
	4.84 (10.55)	Air		
	5.13 (11.29)	Air		
	5.37 (11.83)	Air		
	5.78 (12.72)	Air		
	Number of drops	**Orientation**	**Results**	**Comments**
Case and 50 cc (1.11 lb)	1	End, near top of cylinder	Pass	No visible damage
	2	45° top right corner	Pass	No visible damage
Case and 50 cc (1.11 lb)	8	One drop on each corner	Pass	No visible damage
Specific Packaging	**Weight kg (lb)**	**Contents**	**Results/Comments**	
WHC Grout Sample Packaging				
	178 (391)	Water, lead shot, fluorescent penetrant	Three drop orientations were used: (1) package oriented to drop flat on the bottom, (2) package oriented to drop flat on the top, (3) package oriented to drop flat on the side with bolt down. The damage observed from the drop for each orientation from 1.2 m (4 ft) was as follows: (1) bottom lid of drum bowed out 0.635 cm (1/4 in.), (2) top lid of drum bowed out 0.635 cm (1/4 in.), (3) 0.952-cm (3/8-in.) dent in bolt area. In all three cases, the packaging passed the test.	
Specific	**Weight kg (lb)**	**Contents**	**Results/Comments**	

Packaging				
EG&G Mound Lewis Gas Packaging				
	9.49 (20.875)	Air	See specific test information listed below. Packaging passed test.	
	Number of drops	**Orientation**	**Results**	**Comments**
Package #1	1	45° angle on top [opposite impact point of the 9-m (30-ft) drop conducted just before this test--without opening the packaging].	Pass	No Significant effect determined.
Specific Packaging	**Weight kg (lb)**	**Contents**	**Results/Comments**	
WHC Hedgehog Container				
30-mL version	28.6 (63)	Steel shot, water, and fluorescein	Although damage to the internal foam on the case lid resulted in crevices of varying depth, and slight shifting of the foam pieces, there was no significant movement of the SafeSend[a] container within the cavity area of the Hardigg Case.[b] See specific test information listed below for both versions. Packaging passed test.	
1-L version	18.1 (40)			
39-TU-01 (30-mL)	1	Flat onto lid of packaging	Pass	Although damage to the internal foam on the case lid resulted in crevices of varying depth, and slight shifting of the foam pieces, there was no significant movement of the SafeSend container within the cavity area of the Hardigg Case.
				Internal foam on the lid of the Hardigg Case received a crevice 1.87-cm (0.735-in.) to 1.46-cm (0.575-in.) deep from the impact of the top and bottom of the SafeSend. The lid foam also compressed from the weight of the SafeSend 0.65 to 0.90 cm (0.255 to 0.335 in.) from center to bottom. The top, center foam piece, located in the cavity area of the case, shifted downward into the cavity a distance of 0.239 to 0.475 cm (0.094 to 0.187 in.) from left to right. No further damage.
39-TU-01 (30-mL)	1	Impact top corner of lid, latch side, CG (45° angle)	Pass	Although damage to the internal foam on the case lid resulted in crevices of varying depth, and slight shifting of

				the foam pieces, there was no significant movement of the SafeSend container within the cavity area of the Hardigg Case.
				Internal foam on the lid of the Hardigg Case received a crevice 1.78-cm (0.70-in.) to 1.29-cm (0.509-in.) deep from the impact of the left and right side of the SafeSend. A crevice 1.37-cm (0.54-in.) deep resulted from the impact of the bottom of the SafeSend. The lid foam also compressed from the weight of the SafeSend 0.66 to 0.82 cm (0.260 to 0.322 in.) from center to bottom. The top center foam section located in the cavity area shifted outward a distance of 0.56 to 0.47 cm (0.219 to 0.187 in.) from the left to right side. No further damage.
39-TU-01 (30-mL)	1	Flat onto top of packaging	Pass	Although damage to the internal foam on the case lid resulted in crevices of varying depth, and slight shifting of the foam pieces, there was no significant movement of the SafeSend container within the cavity area of the Hardigg Case.
				Internal foam on the lid of the Hardigg Case received a crevice 1.84-cm (0.725-in.) to 1.52-cm (0.60-in.) deep from the impact of the left side and bottom of the SafeSend. The lid foam also compressed from the weight of the SafeSend 0.787 to 0.729 cm (0.310 to 0.287 in.) (center) to 0.709 cm (0.279 in.) (bottom). No further damage.
39-TU-03 (1-L)	1	Flat onto lid of packaging	Pass	The butterfly latch came unlatched at the base of package as it would normally sit during transportation. Internal foam on the lid of the Hardigg Case received a crevice 1.01-cm (0.40-in.) deep from the impact of the top of the SafeSend. The lid foam also compressed from the weight of the SafeSend 0.315 to 0.335 cm (0.124 to 0.132 in.) from top to bottom. No further damage.
39-TU-03 (1-L)	1	Flat onto top of packaging	Pass	Although damage to the internal foam on the case lid resulted in crevices of varying depth, and slight shifting of

				the foam pieces, there was no significant movement of the SafeSend container within the cavity area of the Hardigg Case.
				Internal foam on the lid of the Hardigg Case received a crevice 1.0-cm (0.397-in.) deep. No further damage.
39-TU-03 (1-L)	1	Flat onto bottom of packaging	Pass	After five drops with this case, the rivets on bottom latch began to loosen. Internal foam on the lid of the Hardigg Case received a crevice 1.0-cm (0.397-in.) deep from the impact of the top of the SafeSend. No further damage.
See Table D-19.b. Free Drop Test Results for Liquid and Gas Packagings.				

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Table D-19.b. Free Drop Test Results for Liquid and Gas Packagings.				
Specific Packaging	**Weight g (lb)**	**Contents**	**Results/Comments**	
WHC 1-L Liquid Shipper				
	3788.2 (8.4)	Steel shot, water, and fluorescein	See specific drop test information listed below. [Docket 95-41-7A]	
			Before reading this section, refer to information presented in Table D-18.c on the two different bottle types used during testing. The 9-m (30-ft) drop test results proved and confirmed that the wide-mouthed FLPE bottle with PP lid was inferior to the narrow-mouthed Teflon[c] FEP bottle with Tefzel[d] ETFE lid. As such, the 1.2 m (4 ft) drop test was only performed on the 1-L Liquid Shipper packaging containing the wide-mouthed bottle type. NOTE: The wide-mouthed bottle is not approved for use in this packaging.	
			NOTE: 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.	
	Number of drops	**Orientation**	**Results**	**Comments**
41-TU-13	1	Flat onto lid of packaging	Pass	No indication of shifting of contents, damage, or leakage.
41-TU-14	1	Impact top corner at locking mechanism, CG (25° angle)	Pass	No indication of shifting of contents, damage, or leakage.
41-TU-15	1	Flat onto bottom of	Pass	No indication of shifting of contents,

		packaging		damage, or leakage.
41-TU-16	1	Impact bottom corner, CG (25° angle)	Pass	No indication of shifting of contents, damage, or leakage.
41-TU-17	1	Flat onto side at locking mechanism	Pass	No indication of shifting of contents, damage, or leakage.

[a]SafeSend is a trademark of the 3M Company.
[b]Hardigg Case is a trademark of Hardigg Industries, Inc.
[c]Teflon is a trademark of E.I. du Pont de Nemours & Company.
[d]Tefzel is a trademark of E.I. du Pont de Nemours & Company.
ETFE = ethylene-tetrafluorethylene
FEP = fluorinated ethylene propylene
FLPE = fluorinated high-density
PP = fluorinated polypropylene
WHC = Westinghouse Hanford Company.
See Table D-19.a. Free Drop Test Results for Liquid and Gas Packagings.

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Table D-20.a. Free Drop Test Results for Miscellaneous Packagings.		
Specific packaging	**Weight kg (lb)**	**Comments**
LLNL-Old Spec 55	23 (50)	Two of these packagings were filled with a water/fluorescein solution, sealed, and dropped on a lid edge. There was no loss of contents, even with these conservative contents. Thus, this packaging meets all requirements.
ORNL TRU Shipping Container	1,701 (3,750)	Because this packaging is certified only for Special Form [49 CFR 173.403(z)] contents, this test has little meaning from a loss of contents standpoint. However, the test was conducted on the top edge with no significant effect on the packaging. Thus, the packaging plus the Special Form contents meet all requirements.
FEMA Source Overpack	91 (200)	Because this package is authorized only for Special Form [49 CFR 173.403(z)] contents, this test has little meaning from a loss of contents standpoint. However, the test was conducted on the top edge with no significant effect on the packaging. Thus, the packaging plus the Special Form contents meet all requirements.
SNL Tritium Waste Package	91 (200)	The inner container was dropped 6 ft on a chime and 4 ft on a protected valve, and the entire package was dropped 4 ft on the top bolt closure ring, all with no loss of contents. The packaging meets all requirements.
LANL Aluminum Packaging (LANL-1)	77 (170)	The same packaging was dropped three times: on the top cover at approximately a 45° angle; flat on a side flange; and flat on an end flange. There were no significant effects on the packaging; there were no significant dents or indents; and there was no movement of the inner contents.
WIPP RH-TRU Canister	2,712 (5,980)	Test Unit LA01 was subjected to three drop tests with varying orientations with no adverse affects.
	2,381 (5,250)	Test Unit LA02 was subjected to three drop tests with varying orientations, also with no adverse affects. [Docket 89-03-7A]
Packaging for Special Form Neutron Source	261 (576)	Test Unit 26-TU-1 was subjected to one 4-ft drop test. The access tube protrusion was pushed into the center of the package by 0.875 in. (maximum). The weld holding the access tube to the container end piece fractured, but it did not fail completely. [Docket 91-26-7A] The package plus the special form material meet all requirements.
TRUPACT II Ten-	3,129 (6,900)	Test Unit 16-TU-01 was subjected to a drop test at a 48° angle, center-of-gravity over top rim, impact point at a filter location. At the point of impact,

Drum Overpack		the lid flange pushed inward 0.91 cm (0.360 in.). The damage tapered off in both directions from the impact point resulting in a crease across the lid with a 61-cm (24-in.) chord. The lid uplifted 1.87 cm (0.735 in.), measured from a distance of 79 cm (31 in.) from the center of the lid, and with the chord of 61 cm (24 in). The shape of the uplifting of the lid is similar to that of a parabolic curve. There was minor flattening along the side of the overpack at the point of impact. Passed with no leakage of contents. [Tested 10/28/93, Docket 90-16-7A]
	3,093 (6,820)	Test Unit 16-TU-02 was subjected to a drop test, flat on side, near lift handle on opposite side of the welded seam. The lift handle pushed against the external side of the TDOP with no resulting damage to the TDOP wall at the point of impact. All four bumpers received minor damage, with the most damage occurring to bumper #4, which dented 3.49 cm (1 3/8 in.) inward with a 53.98-cm (21 1/4-in.) chord. The sides of the overpack near the dented bumpers also received minor damage, with the most damage occurring on the side near bumper #4, which indented 3.49 cm (1 3/8 in.). The bottom portion of the overpack side panel dented inward approximately 2.70 cm (1 1/16 in.) with a chord of 40.6 cm (16 in.). The area of damage to this test package also had a parabolic curve. Damage was minimal at the top of the package, with an increase in the damage occurring more at the bottom of the overpack. Passed with no leakage of contents. [Tested 10/28/93, Docket 90-16-7A]
	3,129 (6,900)	Test Unit 16-TU-03 was subjected to a drop test at a 48° angle, center-of-gravity over bottom rim, impact point at the welded seam. All four bumpers received minor damage, with the most damage occurring to bumper #1 which indented 2.06 cm (13/16 in.) and with a 28-cm (11-in.) chord. The sides of the overpack near the dented bumpers also received minor damage, with the most damage occurring to the side near bumper #1 which indented 1.59 cm (5/8 in.). The damage showed a similar shaped parabolic curve as 16-TU-02; however, the bumpers did not flatten as much. The bottom side wall under bumper #4 dented inward 4 cm (1.573 in.). The bottom pan of the overpack buckled up from the underside and into the overpack, resulting in a dent approximately 5.4 cm (2 1/8 in.) and with a chord of 27.5 cm (1 ft 10 in.). Passed with no leakage of contents. [Tested 10/28/93, Docket 90-16-7A]

See Table D-20.b. Free Drop Test Results for Miscellaneous Packagings.
See Table D-20.c. Free Drop Test Results for Miscellaneous Packagings.
See Table D-20.d. Free Drop Test Results for Miscellaneous Packagings.

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Table D-20.b. Free Drop Test Results for Miscellaneous Packagings.

Specific packaging	Weight kg (lb)	Contents	Results/comments
INEL Mark III Concrete Container	Varied--see specific info noted below	Except where noted below, the simulated contents were sand, soil, stainless steel ingots, and lead bricks. Bracing was also added to protect the bottom, sides, and top of the inside of the container. Bracing consisted of plywood sheets, wooden 2 x 4s, and railroad ties. A mixture of flour and fluorescein was added for leak detection purposes.	Except where noted below, a 0.6-m (2-ft) drop test was conducted. Cracking and the breaking off of the exterior concrete, and cracking of the internal polyethylene liner resulted from drop tests conducted. See specific test information listed below. The packaging passed testing with and without the use of the top impact limiter, as indicated below.
33-TU-01	4,581.28 (10,100)	Container was filled with 30.28 L (8 gal) of water; fluorescein added for leak detection purposes.	This packaging did not include the top impact limiter. This packaging was subjected to a 1.4-m (4.6-ft) drop test to confirm the integrity and performance of the drain valve and plugs.
33-TU-02	10,477.98 (23,100)		This packaging included the top impact limiter.
33-TU-04	10,409.95 (22,950)		This packaging did not include the top impact limiter.
33-TU-05	10,455.30 (23,050)		This packaging included the top impact limiter.
33-TU-05	10,115.11 (22,300)		This packaging was dropped a second time without the top impact limiter.

Note: Drop information for the INEL Mark III Concrete Container is continued in Table D-20.c.
See Table D-20.a. Free Drop Test Results for Miscellaneous Packagings.
See Table D-20.c. Free Drop Test Results for Miscellaneous Packagings.
See Table D-20.d. Free Drop Test Results for Miscellaneous Packagings.

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Table D-20.c. Free Drop Test Results for Miscellaneous Packagings.				
	Number of drops	**Orientation**	**Result**	**Comments**
INEL Mark III Concrete Container (cont.)				
33-TU-01	1	Center of gravity to impact the drain valve and plugs located on the side and bottom of the container body.	Pass	The two drain plugs located on the side of the container body indented symmetrically 0.635 cm (0.25 in.) across the 3.81-cm (1.5-in.) wide plug/valve area. The drain plugs located on the bottom of the container body were not affected.
33-TU-02	1	Flat onto the top of the lid.	Pass	Minimal damage noted to the top impact limiter. External damage to the concrete container was evident only in the lid. Cracking of the concrete occurred in a wave-like pattern along a lengthwise side of the lid and measured a total length of 114.3 cm (45 in.). The concrete lifted outward about 0.3175 cm (0.125 in.) along portions of this crack. Damage noted on the opposite side of the lid consisted of concrete chipping off in chunks 17.78-cm (7-in.) long and 13.97-cm (5.5-in.) long. The polyethylene liner of the lid cracked along a chamfer edge of the lengthwise portion of the lid. The crack was in a wave-like pattern and measured 179.07-cm (70.5-in.) long.

33-TU-04	1	Center of gravity to impact lengthwise edge of lid.	Pass	There was no top impact limiter, and the lid shifted 0.635 cm (0.25-in.) from the initial point of impact toward the side of the slap down. Exterior damage resulted in the concrete breaking off along one edge of the lid a length of 25.4 cm (10 in.) and a depth of 7.62 to 5.08 cm (3 to 2 in.). Rebar was exposed across the exterior of the lid along this area. Cracking of the concrete occurred at a bolt location in the lid. The concrete raised upward 0.3175 cm (0.125 in.) along this crack. Rebar was exposed on the exterior of the lid between two lid bolts. A crack 36.83-cm (14.5-in.) long pushed outward about 0.1588 cm (0.0625 in.) from the concrete container body. The interior lid liner cracked 15.24 cm (6 in.) along one end. Cracks were also noted in the lid liner around two bolt locations. The body of the liner cracked along the location where the outer edge of the concrete container had pushed out 0.1588 cm (0.0625 in.). This crack ran diagonal along the interior of the container for a length of 38.1 cm (15 in.).
33-TU-05	1	Flat onto short, butt-end to impact top impact limiter, and slap down onto container bottom.	Pass	The top impact limiter cracked and broke up; wood split up. A crack measured 39.37-cm (15.5-in.) long, and pushed outward about 0.635 cm (0.25 in.) along one side of the exterior concrete body. A hole measuring 41.91-cm (16.5-in.) across, 27.94-cm (11-in.) high, and 5.08-cm (2-in.) deep occurred in the body of the concrete

				container. On the underside of the body, concrete was broken out 2.54 cm (1 in.) toward the reinforced plate for the lifting eyes and measured 21.59 by 27.94 cm (8.5 by 11 in.). On the opposite edge, the concrete was broken out 19.05 cm (7.5 in.) from the edge. The bottom of the container body hit the clevis hook (from the lifting straps used) during the slap down onto the test pad. Damage resulting from the hook measured 27.94-cm (11-in.) long and 5.08-cm (2-in.) deep. Internal damage noted to the polyethylene liner body at this location resulted in a crack 60.96-cm (24-in.) long intersecting a second crack that was 50.8-cm (20-in.) long (cross-shaped). The liner raised up about 5.08 cm (2 in.).
33-TU-05	1	Flat onto top of lid.	Pass	This was the second drop with this test unit. The top impact limiter was removed. Damage resulting to the lid included a crack 17.79-cm (7-in.) long along one edge. Additional cracks to the lid measured 49.53-cm (19.5-in.) long and 1.905-cm (0.75-in.) deep; 50.8-cm (20-in.) long and 1.905- to 2.54-cm (0.75- to 1-in.) deep; and 49.53-cm (19.5-in.) long and 4.445-cm (1.75-in.) deep. Rebar showed where all concrete was broken out as described. No further damage resulted to this test unit during this drop.

See Table D-20.a. Free Drop Test Results for Miscellaneous Packagings.
See Table D-20.b. Free Drop Test Results for Miscellaneous Packagings.
See Table D-20.d. Free Drop Test Results for Miscellaneous Packagings.

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Table D-20.d. Free Drop Test Results for Miscellaneous Packagings.		
Specific Packaging	**Weight kg (lb)**	**Comments**
INEL ARROW-PAK Packaging	See Below	The simulated contents for both test units were wrapped lead bricks and steel shot. Both test units contained the two optional plywood spacers (as shown in Figure 8-13). Fluorescein was added for leak detection purposes. Both test units were inspected visually and under black light conditions for leakage. Containment was verified by conducting a "soap bubble" test on both test units. No indication of leakage was detected, and both test units passed all drop tests. [Docket 95-40-7A]
40-TU-01	519.8 (1146)	This test unit underwent a total of 4 drops as follows:
		1) Vertical to impact flat onto the end cap without added plugs. Minor damage resulted in slight scarring of the HDPE material on the impacted end cap. (Pass)
		2) Center of gravity (10° angle) to impact the edge of the end cap without added plugs. Damage resulted in a slight circular flattening at the area of impact on the edge of the end cap. The flattened area had a diameter of 5.08-cm (2-in). (Pass)
		3) Horizontal to impact flat onto the side wall of the package. Damage resulted in slight flattening of the beaded edge along the fusion joints. One beaded fusion joint section flattened slightly over a length of 7.62-cm (3-in); the beaded fusion joint on the opposite end flattened slightly over a length of 6.99-cm (2.75-in). There was no flattening of the pipe wall or end caps. (Pass)
		4) Vertical to impact flat onto the end cap with the added plugs. The test unit impacted flat onto the designated end cap, pivoted, and slapped down onto the edge of the drop pad. The package then rolled off the drop pad. Damage resulted in a minor scratch measuring 39.37-cm (15.5-in), diagonal, along the sidewall of the cylindrical pipe/tube, and near the center of the package. One end cap received a minor gouge when it hit an unidentified object when the packaging rolled off the test pad. (Pass)
40-TU-02	507.6 (1119)	This test unit underwent a total of 4 drops as follows:
		1) Vertical to impact flat onto the end cap without added plugs. The package impacted flat onto the designated end cap, pivoted, fell against a turnbuckle and beam located near one edge of the drop pad, and then slapped down onto the edge of the drop pad. The package then rolled off

		the drop pad. One end cap was gouged slightly from striking the turnbuckle. Minor damage also resulted in slight scarring of the HDPE material. A fusion joint received minor damage that resulted in slight flattening over a length of 5.08-cm (2-in). (Pass)
		2) Center of gravity (10° angle) to impact the edge of the end cap without added plugs. Damage resulted in a dimpling of the HDPE material having a diameter of 2.54-cm (1-in). (Pass)
		3) Horizontal to impact flat onto the side wall of the package. Damage resulted in slight flattening of the beaded edge along the fusion joints. Each fusion joint flattened a length of 6.35-cm (2.50-in). There was no flattening of the pipe wall or end caps. (Pass)
		4) Center of gravity (10° angle) to impact the edge of the end cap with the added plugs. Damage resulted in a slight dimpling (diameter of 2.54-cm [1-in]) of the HDPE material at the area of impact on the edge of the end cap. (Pass)
WHC WRAP-1 Drum	See Below	Three drums were drop tested as identified in this table. Qualitative information on the damage to the drum is not available in the recorded test data, only photographs. Qualitative information is needed by the shipper to determine changes in radiation levels at the surface of the package due to damage resulting from testing. Therefore, an evaluation by comparison with the DOT-17C, 208-l (55-gal) steel drum that was tested and evaluated under dockets 89-13-7A/90-18-7A and 94-37-7A was conducted. **Refer to Tables D-10.a and D-10.b** for identification of the damage reported for the packagings tested and evaluated under those dockets. This information should be referenced when determining changes in radiation levels for the WRAP-1 drum configuration.
	464 (1024)	Sample #3 was filled with simulated contents and subjected to a drop test, center-of-gravity over the top corner to impact the locking ring bolt. Passed with no detectable loss of material under visual and ultraviolet light inspection. [Docket 94-35-7A]
	464 (1024)	Sample #4 was filled with simulated contents and subjected to a drop test, center-of-gravity over the top corner to impact the locking ring bolt. Passed with no detectable loss of material under visual and ultraviolet light inspection. [Docket 94-35-7A]
	461 (1018)	Sample #5 was filled with simulated contents and subjected to a drop test, flat onto the side of the packaging to impact the locking ring bolt. Passed with no detectable loss of material under visual and ultraviolet light inspection. [Docket 94-35-7A]

FEMA = Federal Emergency Management Agency
HDPE = high-density polyethelene
INEL = Idaho National Engineering Laboratory
LANL = Los Alamos National Laboratory
LLNL = Lawrence Livermore National Laboratory
ORNL = Oak Ridge National Laboratory
RH = Remotely handled
SNL = Sandia National Laboratory
TDOP = Ten-Drum Overpack

TRU = Transuranic
WIPP = Waste Isolation Pilot Plant.
See Table D-20.a. Free Drop Test Results for Miscellaneous Packagings.
See Table D-20.b. Free Drop Test Results for Miscellaneous Packagings.
See Table D-20.c. Free Drop Test Results for Miscellaneous Packagings.

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Table D-21. Corner Free Drop Test Results for Wooden Boxes.[a]					
Specific packaging	**Weight (lb)**	**Contents**	**No. tested**	**Results**	**Comments**
Mound Wooden Boxes - Configuration A					
MA-1	40	S/Pb[b]	1	1 pass	0.25-in. indent
MA-2	100	S/Pb	1	1 pass	0.25-in. indent
MA-3	100	S/Pb	1	1 pass	0.375-in. indent
MA-4	100	S/Pb	1	1 pass	0.25-in. indent
Mound Wooden Boxes - Configuration B					
MB-1	150	F/F/S/Pb[c]	1	1 pass	0.25-in. indent
MB-2	150	F/F/S/Pb	1	1 pass	0.375-in. indent
MB-3	200	F/F/S/Pb	1	1 pass	0.375-in. indent
MB-4	150	F/F/S/Pb	1	1 pass	0.375-in. indent
MB-5	150	F/F/S/Pb	1	1 pass	0.375-in. indent
MB-6	200	F/F/S/Pb	1	1 pass	0.375-in. indent
Mound Wooden Boxes - Configuration C					
MC-1	150	S/Pb	1	1 pass	0.5-in. indent
MC-2	300	S[d]	1	1 pass	0.25-in. indent
MC-3	250	S/Pb	1	1 pass	0.5-in. indent
MC-4	100	S/Pb	1	1 pass	0.25-in. indent
MC-5	150	S	1	1 pass	0.25-in. indent
Mound Wooden Boxes - Configuration D					
MD-1	200	F/F/S/Pb	1	1 pass	0.25-in. indent
MD-2	200	F/F/S/Pb	1	1 pass	0.25-in. indent
MD-3	250	F/F/S[e]	1	1 pass	0.25-in. indent
MD-4	250	F/F/S	1	1 pass	0.375-in. indent

MD-5	200	F/F/S/Pb	1	1 pass	0.25-in. indent
MD-6	200	F/F/S/Pb	1	1 pass	0.25-in. indent
Mound Wooden Boxes - Configuration E					
ME-1	150	S	1	1 pass	0.25-in. indent
ME-2	150	S	1	1 pass	0.25-in. indent
ME-3	150	S	Not tested	--	Pass, based on testing of similar packagings.
Y-12 Series B Wooden Boxes					
B-1	400	S/Pb	1	1 pass	0.55-in. indent
B-2	400	S/Pb	1	1 pass	0.25-in. indent
B-6	400	S/Pb	1	1 pass	0.125-in. indent

[a]General Comments: Eight 1-ft drops were conducted (one on each corner). There was no loss of contents or other effects on containment integrity. The slight dimensional changes are shown in the last column.
[b]Sand and lead.
[c]Flour, fluorescein, sand, and lead.
[d]Sand.
[e]Flour, fluorescein, and sand.
-- = Not applicable.

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Table D-22. Corner Free Drop Test Results for Fiberboard Boxes.[a]

Specific packaging	Weight(lb)	Contents	No. tested	Results	Comments
12B-65					
1	65	Pb[b]	2	2 pass	0.25-in. indent
2	--	--	Not tested	--	Pass, based on testing of similar packagings.
3	65	S/Pb[c]	1	1 pass	0.25-in. indent
4	65	S[d]	2	2 pass	0.25-in. indent
5	65	Pb	2	2 pass	0.25-in. indent
6	65	S	2	2 pass	0.25-in. indent
7	65	S	2	2 pass	0.25-in. indent
8	65	S	2	2 pass	0.25-in. indent
9	65	S	1	1 pass	0.25-in. indent
10	65	S	2	2 pass	0.25-in. indent
11	65	S	2	2 pass	0.25-in. indent
12	65	S	2	2 pass	0.25-in. indent
13	65	S/Pb	2	2 pass	0.25-in. indent
LLNL 12B-10	--	--	Not tested	--	Pass, based on testing of similar packagings.

[a]General Comments: Eight 1-ft drops were conducted (one on each corner). There was no loss of contents or other effects on containment integrity. The slight dimensional changes are shown in the last column.
[b]Sand and lead.
[c]Flour, fluorescein, sand, and lead.
[d]Sand.
LLNL = Lawrence Livermore National Laboratory
-- = not applicable.

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Table D-23. Corner Free Drop Test Results for DOT-21C Fiberboard Drums.[a]

Specific packaging	Weight(lb)	Contents	No. tested	Results	Comments
1	115	F/F/S/Pb[b]	1	1 pass	0.25-in. indent
2	115	F/F/S/Pb	1	1 pass	0.125-in. indent
3	115	F/F/S/Pb	1	1 pass	0.25-in. indent
4	115	F/F/S/Pb	1	1 pass	0.25-in. indent
5	115	F/F/S[c]	1	1 pass	0.25-in. indent
6	115	F/F/S	1	1 pass	0.25-in. indent

[a]General Comments: Eight 1-ft drops were conducted (one on each of the quarters of each rim). There was no loss of contents or other effects on containment integrity. The slight dimensional changes are shown in the last column.

[b]Flour, fluorescein, sand, and lead.

[c]Flour, fluorescein, and sand.

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Table D-24. Compression Test Results for Steel Drums.						
Specific packaging	**Authorized gross weight (lb)**	**Compression test weight (lb)**	**Test duration (hr)**	**Test/analysis data and results**		**Comments**
				No. tested	**Results**	
DOT-6C 5-gal	80	500	>24	1	1 pass	No detectable effect.
DOT-6C 10-gal	160	928	>24	1	1 pass	No detectable effect.
DOT-17C 5-gal	100	520	>24	1	1 pass	No detectable effect.
DOT-17C 30-gal	500	Not tested[a]	--	--	--	Pass, based on testing of DOT-17H 30-gal drum.
DOT-17C 35-gal	400	2,060	>24	1	1 pass	No detectable effect.
DOT-17C 55-gal	1,000	Not tested[b]	--	--	--	Pass, based on testing of DOT-17H 55-gal drum.[c]
DOT-17C 55-gal with pressure relief devices	1,000	Not tested[c]	--	--	--	Pass, based on testing of DOT-17H 55-gal drum.[c]
DOT-17C 55-gal with HDPE liner	1,000	5,525	>24	1	1 pass	Passed. [Dockets 89-13-7A and 90-18-7A]
DOT-17H 30-gal	500 400	2,700 2,069	>24 >24	1 1	1 pass 1 pass	No detectable effect. No detectable effect. [Dockets 90-17-7A and 90-20-7A]
DOT-17H 55-gal	1,000	5,100	>24	1	1 pass	No detectable effect.

MS-24347-1[d]	10	100	48	1	1 pass	No detectable effect.
MS-24347-7[d]	35	200	48	1	1 pass	No detectable effect.
MS-24684-1[d]	60	300	>24	1	1 pass	No detectable effect.
MS-27684-2[d]	110	Not tested	--	--	--	Pass, based on comparison to test data on comparable drum.
MS-27684-3[d]	80	401	>24	1	1 pass	No detectable effect.
MS-27684-5[d]	80	500	>24	1	1 pass	No detectable effect.
MS-27684-8[d]	200	1,000	>24	1	1 pass	No detectable effect.
MS-27683-7[d]	400	2,072	>24	1	1 pass	No detectable effect.
MS-27683-13[d]	500	2,752	>24	1	1 pass	No detectable effect.
MS-27683-21[d]	800	5,500	>24	1	1 pass	No detectable effect.
PACKAGING SPECIALTIES SQUARE STEEL DRUMS						
Style 1A	1,350	7,506	>24	1	1 pass	The test had no effect on the drum.
Style 1B	1,350	7,492	>24	1	1 pass	The test had no effect on the drum.
Style 2	1,350	7,508	>24	1	1 pass	The test had no effect on the drum.
Style 3	1,350	7,486	>24	1	1 pass	The test had no effect on the drum.

[a]The test data for the DOT-17H 30-gal drum are directly applicable because the construction specifications for these two drums (DOT-17H 30-gal and DOT-17C 30-gal) are essentially the same.

[b]A DOT-17C 55-gal drum filled with concrete was tested to 8,142 lb (for 24 hr) and passed.

[c]The test data for the DOT-17H 55-gal drum are directly applicable (although conservative), because the only major difference between the DOT-17H and the DOT-17C 55-gal drums is the thickness of the body sheet. The DOT-17H body sheet is 18 gauge, and the DOT-17C is 16 gauge.

[d]Drum assembly numbers.
DOT = U.S. Department of Transportation
HDPE = High-density polyethylene
MS = Military specification

-- = Not applicable.

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Table D-25. Compression Test Results for Steel Boxes.

Specific packaging	Authorized gross weight (lb)	Compression test weight (lb)	Test duration (hr)	Test/analysis data and results		Comments
				No. tested	Results	
Capital Industries						
S-0510-0823	7,000	35,000	>24	1	1 pass	No detectable effect.
V-0510-0823	7,000	35,000	>24	1	1 pass	No detectable effect.
S-0450-0844	5,240	Not tested	--	--	--	Pass, based on testing of Model S-0510-0823. This model passed with a load of 2,500 lb/corrugation. Model S-0450-0844 would require a test of 1,871 lb/corrugation, which would be expected to pass.
S-0730-0846	8,700	Not tested	--	--	--	Pass, based on testing of Model S-0730-1006. This model passed with a load of 2,167 lb/corrugation. Model S-0730-0846 would require a test of 2,175 lb/corrugation, which would be expected to pass.
S-0240-0906	3,672	Not tested	--	--	--	Pass, based on testing of Model S-0510-0823. This model passed with a load of 2,500 lb/corrugation. Model S-0240-0906 would require a test of 1,353 lb/corrugation, which would be expected to pass.
S-0480-0906	6,120	Not tested	--	--	--	Pass, based on testing of Model V-0510-0823. This model passed with a load of 2,500 lb/corrugation. Model S-0480-0906 would require a test of 1,913 lb/corrugation, which would be expected to pass.
S-0730-0906	10,400	52,000	>24	1	1 pass	No detectable effect.
S-0840-1440	22,700	124,184	>24	1	1 pass	No detectable effect.
S-0480-1376	--	Not tested	--	--	--	Pass, based on testing of Model S-0730-1006. This model passed with a load of

						2,176 lb/corrugation. Model S-0480-1376 would require a test of 1,936 lb/corrugation, which would be expected to pass.
Container Products Corp.						
B-96-5-S/L-FD	6,050	30,250	>24	1	1 pass	No detectable effect.
B-96-5-S/L-RA	6,801	Not tested	--	--	--	Pass, based on testing of a comparable container, B-96-5-S/L-FD, which met this requirement.
B-96-5-S/L-RA	6,500	Not tested	--	--	--	Pass, based on testing of a comparable container, B-96-5-S/L-FD, which met this requirement.
467-C-S/L-FD TRU Waste Container	4,000	20,000	>24	1	1 pass	No detectable effect.
B-12-44-4-S/L-FD	4,625	Not tested	--	-	-	Pass, based on testing of a comparable container, B-25-4-S/L-FD, which met this requirement.
B-25-4-S/L-FD	4,820	25,000	>24	1	1 pass	No detectable effect.
B-52-4-S/L-FD	4,775	29,000	>24	1	1 pass	No detectable effect.
B-82-6-S/L-FD	6,775	35,000	>24	1	1 pass	No detectable effect.
B-87-6-S/L-FD	6,970	Not tested	--	--	--	Pass, based on testing of a comparable container, B-96-6-S/L-FD, which met this requirement.
B-96-6-S/L-FD	7,005	40,020	>24	1	1 pass	No detectable effect.
B-96-8-S/L-FD	9,100	47,000	>24	1	1 pass	No detectable effect.
Rocky Flats SAND Box						
Style 1	7,000	36,760	>24	2	2 pass	No detectable effect.
Style 2	6,000	32,000	>24	3	3 pass	No detectable effect.
Style 3	6,000	32,000	>24	1	1 pass	No detectable effect.
Style 4	6,000	32,000	>24	2	2 pass	No detectable effect.
Argonne						
M-4 Bin	3,000	Not tested	--	--	--	Pass, based on testing of the M-III steel bin with a compression load of 40,000 lb. The M-4 is of equal or better structural strength and would be expected to meet this requirement.
ANL-W						
Steel Box	960	4,800	>24	1	1 pass	No detectable effect.
TRUPACT-II, TU-2	4,000	21,105	>24	1	1 pass	Test had no detectable effect and there was no loss of contents as

						evidenced by an inspection for fluorescein using ultraviolet light.
ORNL Low Level Waste Container [Docket 89-04-7A]						
Vented	8,150	42,475	24	1	1 pass	No detectable effect.
Nonvented	10,230	51,430	24	1	1 pass	No detectable effect.

ANL-W = Argonne National Laboratory - West
ORNL = Oak Ridge National Laboratory
TRU = Transuranic
-- = Not applicable.

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Table D-26. Compression Test Results for Wooden Boxes.

Specific packaging	Authorized gross weight (lb)	Compression test weight (lb)	Test duration (hr)	Test/analysis data and results		Comments
				No. tested	Results	
ANL-W						
7A-217	217	10,875	24	1	1 pass	No detectable effect.
7A-375	375	4,000	24	1	1 pass	No detectable effect.
7A-880	880	5,168	24	1	1 pass	No detectable effect.
7A-995	995	6,308	24	1	1 pass	No detectable effect.
7A-1315	1,315	7,000	24	1	1 pass	No detectable effect.
7A-670	670	4,000	24	1	1 pass	No detectable effect.
LLNL Flush Panel	2,500	25,000	>24	1	1 pass	No detectable effect.
Mound Wooden Boxes - Configuration A						
MA-1	40	265	>24	1	1 pass	No detectable effect.
MA-2	100	500	>24	1	1 pass	No detectable effect.
MA-3	100	500	>24	1	1 pass	No detectable effect.
MA-4	100	500	>24	1	1 pass	No detectable effect.
Mound Wooden Boxes - Configuration B						
MB-1	150	Not tested	--	--	--	Pass, based on shown testing of boxes of similar materials and construction methods at weights in excess of those actually required.
MB-2	150	1,500	>24	1	1 pass	No detectable effect.
MB-3	200	Not tested	--	--	--	Pass, based on testing of boxes of similar materials and construction methods

						at weights in excess of those actually required.
MB-4	150	Not tested	--	--	--	Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
MB-5	150	Not tested	--	--	--	Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
MB-6	200	1,116	>24	1	1 pass	No detectable effect.
Mound Wooden Boxes - Configuration C						
MC-1	150	770	>24	1	1 pass	No detectable effect.
MC-2	300	1,550	>24	1	1 pass	No detectable effect.
MC-3	250	1,000	>24	1	1 pass	No detectable effect.
MC-4	100	520	>24	1	1 pass	No detectable effect.
MC-5	150	770	>24	1	1 pass	No detectable effect.
Mound Wooden Boxes - Configuration D						
MD-1	200	Not tested	--	--	--	Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
MD-2	300	1,528	>24	1	1 pass	No detectable effect.
MD-3	250	Not tested	--	--	--	Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
MD-4	250	1,351	>24	1	1 pass	No detectable effect.
MD-5	200	Not tested	--	--	--	Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
MD-6	200	Not tested	--	--	--	Pass, based on testing of boxes of similar materials and construction methods at weights in excess of

						those actually required.
Mound Wooden Boxes - Configuration E						
ME-1	150	Not tested	--	--	--	Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
ME-2	150	755	>24	1	1 pass	No detectable effect.
ME-3	150	755	>24	1	1 pass	No detectable effect.
NLO Family of Banded Wooden Boxes						
G-4214	1,805	10,000	>24	1	1 pass	No detectable effect.
G-4245	250	1,000	>24	1	1 pass	No detectable effect.
G-4255	1,500	7,500	>24	1	1 pass	No detectable effect.
G-4273	3,250	18,000	>24	1	1 pass	No detectable effect.
G-4292	852	4,500	>24	1	1 pass	No detectable effect.
Y-12 Series B Wooden Boxes						
B-1	400	2,072	70	1	1 pass	No detectable effect.
B-2	400	2,028	69	1	1 pass	No detectable effect.
B-3	400	2,015	72	1	1 pass	No detectable effect.
B-4	400	2,028	>24	1	1 pass	No detectable effect.
B-5	400	2,072	>24	1	1 pass	No detectable effect.
B-6	400	2,028	>24	1	1 pass	No detectable effect.
B-7	400	2,072	>24	1	1 pass	No detectable effect.
B-8	400	2,028	>24	1	1 pass	No detectable effect.
Y-12 Picture Frame Wooden Boxes						
PF-1	500	Not tested	--	--	--	Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
PF-2	750	3,770	>24	1	1 pass	No detectable effect.
PF-3	1,000	Not tested	--	--	--	Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.

PF-4	500	Not tested	--	--	--	Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
PF-5	750	3,770	>24	1	1 pass	No detectable effect.
PF-6	1,000	5,100	>69	1	1 pass	No detectable effect.
PF-7	750	Not tested	--	--	--	Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
PF-8	1,000	5,100	47	1	1 pass	No detectable effect.
PF-10	2,500	13,320	24	1	1 pass	No detectable effect.
Rocky Flats RA Series of Wooden Boxes						
Configuration 1	900	4,541	24	1	1 pass	No detectable effect.
Configuration 2	1,250	6,664	24	1	1 pass	No detectable effect. Docket 89-01-7A
ORNL Y-12 C-Series						
C-1	1,130	6,000	24	1	1 pass	No detectable effect.
C-2	1,700	9,030	24	1	1 pass	No detectable effect.
C-3	2,230	11,500	24	1	1 pass	No detectable effect.
Y-12 C-280	280	2,387	>24	1	Pass	This weight represents the top surface area times 265 lb/ft^2. There was no effect as a result of this test.
Y-12 C-400	400	2,418	>24	1	Pass	There was no effect.
Y-12 C-600	600	3,974	>24	1	Pass	There was no effect.
Y-12 C-100	1,000	5,013	>24	1	Pass	This weight represents 5 x the gross weight. There was no effect. Docket 89-09-7A
WMCO Banded Wooden Boxes						
G-4214	1,260	7,144	>24	1	1 pass	No detectable effect.
G-4245	225	1,262	>24	1	1 pass	No detectable effect.
G-4255	1,470	10,230	>24	1	1 pass	No detectable effect.

G-4273-5	3,035	17,700	>24	1	1 pass	No detectable effect.
G-4273-6	3,540	17,700	>24	1	1 pass	No detectable effect.
G-4292	1,330	7,650	>24	1	1 pass	No detectable effect.

ANL-W = Argonne National Laboratory - West
LLNL = Lawrence Livermore National Laboratory
NLO = National Lead Corporation
ORNL = Oak Ridge National Laboratory
WMCO = Westinghouse Materials Company of Ohio
-- = Not applicable.

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Table D-27. Compression Test Results for Fiberboard Containers.						
Specific packaging	**Authorized gross weight (lb)**	**Compression test weight (lb)**	**Test duration (hr)**	**Test/analysis data and results**		**Comments**
				No. tested	**Results**	
DOT-12B-65 Fiberboard Boxes						
1	65	Not tested	--	--	--	Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
2	65	Not tested	--	--	--	Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
3	65	Not tested	--	--	--	Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
4	65	330	>24	1	1 pass	No detectable effect.
5	65	Not tested	--	--	--	Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
6	65	330	>24	1	1 pass	No detectable effect.
7	65	325	>24	1	1 pass	No detectable effect.
8	65	328	>24	1	1 pass	No detectable effect.
9	65	328	>24	1	1 pass	No detectable effect.
10	65	325	>24	1	1 pass	No detectable effect.
11	65	328	>24	1	1 pass	No detectable effect.

12	65	Not tested	--	--	--	Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
13	65	Not tested	--	--	--	Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
LLNL 12B-10 with inner metal can	10	100	>24	1	1 pass	No detectable effect.
Tri-Wall Fiberboard Box	350	2,510	>24	2	2 pass	Box was compressed 0.5 in. in the middle as a result of this test.
DOT-21C Fiberboard Drums						
1	115	603	>24	1	1 pass	No detectable effect.
2	115	600	>24	1	1 pass	No detectable effect.
3	115	601	>24	1	1 pass	No detectable effect.
4	115	603	>24	1	1 pass	No detectable effect.
5	115	603	>24	1	1 pass	No detectable effect.
6	115	601	>24	1	1 pass	No detectable effect.
DOT = U.S. Department of Transportation LLNL = Lawrence Livermore National Laboratory -- = Not applicable.						

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Table D-28. Compression Test Results for UF_6 Cylinders.

Packaging	Calculated no. of packages required for stress leading to failure	Results	Comments
1S	60	Pass	Two methods of analysis were used to evaluate the containers:
2S	>100	Pass	
5A	21	Pass	(1) A linear elastic stress and buckling analysis using shell of revolution program BOSOR; and
8A	15	Pass	
12A	>100	Pass	
12B	>100	Pass	(2) A linear elastic buckling analysis and a nonlinear elastic-plastic collapses analysis using the finite element program NASTRAN.[a]
30A	12	Pass	
30B	12	Pass	
48G	9	Pass	
48H	9	Pass	
48HX	12	Pass	
48X	12	Pass	
48Y	9	Pass	
Modified			
5A 5B	--	Pass	Evaluated by analysis. [Docket 89-08-7A]

[a]NASTRAN is a trademark of the National Aeronautics and Space Administration.
-- = Not applicable.

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Table D-29. Compression Test Results for Liquid and Gas Packagings.

Specific packaging	Authorized gross weight kg (lb)	Compression test weight kg (lb)	Test duration (hr)	Test/analysis data and results		Comments
				No. tested	Results	
Steel Drum MS-24347-7	10	Not tested	--	--	--	Pass, see Table D-24 of this addendum for test results on this drum.
LANL 12B-62 Fiberboard Box	62	328	>24	1	1 pass	No detectable effect.
LLNL Steel Drums with Gas Cylinders	--	Not tested	--	--	--	Pass, see Table D-24 for test results on 17H 30-gal steel drums.
ORNL Fiberboard Box - Liquids and Solids	33	165	>24	1	1 pass	Deformation of up to 1 in. on all four sides and less than 0.5 in. on the top end button.
ORNL Fiberboard Box - Gases	33	165	>24	1	1 pass	Deformation of up to 1 in. on all four sides and less than 0.5 in. on the top end button.
ORNL Fiberboard Box - Liquids and Solids with Shielding	33	165	>24	1	1 pass	Deformation of up to 1 in. on all four sides and less than 0.5 in. on the top end button.
ORNL Wooden Box - Returnable, Shielded	212	1,040	>24	1	1 pass	Tests on a slightly smaller packaging at a slightly less compressive load demonstrated that this packaging would be expected to meet this requirement.

ORNL Gas Cylinder Returnable (Hoke Cylinders)	212	1,060	>24	1	1 pass	No damage to the packaging.
HOH-50	9	Not tested	--	--	--	Pass, based on comparison to test data on heaviest cylinder, HOKr-500, shown below.
HOXe-50	15	Not tested	--	--	--	Pass, based on comparison to test data on heaviest cylinder, HOKr-500, shown below.
HOKr-50	15	Not tested	--	--	--	Pass, based on comparison to test data on heaviest cylinder, HOKr-500, shown below.
HOH-150	11	Not tested	--	--	--	Pass, based on comparison to test data on heaviest cylinder, HOKr-500, shown below.
HOXe-150	35	Not tested	--	--	--	Pass, based on comparison to test data on heaviest cylinder, HOKr-500, shown below.
HOKr-150	35	Not tested	--	--	--	Pass, based on comparison to test data on heaviest cylinder, HOKr-500, shown below.
HOH-300	12	Not tested	--	--	--	Pass, based on comparison to test data on heaviest cylinder, HOKr-500, shown below.
HOKr-300	36	Not tested	--	--	--	Pass, based on comparison to test data on heaviest cylinder, HOKr-500, shown below.
HOH-500	15	Not tested	--	--	--	Pass, based on comparison to test data on heaviest cylinder, HOKr-500, shown below.
HOKr-500	50	285	24	1	1 pass	No damage to the packaging. Tests were also conducted with a 1,000-ml container in

						which a compressive load of 580 lb was applied for 24 hr. There was no damage to the package. Because these cylinders are all identical in construction except for size and weight, the testing of the two heaviest packagings represents the worst possible cases. Thus, all of the above cylinders would pass this test.
ORNL Gas Cylinder Returnable (J. L. Shephard)						
Cylinder 1	24	--	--	--	--	Pass, based on evaluation; based on letter describing testing conducted by ORNL, subject "J. L. Shephard Gas Cylinder," D. M. Ferren/D. A. Edling, April 30, 1985.
Cylinder 2	40	--	--	--	--	
Cylinder 3	60	--	--	--	--	
WHC Liquid Sample Packaging	21 (46 3/4)	150 (331)	24	1	1 pass	Pass. This test was conducted with 150 kg (331 lb) for 24 hr with no adverse effects on the package.
SRP Process Water Sample Packaging	54 (118)	911 (2,006)	24	1	1 pass	Pass. This test was conducted with 911 kg (2,006 lb) for 24 hr with no adverse effects on the package.
RF Container Model LWS-1	5.4 (12)	91 (200)	24	1	1 pass	Pass. This test was conducted with 91 kg (200 lb) for 24 hr with no adverse effects on the package.
EG&G Mound Applied Technologies Commercial Tritium Packaging (10, 50, 150, 300 and 500 cc)	5.8 (12.72) Max	227 (500)	>24	1	1 pass	Pass. This test was conducted to 227 kg (500 lb) or well above the required weight.
WHC Grout Sample Packaging	178 (391)	1,388 (3,058)	27	1	1 pass	Pass. This test was conducted with 1,388 kg (3,058 lb) for 27 hr with no

						adverse effects on the package.
EG&G Mound Lewis Gas Packaging	9.49 (20.875)	56.75 (125)	>24	1	1 pass	Pass. This test was conducted with 57 kg (125 lb) for >24 hr with no detectable effect.
WHC Hedgehog Container	28.6 (63)	318 (700)	24	1	1 pass	This test was conducted on test unit 39-TU-02 (empty case). The compressive load was applied with no adverse effects on the package.
WHC 1-L Liquid Shipper	3830.5 (8.4)	51 (112)	24	1	Pass	This test was conducted on test unit 41-TU-11. There was no deformation to the SafeSend canister or lid, or breakage of the internal, narrow-mouthed bottle. [Docket 95-41-7A]

LANL = Los Alamos National Laboratory
LLNL = Lawrence Livermore National Laboratory
ORNL = Oak Ridge National Laboratory
RF = Rocky Flats
SRP = Savannah River Plant
WHC = Westinghouse Hanford Company
-- = Not applicable.

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Table D-30. Compression Test Results for Miscellaneous Packagings.

Specific packaging	Authorized gross weight kg (lb)	Compression test weight kg (lb)	Test duration (hr)	Test/analysis data and results		Comments
				No. tested	Results	
LLNL Old Spec 55	23 (50)	136 (300)	>24	1	1 pass	No detectable effect.
ORNL TRU Shipping Container	1,680 (3,700)	Not tested	--	--	--	Analysis demonstrates that even 22,700 kg (50,000 lb), a severe over-test, would not have a significant effect.
FEMA Source Overpack	91 (200)	486 (1,070)	>24	1	1 pass	No detectable effect.
SNL Tritium Waste Package	91 (200)	Not tested	--	--	--	Pass, see Table D-24 of this document for test data on the DOT-17H 114-L (30-gal) drum.
LANL-1	77 (170)	Not tested	--	--	--	This test was not conducted because a comparison to other metal packagings demonstrates that this test would have no effect. In addition, the configuration of this package would make stacking of similar packagings impossible and the application of a compressive load very difficult.
WIPP RH-TRU Canister	2,715 (5,980) 2,384 (5,250)	13,638 (30,040)	24	1	1 pass	No detectable effect. [Docket 89-03-7A]
Packaging for Special Form Neutron	262 (576)	1,337 (2,945)	>24	1	1 pass	No detectable effect. [Docket 91-26-7A]

Source						
TRUPACT II Ten-Drum Overpack	3,039 (6,700)	16,757 (36,950)	24	1	Pass	No detectable effect was observed on Test Package #130409 (tested 7/31/90). Further testing was not necessary for the tests conducted on 10/28/93 as it was determined that the design modifications would not have any negative effect on the testing previously conducted. [Docket 90-16-7A]
INEL Mark III Concrete Container	Without impact limiter = 9,888 (21,800) With impact limiter = 10,338.5 (22,550)	53,369.681 (117,660)	24	1	Pass	No detectable effect was observed on test unit 33-TU-04. There was no cracking or bulging noted on the exterior or interior surfaces of the container. [Docket 92-33-7A]
INEL ARROW-PAK	519.82 (1146.0)	2920.0 (6437.5)	41.5	1	Pass	The beaded edge along the fusion joint areas showed slight flattening over a length of 5.715 to 6.35-cm (2.25 to 2.50-in). The package remained "round." No further damage. [Docket 95-40-7A]

DOT = U.S. Department of Transportation
FEMA = Federal Emergency Management Agency
INEL = Idaho National Engineering Laboratory
LANL = Los Alamos National Laboratory
LLNL = Lawrence Livermore National Laboratory
ORNL = Oak Ridge National Laboratory
RH-TRU = Remotely handled transuranic
SNL = Sandia National Laboratory
TRU = Transuranic
TRUPACT = Transuranic package transporter
WIPP = Waste Isolation Pilot Plant
-- = Not applicable.

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Table D-31. Penetration Test Results for Steel Drums.

Specific packaging	Test/analysis results			Comments
	No. tested	Location	Results	
DOT-6C (5-gal)	1	Lid at center	1 pass	0.50-in. dent
	1	Side at seam	1 pass	1.00-in. dent
	1	Lid near closure ring	1 pass	0.25-in. dent
DOT-6C (10-gal)	1	Lid at center	1 pass	0.50-in. dent
	1	Side at seam	1 pass	0.75-in. dent
	1	Lid near closure ring	1 pass	0.50-in. dent
DOT-17C (5-gal)	Not tested	--	--	Pass, based on test data shown for comparable or lesser gauge steels.
DOT-17C (30-gal)	Not tested	--	--	Pass, based on test data shown for comparable or lesser gauge steels.
DOT-17C (35-gal)	1	Lid near center	1 pass	0.625-in. dent
	2	Lid near edge	2 pass	0.500-in. dent max.
	1	Side near seam	1 pass	0.250-in. dent
DOT-17C (55-gal)	Not tested	--	--	Pass, based on test data shown for comparable or lesser gauge steels.
DOT-17C (55-gal) Pressure Relief Device Nucfil[a] Filter	3	Center of filter	3 pass	Air flow was established after each test with flour/fluorescein as contents. There was no visible evidence of loss of contents, and no loss of contents was detected under a black light.
DOT-17C (55-gal) with HDPE Liners	1	Lid center	1 pass	Minor damage
	1	Side	1 pass	Same result
	1	Bottom	1 pass	Same result
	1	Filter	1 pass	Minor damage [Dockets 89-13-7A and 90-18-7A]

DOT-17H (30-gal)	1	Lid at center	1 pass	0.125-in. dent
	1	Side at seam	1 pass	0.125-in. dent
	1	Lid near closure ring	1 pass	0.055-in. dent
	1	Lid	1 pass	0.230-in. dent [Dockets 90-17-7A and 90-20-7A]
	1	Bottom	1 pass	0.320-in. dent [Dockets 90-17-7A and 90-20-7A]
	1	Side	1 pass	0.300-in. dent [Dockets 90-17-7A and 90-20-7A]
DOT-17H (55-gal)	1	Lid at center	1 pass	0.125-in. dent
	1	Side at seam	1 pass	0.125-in. dent
	1	Lid near closure ring	1 pass	0.055-in. dent
MS-24347-1 (0.25-gal)[b]	1	Lid at middle	1 pass	0.075-in. dent
	1	Side at seam	1 pass	1.250-in. dent
MS-24347-7 (1.25-gal)[b]	1	Lid at middle	1 pass	0.500-in. dent
	1	Side at seam	1 pass	1.250-in. dent
	1	Lid near closure ring	1 pass	0.125-in. dent
MS-27684-1 (3-gal)[b]	1	Lid at middle	1 pass	0.75-in. dent
	1	Side at seam	1 pass	1.00-in. dent
MS-27684-2 (4-gal)[b]	Not tested	--	--	Pass, based on test data shown for drums of lesser gauge and size.
MS-27684-3 (6-gal)[b]	1	Lid at middle	1 pass	1.00-in. dent
	1	Side at seam	1 pass	0.50-in. dent
MS-27684-6 (8-gal)[b]	1	Lid at middle	1 pass	0.125-in. dent
	1	Side at seam	1 pass	1.000-in. dent
MS-27684-8 (12-gal)[b]	1	Lid at middle	1 pass	1.000-in. dent
	1	Side at seam	1 pass	0.562-in. dent
MS-27683-7 (30-gal)[b]	1	Lid at middle	1 pass	1.000-in. dent
	1	Side at seam	1 pass	0.562-in. dent
MS-27683-13 (45-gal)[b]	1	Lid at middle	1 pass	0.125-in. dent
	1	Side at seam	1 pass	0.125-in. dent

MS-27683-21 (85-gal)[b]	Not tested	--	--	Pass, based on test data shown for drums of lesser gauge and size.
PACKAGING SPECIALTIES SQUARE STEEL DRUMS				
Style 1A	1	Center of cover	1 pass	Only effect was a dent of approximately 0.25 in.
	1	Center of bung	1 pass	Only effect was a dent of approximately 0.25 in.
Style 1B	1	Center of cover	1 pass	Only effect was a dent of approximately 0.25 in.
	1	Center of bung	1 pass	Only effect was a minor scrape (no dent)
Style 2	1	Center of cover	1 pass	Only effect was a dent of approximately 0.0625 in.
	1	Center of bung	1 pass	Only effect was a minor scrape (no dent)
	1	On lug closure	1 pass	No effect
Style 3	1	Center of cover	1 pass	Only effect was a dent of approximately 0.25 in.
	1	Center of bung	1 pass	No effect
	1	On lug closure	1 pass	No effect

[a]Nucfil is a trademark of Nuclear Filter Technology, Inc.
[b]Drum assembly numbers.
DOT = U.S. Department of Transportation
HDPE = High-density polyethylene
MS = Military specifications
-- = Not applicable.

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Table D-32. Penetration Test Results for Steel Boxes.				
Specific packaging	**Test/analysis results**			**Comments**
	No. tested	**Location**	**Results**	
Capital Industries				
S-0510-0823	1	Middle top	Pass	In all cases below, including the filter test, the only effect was a minor dent. This is expected based on materials of construction and comparative testing of lesser gauge materials.
V-0510-0823	1	Center of filter	Pass	
S-0840-1440	1	Middle top	Pass	
S-0730-1006	1	Middle top	Pass	
S-0730-0846	Not tested	--	Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials) to packaging S-0730-1006, which was tested and evaluated. All materials and methods of construction were equal to or better than those of the tested packaging.
S-0480-0906	Not tested	--	Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials) to packaging S-0510-0823, which was tested and evaluated. All materials and methods of construction were equal to or better than those of the tested packaging.
S-0450-0846	Not tested	--	Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials) to packaging S-0580-0823, which was tested and evaluated. All materials and methods of construction were equal to or better than those of the tested packaging.
S-0240-0906	Not tested	--	Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials) to packaging S-0580-0823, which was tested and evaluated. All materials and methods of construction were equal to or better than those of the tested packaging.

S-0480-1736	Not tested	--	Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials) to packaging S-0730-1006, which was tested and evaluated. All materials and methods of construction were equal to or better than those of the tested packaging.
Container Products Corp.				
B-12-44-4-S/L FD Drawing No. 01-3100-1-00 Rev. B	Not tested	--	Pass	Evaluated by analysis and comparison to packaging B-25-4-S/L FD, whose top is constructed of materials of equal thickness.
B-25-4-S/L FD Drawing No. 01-2800-1-00 Rev. C	1	Top Cover	Pass	Only effect was a minor dent.
B-52-4-S/L FD Drawing No. 04-1000-1-00 Rev. F	1	Top Cover	Pass	Only effect was a minor dent.
B-82-6-S/L FD Drawing No. 01-2300-1-00 Rev. D	1	Top Cover	Pass	Only effect was a minor dent.
B-87-6-S/L FD Drawing No. 04-1300-1-00 Rev. B	Not tested	--	Pass	Evaluated by analysis and comparison to packaging B-96-6-S/L FD, whose top is constructed of materials of equal thickness.
B-96-6-S/L FD Drawing No. 04-1200-1-00 Rev. 0	1	Top cover	Pass	Only effect was a minor dent.
B-96-8-S/L FD Drawing No. 04-1200-2-00 Rev. 0	1	Top cover	Pass	Only effect was a minor dent.
B-96-5-S/L FD Drawing No. 01-2101-1-00 Rev. 0	1	Top	Pass	Only effect was a minor dent.
B-96-5-S/L RA Drawing No. 01-1901-1-00 Rev. 0	Not tested	--	Pass	Evaluated by analysis and comparison to packaging B-96-5-S/L FD, whose top is constructed of materials of equal thickness.
B-96-5-RA-B Drawing No. 01-2201-1-01 Rev. 0	Not tested	--	Pass	Evaluated by analysis and comparison to packaging B-96-5-S/L FD, whose top is constructed of materials of equal thickness.
467-C-S/L FD Drawing No. 01-	1	Top cover	Pass	Only effect was a minor dent.

3700-1-00 Rev. C				
RoGar Chemical and Nuclear Services				
Model R-1	Not tested	--	Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials of construction) to test package (Model R-3). All materials and methods of construction were equal to or better than those of the tested packaging.
Model R-2	Not tested	--	Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials of construction) to test package (Model R-3). All materials and methods of construction were equal to or better than those of the tested packaging.
Model R-3	1	Top cover	Pass	The only effect was a minor dent.
	1	Center of filter	Pass	The only effect was a minor dent.
Model R-4	Not tested	--	Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials of construction) to test package (Model R-3). All materials and methods of construction were equal to or better than those of the tested packaging.
Rocky Flats SAND Box				
Style 1	1	Top	1 pass	Other than a minor dent, there was no damage in any instance.
	1	Side	1 pass	
	1	Filter	1 pass	
Style 2	1	Top	1 pass	Other than a minor dent, there was no damage in any instance.
	1	Side	1 pass	
	1	Filter	1 pass	
Style 3	1	Top	1 pass	Other than a minor dent, there was no damage in any instance.
	1	Side	1 pass	
	1	Filter	1 pass	
Style 4	1	Top	1 pass	Other than a minor dent, there was no damage in any instance.
	1	Side	1 pass	
	1	Filter	1 pass	

ANL-E M-4 Bin	1	Top	1 pass	Other than a minor dent, there was no damage in any instance.
	1	Side	1 pass	
ANL-W 7A-960	1	Top	1 pass	Other than a minor dent, there was no damage in any instance.
TRUPACT-II - SWB	1	Center of cover	1 pass	There was no effect, not even a minor dent.
	1	Filter housing	1 pass	The filter housing was scuffed/scraped at the point of impact, but that was the only visible effect. An inspection with the ultraviolet light provided no indication of fluorescein.
ORNL Low-Level Waste Container Vented/Nonvented	1	Center of lid	1 pass	Slight indentation. Docket 89-04-7A

ANL-E = Argonne National Laboratory - East
ANL-W = Argonne National Laboratory - West
ORNL = Oak Ridge National Laboratory
SWB = Standard waste box
-- = Not applicable.

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Table D-33. Penetration Test Results for Wooden Boxes.				
Specific packaging	**Test/analysis results**			**Comments**
	No. tested	**Location**	**Results**	
ANL-W				
7A-217	1	Top	1 pass	Only effect was a minor dent in each case.
7A-375	1	Top	1 pass	
7A-880	1	Top	1 pass	
7A-995	1	Top	1 pass	
7A-1315	1	Top	1 pass	
7A-670	1	Top	1 pass	
LLNL				
Flush panel	1	Top	1 pass	Only effect was a minor dent.
Mound - Configuration A				
MA-1	1	Top	1 pass	Only effect was a minor dent in each case.
	1	Side	1 pass	
MA-2	1	Top	1 pass	Only effect was a minor dent in each case.
	1	Side	1 pass	
MA-3	1	Top	1 pass	Only effect was a minor dent in each case.
	1	Side	1 pass	
MA-4	1	Top	1 pass	Only effect was a minor dent in each case.
	1	Side	1 pass	
Mound - Configuration B				
MB-1	Not tested	--	--	Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
MB-2	1	Bottom	1 pass	Only effect was a minor dent in each case. The bottom was chosen because it was still wet at

	1	Side	1 pass	the time.
MB-3	Not tested	--	--	Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
MB-4	Not tested	--	--	Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
MB-5	Not tested	--	--	Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
MB-6	1	Top	1 pass	Only effect was a minor dent in each case.
	1	Side	1 pass	
Mound - Configuration C				
MC-1	1	Top	1 pass	Only effect was a minor dent in each case.
	1	Side	1 pass	
MC-2	1	Top	1 pass	Only effect was a minor dent in each case.
	1	Side	1 pass	
MC-3	1	Top	1 pass	Only effect was a minor dent in each case.
	1	Side	1 pass	
MC-4	1	Top	1 pass	Only effect was a minor dent in each case.
	1	Side	1 pass	
MC-5	1	Top	1 pass	Only effect was a minor dent in each case.
	1	Side	1 pass	
Mound - Configuration D				
MD-1	Not tested	--	--	Pass, based on testing of boxes of similar materials and construction methods.
MD-2	Not tested	--	--	Pass, based on testing of boxes of similar materials and construction methods.
MD-3	Not tested	--	--	Pass, based on testing of boxes of similar materials and construction methods.
MD-4	Not tested	--	--	Pass, based on testing of boxes of similar materials and construction methods.
MD-5	Not tested	--	--	Pass, based on testing of boxes of similar materials and construction methods.
MD-6	Not tested	--	--	Pass, based on testing of boxes of similar materials and construction methods.

Mound - Configuration E				
ME-1	1	Top	1 pass	Only effect was a minor dent in each case.
	1	Side	1 pass	
ME-2	1	Top	1 pass	Only effect was a minor dent in each case.
	1	Side	1 pass	
ME-3	1	Top	1 pass	Only effect was a minor dent in each case.
	1	Side	1 pass	
NLO Family of Banded Wooden Boxes				
G-4214	1	Top	1 pass	Only effect was a minor dent in each case.
G-4245	1	Top	1 pass	Only effect was a minor dent in each case.
G-4255	1	Top	1 pass	Only effect was a minor dent in each case.
G-4273	1	Top	1 pass	Only effect was a minor dent in each case.
G-4292	1	Top	1 pass	Only effect was a minor dent in each case.
Y-12 Series B				
B-1	1	Top	1 pass	All packages were water spray tested before testing. Only effect of the test was a minor dent in each case.
	1	Side	1 pass	
B-2	1	Top	1 pass	All packages were water spray tested before testing. Only effect of the test was a minor dent in each case.
	1	Side	1 pass	
B-3	1	Top	1 pass	All packages were water spray tested before testing. Only effect of the test was a minor dent in each case.
	1	Side	1 pass	
B-4	1	Top	1 pass	All packages were water spray tested before testing. Only effect of the test was a minor dent in each case.
	1	Side	1 pass	
B-5	1	Top	1 pass	All packages were water spray tested before testing. Only effect of the test was a minor dent in each case.
	1	Side	1 pass	
B-6	1	Top	1 pass	All packages were water spray tested before testing. Only effect of the test was a minor dent in each case.
	1	Side	1 pass	
B-7	1	Top	1 pass	All packages were water spray tested before testing. Only effect of the test was a minor dent in each case.
	1	Side	1 pass	
B-8	1	Top	1 pass	All packages were water spray tested before

	1	Side	1 pass	testing. Only effect of the test was a minor dent in each case.
Y-12 Picture Frame				
PF-1	1	Top center	1 pass	Only effect was a minor dent in each case.
	1	Top edge	1 pass	
PF-2	Not tested	--	--	Pass, based on testing of boxes of similar materials and construction methods.
PF-3	Not tested	--	--	Pass, based on testing of boxes of similar materials and construction methods.
PF-4	Not tested	--	--	Pass, based on testing of boxes of similar materials and construction methods.
PF-5	1	Top center	1 pass	Only effect was a minor dent in each case.
	1	Top edge	1 pass	
PF-6	1	Top center	1 pass	Only effect was a minor dent in each case.
	1	Top edge	1 pass	
PF-7	Not tested	--	--	Pass, based on testing of boxes of similar materials and construction methods.
PF-8	Not tested	--	--	Pass, based on testing of boxes of similar materials and construction methods.
PF-10	1	Top center	1 pass	Only effect was a minor dent.
	1	Top edge	1 pass	
Rocky Flats RA Series				
Configuration 1	1	Top	1 pass	Only effect was a minor dent in each case. Docket 89-01-7A
Configuration 2	1	Top	1 pass	
ORNL Y-12 C-Series				
C-1	1	Top	1 pass	Minor dent.
C-2	1	Top	1 pass	Minor dent.
C-3	1	Top	1 pass	Minor dent.
Y-12 C-280	1	Top center	Pass	Only effect was a 1/16-in. dent.
		Cover near latch	Pass	Only effect was a 1/4-in. dent.
		Right latch	Pass	Only effect was a minor dent. Latch did not loosen.

Y-12 C-400	1	Top center	Pass	Only effect was a 1/32-in. dent.
		Cover at latch	Pass	No effect.
		Side near latch	Pass	Only effect was a 1/16-in. dent.
		Side at latch	Pass	Only effect was a 1/8-in. dent.
Y-12 C-600	--	Engineering analysis (EA)	Pass	The test was not done because tests on similar packagings as shown above (C-280 and C-400) demonstrate that this test has very little effect and would pass this test since the materials and methods of construction are the same.
Y-12 C-1000	--	EA	Pass	Same as above (C-600). Docket 89-09-7A
WMCO Banded Wooden Boxes				
G-4214	1	Top	1 pass	Only effect was a minor imprint in lid.
G-4245	1	Top	1 pass	Minor indentation and slight cracking of lid.
G-4255	1	Top	1 pass	Only effect was a minor imprint in lid.
G-4273-5	1	Top	1 pass	Only effect was a minor imprint in lid.
G-4273-6	1	Top	1 pass	Only effect was a minor imprint in lid.
G-4292	1	Top	1 pass	Only effect was a minor imprint in lid.

ANL-W = Argonne National Laboratory - West
LLNL = Lawrence Livermore National Laboratory
NLO = National Lead Corporation
ORNL = Oak Ridge National Laboratory
WMCO = Westinghouse Materials Company of Ohio
-- = Not applicable.

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Table D-34. Penetration Test Results for Fiberboard Containers.

Specific packaging	Test/analysis results			Comments
	No. tested	Location	Results	
12B-65 Fiberboard Boxes				
1	1	Bottom	Pass	No penetration. Only effect was a minor dent in each case.
	1	Top	Pass	
	1	Side	Pass	
2	1	Side	Pass	No penetration.
3	Not tested	--	--	Pass, based on testing of boxes of similar materials and construction methods.
4	1	Top	Pass	Penetration.
	1	Side	Pass	Penetration.
5	1	Top	Pass	No penetration. Only effect was a minor dent in each case.
	1	Side	Pass	
6	1	Top	Pass	Penetration.
	1	Side	Pass	Penetration.
7	1	Top	Pass	Penetration. Only effect was a minor dent in each case.
	1	Side	Pass	
8	1	Top	Pass	Penetration.
	1	Side	Pass	Penetration.
9	1	Top	Pass	No penetration. Only effect was a minor dent in each case.
	1	Side	Pass	
10	1	Top	Pass	Penetration. Only effect was a minor dent in each case.
	1	Side	Pass	
11	Not tested	--	--	Pass, based on testing of boxes of similar materials and construction methods.

12	1	Top	Pass	Penetration. Only effect was a minor dent in each case.
	1	Side	Pass	
13	1	Top	Pass	No penetration on top. Penetration on side. Only effect was a minor dent in each case.
			Pass	
12B-10 with inner metal can	1	Top	Pass	Bar made 0.5-in. dent in inner can in each case. A leak check (air) of the can in each case demonstrated continued leak tightness.
		Side	Pass	
Tri-Wall Fiberboard Box				
	1	Top	Pass	Penetration.
	1	Side	Pass	Penetration.
21C Fiberboard Drums				
1	1	Top	Pass	No penetration in either case.
	1	Side	Pass	
2	1	Top	Pass	No penetration in either case.
	1	Side	Pass	
3	1	Top	Pass	No penetration in either case.
	1	Side	Pass	
4	1	Top	Pass	No penetration on top. Penetration on side.
	1	Side	Pass	
5	1	Top	Pass	No penetration on top. Penetration on side.
	1	Side	Pass	
6	1	Top	Pass	No penetration in either case.
	1	Side	Pass	
-- = Not applicable.				

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Table D-35. Penetration Test Results for UF_6 Cylinders.	
Specific packaging	**Test/analysis results**
Model No.	
1S	Evaluated based on the materials and material thicknesses and by comparison to test data shown for much lesser thicknesses. This test would not have any effect (as verified by testing) on the sides of these cylinders. Testing was also conducted to demonstrate that this test, when conducted on the valve assembly/assembly cover, would also have no effect. Thus, all these cylinders meet this requirement.
2S	
5A	
8A	
12A	
12B	
30A	
30B	
48G	
48H	
48HX	
48X	
48Y	
Modified	
5A	Two penetration impacts were performed on two test unit packages. Each resulted in only a slight impression. [Docket 89-08-7A]
5B	

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Table D-36. Penetration Test Results for Liquid and Gas Packagings.

Specific packaging	Test/analysis results			Comments
	No. tested	Location	Results	
Steel Drum MS-24347-7	--	--	--	Pass, based on test data shown on Table D-31.
LANL 12B-62 Fiberboard Box	1	Top	1 pass	There was penetration in both tests, but the bar did not contact the inner container in either case.
	1	Side	1 pass	
LLNL Steel Drums with Gas Cylinders	--	--	--	Pass, based on test data shown on Table D-31.
ORNL Fiberboard Box - Liquids and Solids	1	Top (center)	1 pass	A nonpenetrating deformation of the wet cardboard box and a 0.55-in.-deep by 0.75-in.-diameter indentation in the top of the inner metal can.
ORNL Fiberboard Box - Gases	1	Top (center)	1 pass	A nonpenetrating deformation of the wet cardboard box and a 0.55-in.-deep by 0.75-in.-diameter indentation in the top of the inner can.
ORNL Fiberboard Box - Liquids and Solids	1	Top (center)	1 pass	A nonpenetrating deformation of the wet cardboard box and a 0.55-in.-deep by 0.75-in.-diameter indentation in the top of the inner metal can.
ORNL Wooden Box Returnable, Shielded	1	Top (center)	1 pass	Minor, nonpenetrating dent.
ORNL Gas Cylinder Returnable (Hoke Cylinders)				
HOH-50	1	Top (center of protective valve	1 pass	This test was conducted on the HOKr 1000-mL cylinder (which is not listed), but the results can be

HOXe-50		cap)		used to evaluate the smaller packagings.
HOKr-50				
HOH-150				
HOXe-150				
HOKr-150				
HOH-300				
HOKr-300				
HOH-500				
HPKr-500				
ORNL Gas Cylinder Returnable (J. L. Shephard)				
Cylinder 1	--	--	Pass	Evaluated based on testing conducted by ORNL, letter dated April 30, 1985, D. M. Ferren/D. A. Edling.
Cylinder 2				
Cylinder 3				
LLNL Old Spec 55	2	Lid bolts	2 pass	No detectable effect other than a scratch.
ORNL TRU Shipping Container	1	Top	1 pass	Only effect was a minor dent in each case.
	1	Side	1 pass	
FEMA Source Overpack	1	Top	1 pass	Only effect was a minor scratch.
LANL-2	1	Lid at Center	1 pass	0.125-in. dent
	1	Side at Seam	1 pass	0.125-in. dent
	1	Lid near closure ring	1 pass	0.055-in. dent
WHC Liquid Sample	1	Top	1 pass	Movement of surface inward was less than 1.27 cm (1/2 in.).
		Side	1 pass	Movement of surface inward was less than 1.6 cm (5/8 in.).
SRP Process Water Packaging	1	Top center	1 pass	No significant distortion.
RF Container Model	1	Top center	1 pass	Movement of surface inward was less than 2.54 cm (1 in.).
		Side	1 pass	Movement of surface inward was less than 2.54 cm (1 in.).

EG&G Mound Applied Technologies Commercial Tritium Packaging (10, 50, 150, 300 and 500 cc)	4	Top center	Pass	Only effect was a mark, not measurable.
		Left hatch	Pass	Dent in latch.
		Bottom of hinge/ back side	Pass	Dent, nonmeasurable.
		Top of hinge/ back side	Pass	Dent, nonmeasurable.
	4	Top 5.08 cm (2 in.) from back	Pass	Package split and bar entered, but did not contact cylinder because of foam.
		Left latch	Pass	Dent in latch.
		Hinge in back	Pass	Dent, nonmeasurable.
		On valve	Pass	Bent valve slightly.
WHC Grout Sample Packaging	1	Bottom center	1 pass	Movement of surface inward was less than 0.635 cm (1/4 in.).
	1	Side	1 pass	Movement of surface inward was less than 0.397 cm (5/32 in.).
EG&G Mound Lewis Gas Packaging	2	Impact at center of drum lid	1 pass	Only effect was a 0.635-cm (1/4-in.) dent at point of impact.
		Impact at middle of side of drum	1 pass	Only effect was a 2.54-cm (1-in.) dent at point of impact.
WHC Hedgehog Container				
1-m (3.3 ft)	1	Between center and edge bumper of lid of Hardigg Case[a]	Pass	No significant distortion. Indented 0.594-cm (0.234-in.) deep and 1.9-cm (0.75-in.) across at point of impact.
1.7-m (5.5 ft)	1	Between center and edge bumper of lid of Hardigg Case	Pass	No significant distortion. Indented 0.879-cm (0.346-in.) deep and 1.9-cm (0.75-in.) across at point of impact.
WHC 1-L Liquid Shipper				
1-m (3.3-ft)	1	SafeSend locking mechanism	Pass	Test unit 41-TU-11 was used for this test. The SafeSend container was laid on its horizontal side. The locking mechanism broke off and shattered. No significant distortion and no further damage occurred to the SafeSend. [Docket 95-41-7A]
1.7-m (5.5-ft)	1	Center of SafeSend sidewall	Pass	Test unit 41-TU-11 was used for this test. The SafeSend container was laid on its horizontal side. A slight indentation measuring 0.3175-cm (0.125-in) deep and 3.81-cm (1.50-in) across occurred to the outside wall of the SafeSend at the point of impact. [Docket 95-41-7A]

[a]Hardigg Case is a trademark of Hardigg Industries, Inc.
FEMA = Federal Emergency Management Agency.
LANL = Los Alamos National Laboratory.
LLNL = Lawrence Livermore National Laboratory.
ORNL = Oak Ridge National Laboratory.
RF = Rocky Flats.
TRU = Transuranic.
SRP = Savannah River Plant.
WHC = Westinghouse Hanford Company.
-- = Not applicable.

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Table D-37. Penetration Test Results for Miscellaneous Packagings.				
Specific packaging	**Test/analysis results**			**Comments**
	No. tested	**Location**	**Results**	
SNL Tritium Waste Package	--	--	--	Pass, based on test data shown on Table D-31.
LANL Aluminum Packaging (LANL-1)	1	Top of cover	Pass	There was no measurable dent.
	1	Flange	Pass	There was no measurable dent.
	1	Eyebolt	Pass	There was no measurable dent.
WIPP RH-TRU Canister	1	Top center	Pass	Slight depression.
	1	Side center	Pass	Slight depression. [Docket 89-03-7A]
Packaging for Special Form Neutron Source	1	End piece	Pass	Slight depression. [Docket 91-26-7A]
TRUPACT II Ten-Drum Overpack	1	Top center	Pass	Slight depression. Further testing was not necessary for tests conducted on 10/28/93 as it was determined that the design modifications would not have any negative effect on testing conducted previously. [Test Package 130408, tested 7/27/90, Docket 90-16-7A]
	1	Side	Pass	Slight depression. Further testing was not necessary for tests conducted on 10/28/93 as it was determined that the design modifications would not have any negative effect on testing conducted previously. [Test Package 130408, tested 7/27/90, Docket 90-16-7A]
INEL Mark III Concrete	1	Vent plug in lid	Pass	There was no measurable damage. [Docket 92-33-7A]

Container				
INEL ARROW-PAK Packaging	1	Center of cylindrical tube/side	Pass	The point of impact caused a slight dimple measuring 1.27-cm (0.50-in) across. [Docket 95-40-7A]

INEL = Idaho National Engineering Laboratory.
LANL = Los Alamos National Laboratory.
RH-TRU = Remotely handled transuranic.
SNL = Sandia National Laboratory.
TRUPACT = Transuranic package transporter.
WIPP = Waste Isolation Pilot Plant.
-- = Not applicable.

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Table E-1. Steel Drums--Compliance With Vibration Standard (49 CFR 178.608).

Specific packaging	No. tested	Weight (lb)	Contents	Results	Comments
Packagings for dockets in this category that are pre-HM-181 are considered to be acceptable based on evaluation and/or by comparison with similar packagings.					
DOT-17C (UN1A2) (55-gal)	2	1,000	Sand and lead bricks	2 pass	Drums were observed for leakage at filter location, ring and bolt location, and bottom of drum; nothing was detected.
	1	900	Flour/fluorescein sand, lead bricks	1 pass	Drums were observed for leakage at filter location, ring and bolt location, and bottom of drum; nothing was detected.

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Table E-2. Steel Boxes--Compliance With Vibration Standard (49 CFR 178-608).					
Specific packaging	**No. tested**	**Weight (lb)**	**Contents**	**Results**	**Comments**
Packagings for dockets in this category that are pre-HM-181 are considered to be acceptable based on evaluation and/or by comparison with similar packagings.					

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Table E-3. Wooden Boxes--Compliance With Vibration Standard (49 CFR 178-608).					
Specific packaging	**No. tested**	**Weight (lb)**	**Contents**	**Results**	**Comments**
Packagings for dockets in this category that are pre-HM-181 are considered to be acceptable based on evaluation and/or by comparison with similar packagings.					

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Table E-4. Fiberboard Containers--Compliance With Vibration Standard (49 CFR 178-608).					
Specific packaging	**No. tested**	**Weight (lb)**	**Contents**	**Results**	**Comments**
Packagings for dockets in this category that are pre-HM-181 are considered to be acceptable based on evaluation and/or by comparison with similar packagings.					

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Table E-5. UF_6 Cylinders--Compliance With Vibration Standard (49 CFR 178-608).					
Specific packaging	**No. tested**	**Weight (lb)**	**Contents**	**Results**	**Comments**
Packagings for dockets in this category that are pre-HM-181 are considered to be acceptable based on evaluation and/or by comparison with similar packagings.					

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Table E-6. Liquid and Gas Packagings--Compliance With Vibration Standard (49 CFR 178-608).

Specific packaging	No. tested	Weight kg (lb)	Contents	Results	Comments
Packagings for dockets in this category that are pre-HM-181 are considered to be acceptable based on evaluation and/or by comparison with similar packagings.					
WHC Hedgehog Container					
1-L version	1	18.1 (40)	Steel shot, water, and fluorescein	Pass	No loosening of lids or component parts. Slight indication of rubbing on interior foam on Hardigg Case[a] lid. No significant damage and no loss of material.
250 mL-version	1	24.0 (53)	Steel shot, water, and fluorescein	Pass	No loosening of lids or component parts. Slight indication of rubbing on interior foam on Hardigg Case lid. No significant damage and no loss of material.
30-mL version	1	28.6 (63)	Steel shot, water, and fluorescein	Pass	No loosening of lids or component parts. Slight indication of rubbing on interior foam on Hardigg Case lid. No significant damage and no loss of material.
					The 125-mL version was not tested due to its similarity with

					the 30- and 250-mL versions. Based on evaluation, no significant damage and no loss of material should occur.
WHC 1-L Liquid Shipper	6	3830.5 (8.4)	Steel shot, water, and fluorescein	Pass	No observable damage and no loss of material from any test units. [Docket 95-41-7A]
[a]Hargigg Case is a trademark of Hardigg Industries, Inc.					

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Table E-7. Miscellaneous Packagings--Compliance with Vibration Standard (49 CFR 178-608).

Specific packaging	No. tested	Weight kg (lb)	Contents	Results	Comments
Packaging for dockets in this category that are pre HM-181 are considered to be acceptable based on evaluation and/or by comparison with similar packagings.					
INEL ARROW-PAK	1	519.8 (1146)	Wrapped lead bricks, steel shot, and fluorescein	Pass	Test unit 40-TU-01: Fusion joints flattened 2.54 to 3.175-cm (1 to 1.25-in) across a 10.16-cm (4-in) length on one end of the packaging, and measured 1.905 to 2.54-cm (0.75 to 1-in) across an 8.255-cm (3.25-in) length on the opposite end of the packaging. There was no loss of material from the package. [Docket 95-40-7A].
	1	507.6 (1119)	Wrapped lead bricks, steel shot, and fluorescein	Pass	Test unit 40-TU-02: Fusion joints flattened 2.54 to 3.175-cm (1 to 1.25-in) across a 8.89-cm (3.5-in) length on one end of the packaging, and measured 1.905 to 2.54-cm (0.75 to 1-in) across a 7.62-cm (3.0-in) length on the opposite end of the packaging. There was no loss of material from the package. [Docket 95-40-7A].
WHC WRAP-1	1	468 (1032)	Sand/soil, lead bricks, flour, and fluorescein	Pass	No observed damage to drum, no indication of distortion of sealing

Drum					area, and no release of contents under visual and UV light inspection. [Docket 94-35-7A]
					Note: Refer to Table E-1 for additional testing information regarding the DOT-17C drum tested under docket 94-37-7A.

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Table F-1. Steel Drums--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). Post-HM-181 (Post-October 1994).		
Regulatory requirement: 49 CFR 173.24	**Action required/by whom**	**Packaging category--steel drums**
(a) Applicability. Except as otherwise provided in this subchapter, the provisions of this section apply to--		All packagings described have been tested and/or evaluated and meet DOT-7A Type A packaging criteria.
(1) Bulk and non-bulk packagings;	To be considered during package design evaluation. Shipper responsibility to ensure.	
(2) New packagings and packagings that are reused; and		
(3) Specification and non-specification packagings.		
(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	To be considered during package	All packagings met the intent of this

otherwise provided in this subchapter, there will be no identifiable (without the use of instruments) release of hazardous materials to the environment;	design evaluation. Shipper responsibility to ensure.	requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.411, .412, .465, and/or .466 as demonstrated in Section 2.0 and Appendices B, C, and D.
(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;	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	NOTE: Shipper responsibility to consider and evaluate, if necessary, the effect of the content.
(3) There will be no mixture of gases or vapors in the package that could, through any credible spontaneous increase of heat or pressure, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(c) Authorized packagings. A packaging is authorized for a hazardous material only if--		
(1) The packaging is prescribed or	Shipper responsibility to ensure that packagings used are in compliance	All packagings described have been qualified to meet Specification 7A

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 spacial provisions of Column 7 of the section 172.101 Table and, for specification packagings (including UN standard packagings), the specification requirements in parts 178 and 179 of this subchapter; or	with the design.	packaging requirements in accordance with 49 CFR 178.350.
(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 chapter.		
(d) DOT specification and UN standard packagings. For DOT specification packagings (including UN standard packagings), conformance to the applicable specifications in parts 178 and 179 of this subchapter is required in all	Shipper responsibility to ensure that packagings used are in compliance with the design.	All packagings described have been qualified to meet Specification 7A packaging requirements in accordance with 49 CFR 178.350.

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.		
(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.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Packaging materials and contents must be such that there will be so significant chemical or	Shipper responsibility to ensure.	Shipper responsibility to ensure.

galvanic reaction between the materials and contents of the package.		
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) Each plastic packaging or receptacle that 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;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Shipper responsibility to ensure.	Shipper responsibility to ensure.

specifically approved by the Associate Administrator for Hazardous Materials Safety.		
(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;	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) Evolution of flammable or poisonous gases; or		
(iii) Formation of unstable or corrosive materials.		
(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.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(g) Venting. Venting of packagings, to reduce internal pressure that may develop by the evolution of gas from the contents, is permitted only when--		

(1) Transportation by aircraft is not involved;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.		
(h) Outage and filling limits--		
(1) *General*. When filling packagings and receptacles for liquids, sufficient ullage (outage) must be left to ensure that neither	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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 sections 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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table F-2. Steel Boxes--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). Post-HM-181 (Post-October 1994).		
Regulatory requirement: 49 CFR 173.24	**Action required/by whom**	**Packaging category--steel boxes**
(a) Applicability. Except as otherwise provided in this subchapter, the provisions of this section apply to--		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(1) Bulk and non-bulk packagings;	To be considered during package design evaluation. Shipper responsibility to ensure.	
(2) New packagings and packagings that are reused; and		
(3) Specification and non-specification packagings.		
(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	To be considered during package	

otherwise provided in this subchapter, there will be no identifiable (without the use of instruments) release of hazardous materials to the environment;	design evaluation. Shipper responsibility to ensure.	
(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;	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	
(3) There will be no mixture of gases or vapors in the package that could, through any credible spontaneous increase of heat or pressure, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(c) Authorized packagings. A packaging is authorized for a hazardous material only if--		
(1) The packaging is prescribed or	Shipper responsibility to ensure that packagings used are in compliance	

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 spacial provisions of Column 7 of the section 172.101 Table and, for specification packagings (including UN standard packagings), the specification requirements in parts 178 and 179 of this subchapter; or	with the design.	
(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 chapter.		
(d) DOT specification and UN standard packagings. For DOT specification packagings (including UN standard packagings), conformance to the applicable specifications in parts 178 and 179 of this subchapter is required in all	Shipper responsibility to ensure that packagings used are in compliance with the design.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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.		
(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.	Shipper responsibility to ensure.	
(2) Packaging materials and contents must be such that there will be so significant chemical or	Shipper responsibility to ensure.	

galvanic reaction between the materials and contents of the package.		
(3) Plastic packagings and receptacles.		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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.	Designer to do and shipper responsibility to ensure.	
(ii) Each plastic packaging or receptacle that 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;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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	Shipper responsibility to ensure.	

specifically approved by the Associate Administrator for Hazardous Materials Safety.		
(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;	Shipper responsibility to ensure.	
(ii) Evolution of flammable or poisonous gases; or		
(iii) Formation of unstable or corrosive materials.		
(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.	Shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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	Designer to do and shipper responsibility to ensure.	
(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.	Designer to do and shipper responsibility to ensure.	
(g) Venting. Venting of packagings, to reduce internal pressure that may develop by the evolution of gas from the contents, is permitted only when--		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

(1) Transportation by aircraft is not involved;	Designer to do and shipper responsibility to ensure.	
(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.		
(h) Outage and filling limits--		NOTE: Packaging category compliance information will be added for this packaging types upon completion of testing for this packaging type.
(1) *General*. When filling packagings and receptacles for liquids, sufficient ullage (outage) must be left to ensure that neither	Designer to do and shipper responsibility to ensure.	

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 sections 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.	Designer to do and shipper responsibility to ensure.	
(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.	Shipper responsibility to ensure.	

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Table F-3. Wooden Boxes--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). Post-HM-181 (Post-October 1994).		
Regulatory requirement: 49 CFR 173.24	**Action required/by whom**	**Packaging category--wooden boxes**
(a) Applicability. Except as otherwise provided in this subchapter, the provisions of this section apply to--		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(1) Bulk and non-bulk packagings;	To be considered during package design evaluation. Shipper responsibility to ensure.	
(2) New packagings and packagings that are reused; and		
(3) Specification and non-specification packagings.		
(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	To be considered during package	

otherwise provided in this subchapter, there will be no identifiable (without the use of instruments) release of hazardous materials to the environment;	design evaluation. Shipper responsibility to ensure.	
(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;	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	
(3) There will be no mixture of gases or vapors in the package that could, through any credible spontaneous increase of heat or pressure, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(c) Authorized packagings. A packaging is authorized for a hazardous material only if--		
(1) The packaging is prescribed or	Shipper responsibility to ensure that packagings used are in compliance	

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 spacial provisions of Column 7 of the section 172.101 Table and, for specification packagings (including UN standard packagings), the specification requirements in parts 178 and 179 of this subchapter; or	with the design.	
(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 chapter.		
(d) DOT specification and UN standard packagings. For DOT specification packagings (including UN standard packagings), conformance to the applicable specifications in parts 178 and 179 of this subchapter is required in all	Shipper responsibility to ensure that packagings used are in compliance with the design.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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.		
(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.	Shipper responsibility to ensure.	
(2) Packaging materials and contents must be such that there will be so significant chemical or	Shipper responsibility to ensure.	

galvanic reaction between the materials and contents of the package.		
(3) Plastic packagings and receptacles.		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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.	Designer to do and shipper responsibility to ensure.	
(ii) Each plastic packaging or receptacle that 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;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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	Shipper responsibility to ensure.	

specifically approved by the Associate Administrator for Hazardous Materials Safety.		
(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;	Shipper responsibility to ensure.	
(ii) Evolution of flammable or poisonous gases; or		
(iii) Formation of unstable or corrosive materials.		
(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.	Shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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	Designer to do and shipper responsibility to ensure.	
(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.	Designer to do and shipper responsibility to ensure.	
(g) Venting. Venting of packagings, to reduce internal pressure that may develop by the evolution of gas from the contents, is permitted only when--		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

(1) Transportation by aircraft is not involved;	Designer to do and shipper responsibility to ensure.	
(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.		
(h) Outage and filling limits--		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(1) *General*. When filling packagings and receptacles for liquids, sufficient ullage (outage) must be left to ensure that neither	Designer to do and shipper responsibility to ensure.	

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 sections 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.	Designer to do and shipper responsibility to ensure.	
(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.	Shipper responsibility to ensure.	

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Table F-4. Fiberboard Containers--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). Post-HM-181 (Post-October 1994).		
Regulatory requirement: 49 CFR 173.24	**Action required/by whom**	**Packaging category--fiberboard containers**
(a) Applicability. Except as otherwise provided in this subchapter, the provisions of this section apply to--		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(1) Bulk and non-bulk packagings;	To be considered during package design evaluation. Shipper responsibility to ensure.	
(2) New packagings and packagings that are reused; and		
(3) Specification and non-specification packagings.		
(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	To be considered during package	

otherwise provided in this subchapter, there will be no identifiable (without the use of instruments) release of hazardous materials to the environment;	design evaluation. Shipper responsibility to ensure.	
(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;	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	
(3) There will be no mixture of gases or vapors in the package that could, through any credible spontaneous increase of heat or pressure, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(c) Authorized packagings. A packaging is authorized for a hazardous material only if--		
(1) The packaging is prescribed or	Shipper responsibility to ensure that packagings used are in compliance	

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 spacial provisions of Column 7 of the section 172.101 Table and, for specification packagings (including UN standard packagings), the specification requirements in parts 178 and 179 of this subchapter; or	with the design.	
(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 chapter.		
(d) DOT specification and UN standard packagings. For DOT specification packagings (including UN standard packagings), conformance to the applicable specifications in parts 178 and 179 of this subchapter is required in all	Shipper responsibility to ensure that packagings used are in compliance with the design.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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.		
(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.	Shipper responsibility to ensure.	
(2) Packaging materials and contents must be such that there will be so significant chemical or	Shipper responsibility to ensure.	

galvanic reaction between the materials and contents of the package.		
(3) Plastic packagings and receptacles.		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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.	Designer to do and shipper responsibility to ensure.	
(ii) Each plastic packaging or receptacle that 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;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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	Shipper responsibility to ensure.	

specifically approved by the Associate Administrator for Hazardous Materials Safety.		
(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;	Shipper responsibility to ensure.	
(ii) Evolution of flammable or poisonous gases; or		
(iii) Formation of unstable or corrosive materials.		
(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.	Shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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	Designer to do and shipper responsibility to ensure.	
(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.	Designer to do and shipper responsibility to ensure.	
(g) Venting. Venting of packagings, to reduce internal pressure that may develop by the evolution of gas from the contents, is permitted only when--		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

(1) Transportation by aircraft is not involved;	Designer to do and shipper responsibility to ensure.	
(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.		
(h) Outage and filling limits--		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(1) *General*. When filling packagings and receptacles for liquids, sufficient ullage (outage) must be left to ensure that neither	Designer to do and shipper responsibility to ensure.	

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 sections 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.	Designer to do and shipper responsibility to ensure.	
(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.	Shipper responsibility to ensure.	

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Table F-5. UF_6--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). Post-HM-181 (Post-October 1994).		
Regulatory requirement: 49 CFR 173.24	**Action required/by whom**	**Packaging category--UF_6**
(a) Applicability. Except as otherwise provided in this subchapter, the provisions of this section apply to--		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(1) Bulk and non-bulk packagings;	To be considered during package design evaluation. Shipper responsibility to ensure.	
(2) New packagings and packagings that are reused; and		
(3) Specification and non-specification packagings.		
(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	To be considered during package	

otherwise provided in this subchapter, there will be no identifiable (without the use of instruments) release of hazardous materials to the environment;	design evaluation. Shipper responsibility to ensure.	
(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;	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	
(3) There will be no mixture of gases or vapors in the package that could, through any credible spontaneous increase of heat or pressure, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(c) Authorized packagings. A packaging is authorized for a hazardous material only if--		
(1) The packaging is prescribed or	Shipper responsibility to ensure that packagings used are in compliance	

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 spacial provisions of Column 7 of the section 172.101 Table and, for specification packagings (including UN standard packagings), the specification requirements in parts 178 and 179 of this subchapter; or	with the design.	
(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 chapter.		
(d) DOT specification and UN standard packagings. For DOT specification packagings (including UN standard packagings), conformance to the applicable specifications in parts 178 and 179 of this subchapter is required in all	Shipper responsibility to ensure that packagings used are in compliance with the design.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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.		
(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.	Shipper responsibility to ensure.	
(2) Packaging materials and contents must be such that there will be so significant chemical or	Shipper responsibility to ensure.	

galvanic reaction between the materials and contents of the package.		
(3) Plastic packagings and receptacles.		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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.	Designer to do and shipper responsibility to ensure.	
(ii) Each plastic packaging or receptacle that 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;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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	Shipper responsibility to ensure.	

specifically approved by the Associate Administrator for Hazardous Materials Safety.		
(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;	Shipper responsibility to ensure.	
(ii) Evolution of flammable or poisonous gases; or		
(iii) Formation of unstable or corrosive materials.		
(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.	Shipper responsibility to ensure.	NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(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	Designer to do and shipper responsibility to ensure.	
(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.	Designer to do and shipper responsibility to ensure.	
(g) Venting. Venting of packagings, to reduce internal pressure that may develop by the evolution of gas from the contents, is permitted only when--		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

(1) Transportation by aircraft is not involved;	Designer to do and shipper responsibility to ensure.	
(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.		
(h) Outage and filling limits--		NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.
(1) *General*. When filling packagings and receptacles for liquids, sufficient ullage (outage) must be left to ensure that neither	Designer to do and shipper responsibility to ensure.	

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 sections 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.	Designer to do and shipper responsibility to ensure.	
(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.	Shipper responsibility to ensure.	

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Table F-6. Liquid and Gas Packagings--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). Post-HM-181 (Post-October 1994).		
Regulatory requirement: 49 CFR 173.24	**Action required/by whom**	**Packaging category--liquid and gas**
(a) Applicability. Except as otherwise provided in this subchapter, the provisions of this section apply to--		
(1) Bulk and non-bulk packagings;	To be considered during package design evaluation. Shipper responsibility to ensure.	All packagings described have been tested and/or evaluated and meet DOT-7A Type A packaging criteria.
(2) New packagings and packagings that are reused; and		
(3) Specification and non-specification packagings.		
(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	To be considered during package	All packagings met the intent of this

otherwise provided in this subchapter, there will be no identifiable (without the use of instruments) release of hazardous materials to the environment;	design evaluation. Shipper responsibility to ensure.	requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.411, .412, .465, and/or .466 as demonstrated in Section 7.0 and Appendices B, C, and D.
(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;	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.411, .412, .465, and/or .466 as demonstrated in Section 7.0 and Appendices B, C, and D. Note: Shipper responsibility to consider and evaluate, if necessary, the effect of the contents.
(3) There will be no mixture of gases or vapors in the package that could, through any credible spontaneous increase of heat or pressure, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(c) Authorized packagings. A packaging is authorized for a hazardous material only if--		
(1) The packaging is prescribed or	Shipper responsibility to ensure that packagings used are in compliance	All packagings described have been qualified to meet Specification 7A

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 spacial provisions of Column 7 of the section 172.101 Table and, for specification packagings (including UN standard packagings), the specification requirements in parts 178 and 179 of this subchapter; or	with the design.	packaging requirements in accordance with 49 CFR 178.350.
(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 chapter.		
(d) DOT specification and UN standard packagings. For DOT specification packagings (including UN standard packagings), conformance to the applicable specifications in parts 178 and 179 of this subchapter is required in all	Shipper responsibility to ensure that packagings used are in compliance with the design.	All packagings described have been qualified to meet Specification 7A packaging requirements in accordance with 49 CFR 178.350.

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.		
(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.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Packaging materials and contents must be such that there will be so significant chemical or	Shipper responsibility to ensure.	Shipper responsibility to ensure.

galvanic reaction between the materials and contents of the package.		
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) Each plastic packaging or receptacle that 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;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Shipper responsibility to ensure.	Shipper responsibility to ensure.

specifically approved by the Associate Administrator for Hazardous Materials Safety.		
(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;	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) Evolution of flammable or poisonous gases; or		
(iii) Formation of unstable or corrosive materials.		
(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.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(g) Venting. Venting of packagings, to reduce internal pressure that may develop by the evolution of gas from the contents, is permitted only when--		

(1) Transportation by aircraft is not involved;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.		
(h) Outage and filling limits--		
(1) *General*. When filling packagings and receptacles for liquids, sufficient ullage (outage) must be left to ensure that neither	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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 sections 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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table F-7. Miscellaneous Packagings--Compliance with General Requirements for Packages and Packaging (49 CFR 173.24). Post-HM-181 (Post-October 1994).		
Regulatory requirement: 49 CFR 173.24	**Action required/by whom**	**Packaging category--miscellaneous**
(a) Applicability. Except as otherwise provided in this subchapter, the provisions of this section apply to--		
(1) Bulk and non-bulk packagings;	To be considered during package design evaluation. Shipper responsibility to ensure.	All packagings described have been tested and/or evaluated and meet DOT-7A Type A packaging criteria.
(2) New packagings and packagings that are reused; and		
(3) Specification and non-specification packagings.		
(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	To be considered during package	All packagings met the intent of this

otherwise provided in this subchapter, there will be no identifiable (without the use of instruments) release of hazardous materials to the environment;	design evaluation. Shipper responsibility to ensure.	requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.411, .412, .465, and/or .466 as demonstrated in Section 8.0 and Appendices B, C, and D.
(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;	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 49 CFR 173.411, .412, .465, and/or .466 as demonstrated in Section 8.0 and Appendices B, C, and D.
		Note: Shipper responsibility to consider and evaluate, if necessary, the effect of the contents.
(3) There will be no mixture of gases or vapors in the package that could, through any credible spontaneous increase of heat or pressure, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(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 spacial provisions of Column 7 of the section 172.101 Table and, for specification packagings (including UN standard packagings), the specification requirements in parts 178 and 179 of this subchapter; or	Shipper responsibility to ensure that packagings used are in compliance with the design.	All packagings described have been qualified to meet Specification 7A packaging requirements in accordance with 49 CFR 178.350.
(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 chapter.		
(d) DOT specification and UN standard packagings. For DOT specification packagings (including UN standard packagings), conformance to the applicable	Shipper responsibility to ensure that packagings used are in compliance with the design.	All packagings described have been qualified to meet Specification 7A packaging requirements in accordance with 49 CFR 178.350.

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.		
(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.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Packaging materials and contents must be	Shipper responsibility to ensure.	Shipper responsibility to ensure.

such that there will be so significant chemical or galvanic reaction between the materials and contents of the package.		
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) Each plastic packaging or receptacle that 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;	Designer, tester, and evaluator to do; shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Shipper responsibility to ensure.	Shipper responsibility to ensure.

that provided by paragraph (e)(3)(ii) of this section and are specifically approved by the Associate Administrator for Hazardous Materials Safety.		
(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;	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) Evolution of flammable or poisonous gases; or		
(iii) Formation of unstable or corrosive materials.		
(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	Shipper responsibility to ensure.	Shipper responsibility to ensure.

in the liquid state.		
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(g) Venting. Venting of packagings, to reduce internal pressure that may develop by the		

evolution of gas from the contents, is permitted only when--		
(1) Transportation by aircraft is not involved;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.		
(h) Outage and filling limits--		
(1) *General*. When filling packagings and receptacles for	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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 sections 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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) Air transportation. Packages offered or intended for transportation by aircraft must conform to the general requirements for transportation by	Shipper responsibility to ensure.	Shipper responsibility to ensure.

aircraft in section 171.11 of this subchapter.		

DOT = U.S. Department of Transportation.
UN = United Nations.

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Table G-1. Steel Drums--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). Post-HM-181 (Post-October 1994).		
Regulatory requirement: 49 CFR 173.24a	**Action required/by whom**	**Packaging category--steel drums**
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

stability of the contents.		
(3) *Securing and cushioning*. Inner packagings or 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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(5) *Vibration*. Each non-bulk package must be capable of withstanding, without rupture	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure. For specific vibration test data, refer to Appendix E, Table E-1.

or leakage, the vibration test procedure specified in section 178.608 of this subchapter.		
(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:	Designer to do and shipper responsibility to ensure that the material being shipped falls within the envelope of acceptable materials based on design and testing. Type A packagings are not required to be marked with specific gravity.	Shipper responsibility to ensure.
(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;	This is not applicable as a Type A packaging does not incorporate packing groups.	
(ii) A Packing Group I packaging may	This is not applicable as a Type A packaging does not incorporate packing groups.	

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 as a Type A packaging does not incorporate packing groups.	
(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	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.	

maximum gross mass marked on the packaging.		
(3) A single or composite non-bulk packaging that 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:	Designer to do and shipper responsibility to ensure that the material being shipped falls within the envelope of acceptable materials based on design and testing.	Shipper responsibility to ensure.
(i) A single or composite non-bulk packaging that 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	This not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	

marked.		
(ii) A single or composite non-bulk packaging that 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.	This is not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	
(iii) A single or composite non-bulk packaging that 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	This is not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	

on the packaging, of 1.2 if not marked.		
(4) Packagings tested as prescribed in section 178.605 or 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 confirms to one of the following:	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(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;	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	

(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	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	
(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. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	
(5) No hazardous material may remain on the outside of a package after filling.	This is modified for a Type A packaging (see 49 CFR 173.443). Shipper responsibility to ensure.	Shipper responsibility to ensure.
(c) Mixed contents.		
(1) An outer non-bulk packaging may contain more than one hazardous material only when--	For entire subsection (c), designer to do and shipper responsibility to ensure. For Type A packagings that are to contain other nonradioactive material, the package must meet both Type A and the required performance requirements.	Shipper responsibility to ensure.
(i) The inner and outer packagings used for each hazardous material conform to the relevant packaging sections of this part applicable		Shipper responsibility to ensure.

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;		Shipper responsibility to ensure.
(iii) Corrosive materials (except ORM-D) in bottles are further packed in securely closed inner receptacles before packing in outer packagings; and		Shipper responsibility to ensure.
(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		Shipper responsibility to ensure.

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.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(d) Liquids must not completely fill a receptacle at a temperature of 55 °C (131 °F) or less.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table G-2. Steel Boxes--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). Post-HM-181 (Post-October 1994).		
Regulatory requirement: 49 CFR 173.24a	**Action required/by whom**	**Packaging category--steel boxes**
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(3) *Securing and cushioning*. Inner packagings or	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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.		
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure. For specific vibration test data, refer to Appendix E, Table E-2.
(b) Non-bulk packaging filling limits.		
(1) A single or composite non-	Designer to do and shipper responsibility to ensure that the	Shipper responsibility to ensure.

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:	material being shipped falls within the envelope of acceptable materials based on design and testing. Type A packagings are not required to be marked with specific gravity.	
(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;	This is not applicable as a Type A packaging does not incorporate packing groups.	
(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	This is not applicable as a Type A packaging does not incorporate packing groups.	
(iii) A Packing	This is not applicable as a Type A	

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.	packaging does not incorporate packing groups.	
(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 that 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:	Designer to do and shipper responsibility to ensure that the material being shipped falls within the envelope of acceptable materials based on design and testing.	Shipper responsibility to ensure.

(i) A single or composite non-bulk packaging that 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.	This not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	
(ii) A single or composite non-bulk packaging that 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.	This is not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	
(iii) A single or composite non-bulk packaging that is tested and marked for Packing Group II liquid hazardous materials may be	This is not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	

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, of 1.2 if not marked.		
(4) Packagings tested as prescribed in section 178.605 or 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 confirms to one of the following:	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(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	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	

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	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	
(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. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	
(5) No hazardous material may remain on the outside of a package after filling.	This is modified for a Type A packaging (see 49 CFR 173.443). Shipper responsibility to ensure.	Shipper responsibility to ensure.
(c) Mixed contents.		
(1) An outer non-bulk packaging may contain more than one hazardous material only when--	For entire subsection (c), designer to do and shipper responsibility to ensure. For Type A packagings that are to contain other nonradioactive material, the package must meet both Type A and the required performance requirements.	Shipper responsibility to ensure.
(i) The inner and outer packagings used for each hazardous material conform to the relevant packaging sections of this part applicable to that hazardous		Shipper responsibility to ensure.

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;		Shipper responsibility to ensure.
(iii) Corrosive materials (except ORM-D) in bottles are further packed in securely closed inner receptacles before packing in outer packagings; and		Shipper responsibility to ensure.
(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.		Shipper responsibility to ensure.
(2) A packaging containing inner packagings of Division 6.2 materials may not	Shipper responsibility to ensure.	Shipper responsibility to ensure.

contain other hazardous materials, except dry ice.		
(d) Liquids must not completely fill a receptacle at a temperature of 55 °C (131 °F) or less.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table G-3. Wooden Boxes--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). Post-HM-181 (Post-October 1994).		
Regulatory requirement: 49 CFR 173.24a	**Action required/by whom**	**Packaging category--wooden boxes**
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(3) *Securing and cushioning*. Inner packagings or	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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.		
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure. For specific vibration test data, refer to Appendix E, Table E-3.
(b) Non-bulk packaging filling limits.		
(1) A single or composite non-	Designer to do and shipper responsibility to ensure that the	Shipper responsibility to ensure.

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:	material being shipped falls within the envelope of acceptable materials based on design and testing. Type A packagings are not required to be marked with specific gravity.	
(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;	This is not applicable as a Type A packaging does not incorporate packing groups.	
(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	This is not applicable as a Type A packaging does not incorporate packing groups.	
(iii) A Packing	This is not applicable as a Type A	

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.	packaging does not incorporate packing groups.	
(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 that 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:	Designer to do and shipper responsibility to ensure that the material being shipped falls within the envelope of acceptable materials based on design and testing.	Shipper responsibility to ensure.

(i) A single or composite non-bulk packaging that 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.	This not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	
(ii) A single or composite non-bulk packaging that 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.	This is not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	
(iii) A single or composite non-bulk packaging that is tested and marked for Packing Group II liquid hazardous materials may be	This is not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	

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, of 1.2 if not marked.		
(4) Packagings tested as prescribed in section 178.605 or 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 confirms to one of the following:	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(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	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	

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	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	
(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. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	
(5) No hazardous material may remain on the outside of a package after filling.	This is modified for a Type A packaging (see 49 CFR 173.443). Shipper responsibility to ensure.	Shipper responsibility to ensure.
(c) Mixed contents.		
(1) An outer non-bulk packaging may contain more than one hazardous material only when--	For entire subsection (c), designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
	For Type A packagings that are to contain other nonradioactive material, the package must meet both Type A and the required performance requirements.	
(i) The inner and outer packagings used for each hazardous material conform to the relevant packaging		Shipper responsibility to ensure.

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;		Shipper responsibility to ensure.
(iii) Corrosive materials (except ORM-D) in bottles are further packed in securely closed inner receptacles before packing in outer packagings; and		Shipper responsibility to ensure.
(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.		Shipper responsibility to ensure.
(2) A packaging containing inner	Shipper responsibility to ensure.	Shipper responsibility to ensure.

packagings of Division 6.2 materials may not contain other hazardous materials, except dry ice.		
(d) Liquids must not completely fill a receptacle at a temperature of 55 °C (131 °F) or less.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table G-4. Fiberboard Containers--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). Post HM-181 (Post-October 1994).		
Regulatory requirement: 49 CFR 173.24a	**Action required/by whom**	**Packaging category--fiberboard containers**
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(3) *Securing and cushioning*. Inner packagings or	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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.		
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure. For specific vibration test data, refer to Appendix E, Table E-4.
(b) Non-bulk packaging filling limits.		
(1) A single or composite non-	Designer to do and shipper responsibility to ensure that the	Shipper responsibility to ensure.

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:	material being shipped falls within the envelope of acceptable materials based on design and testing. Type A packagings are not required to be marked with specific gravity.	
(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;	This is not applicable as a Type A packaging does not incorporate packing groups.	
(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	This is not applicable as a Type A packaging does not incorporate packing groups.	
(iii) A Packing	This is not applicable as a Type A	

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.	packaging does not incorporate packing groups.	
(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 that 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:	Designer to do and shipper responsibility to ensure that the material being shipped falls within the envelope of acceptable materials based on design and testing.	Shipper responsibility to ensure.

(i) A single or composite non-bulk packaging that 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.	This not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	
(ii) A single or composite non-bulk packaging that 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.	This is not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	
(iii) A single or composite non-bulk packaging that is tested and marked for Packing Group II liquid hazardous materials may be	This is not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	

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, of 1.2 if not marked.		
(4) Packagings tested as prescribed in section 178.605 or 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 confirms to one of the following:	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(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	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	

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	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	
(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. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	
(5) No hazardous material may remain on the outside of a package after filling.	This is modified for a Type A packaging (see 49 CFR 173.443). Shipper responsibility to ensure.	Shipper responsibility to ensure.
(c) Mixed contents.		
(1) An outer non-bulk packaging may contain more than one hazardous material only when--	For entire subsection (c), designer to do and shipper responsibility to ensure. For Type A packagings that are to contain other nonradioactive material, the package must meet both Type A and the required performance requirements.	Shipper responsibility to ensure.
(i) The inner and outer packagings used for each hazardous material conform to the relevant packaging sections of this part applicable to		Shipper responsibility to ensure.

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;		Shipper responsibility to ensure.
(iii) Corrosive materials (except ORM-D) in bottles are further packed in securely closed inner receptacles before packing in outer packagings; and		Shipper responsibility to ensure.
(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.		Shipper responsibility to ensure.
(2) A packaging containing inner packagings of Division 6.2	Shipper responsibility to ensure.	Shipper responsibility to ensure.

materials may not contain other hazardous materials, except dry ice.		
(d) Liquids must not completely fill a receptacle at a temperature of 55 °C (131 °F) or less.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table G-5. UF_6--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). Post-HM-181 (Post-October 1994).		
Regulatory requirement: 49 CFR 173.24a	**Action required/by whom**	**Packaging category--UF_6**
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(3) *Securing and cushioning*. Inner packagings or	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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.		
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure. For specific vibration test data, refer to Appendix E, Table E-5.
(b) Non-bulk packaging filling limits.		
(1) A single or composite non-	Designer to do and shipper responsibility to ensure that the	Shipper responsibility to ensure.

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:	material being shipped falls within the envelope of acceptable materials based on design and testing. Type A packagings are not required to be marked with specific gravity.	
(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;	This is not applicable as a Type A packaging does not incorporate packing groups.	
(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	This is not applicable as a Type A packaging does not incorporate packing groups.	
(iii) A Packing	This is not applicable as a Type A	

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.	packaging does not incorporate packing groups.	
(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 that 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:	Designer to do and shipper responsibility to ensure that the material being shipped falls within the envelope of acceptable materials based on design and testing.	Shipper responsibility to ensure.

(i) A single or composite non-bulk packaging that 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.	This not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	
(ii) A single or composite non-bulk packaging that 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.	This is not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	
(iii) A single or composite non-bulk packaging that is tested and marked for Packing Group II liquid hazardous materials may be	This is not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	

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, of 1.2 if not marked.		
(4) Packagings tested as prescribed in section 178.605 or 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 confirms to one of the following:	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(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	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	

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	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	
(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. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	
(5) No hazardous material may remain on the outside of a package after filling.	This is modified for a Type A packaging (see 49 CFR 173.443). Shipper responsibility to ensure.	Shipper responsibility to ensure.
(c) Mixed contents.		
(1) An outer non-bulk packaging may contain more than one hazardous material only when--	For entire subsection (c), designer to do and shipper responsibility to ensure. For Type A packagings that are to contain other nonradioactive material, the package must meet both Type A and the required performance requirements.	Shipper responsibility to ensure.
(i) The inner and outer packagings used for each hazardous material conform to the relevant packaging sections of this part applicable to that hazardous		Shipper responsibility to ensure.

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;		Shipper responsibility to ensure.
(iii) Corrosive materials (except ORM-D) in bottles are further packed in securely closed inner receptacles before packing in outer packagings; and		Shipper responsibility to ensure.
(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.		Shipper responsibility to ensure.
(2) A packaging containing inner packagings of Division 6.2 materials may not	Shipper responsibility to ensure.	Shipper responsibility to ensure.

contain other hazardous materials, except dry ice.		
(d) Liquids must not completely fill a receptacle at a temperature of 55 °C (131 °F) or less.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table G-6. Liquid and Gas Packagings--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). Post-HM-181 (Post-October 1994).		
Regulatory requirement: 49 CFR 173.24a	**Action required/by whom**	**Packaging category--liquids and gas**
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(3) *Securing and cushioning*. Inner packagings or	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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.		
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure. For specific vibration test data, refer to Appendix E, Table E-6.
(b) Non-bulk packaging filling limits.		
(1) A single or composite non-	Designer to do and shipper responsibility to ensure that the	Shipper responsibility to ensure.

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:	material being shipped falls within the envelope of acceptable materials based on design and testing. Type A packagings are not required to be marked with specific gravity.	
(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;	This is not applicable as a Type A packaging does not incorporate packing groups.	
(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	This is not applicable as a Type A packaging does not incorporate packing groups.	
(iii) A Packing	This is not applicable as a Type A	

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.	packaging does not incorporate packing groups.	
(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 that 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:	Designer to do and shipper responsibility to ensure that the material being shipped falls within the envelope of acceptable materials based on design and testing.	Shipper responsibility to ensure.

(i) A single or composite non-bulk packaging that 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.	This not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	
(ii) A single or composite non-bulk packaging that 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.	This is not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	
(iii) A single or composite non-bulk packaging that is tested and marked for Packing Group II liquid hazardous materials may be	This is not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	

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, of 1.2 if not marked.		
(4) Packagings tested as prescribed in section 178.605 or 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 confirms to one of the following:	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(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	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	

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	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	
(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. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	
(5) No hazardous material may remain on the outside of a package after filling.	This is modified for a Type A packaging (see 49 CFR 173.443). Shipper responsibility to ensure.	Shipper responsibility to ensure.
(c) Mixed contents.		
(1) An outer non-bulk packaging may contain more than one hazardous material only when--	For entire subsection (c), designer to do and shipper responsibility to ensure. For Type A packagings that are to contain other nonradioactive material, the package must meet both Type A and the required performance requirements.	Shipper responsibility to ensure.
(i) The inner and outer packagings used for each hazardous material conform to the relevant packaging sections of this part applicable to		Shipper responsibility to ensure.

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;		Shipper responsibility to ensure.
(iii) Corrosive materials (except ORM-D) in bottles are further packed in securely closed inner receptacles before packing in outer packagings; and		Shipper responsibility to ensure.
(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.		Shipper responsibility to ensure.
(2) A packaging containing inner packagings of	Shipper responsibility to ensure.	Shipper responsibility to ensure.

Division 6.2 materials may not contain other hazardous materials, except dry ice.		
(d) Liquids must not completely fill a receptacle at a temperature of 55 °C (131 °F) or less.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table G-7. Miscellaneous Packagings--Compliance with Additional General Requirements for Non-Bulk Packaging and Packages (49 CFR 173.24a). Post-HM-181 (Post-October 1994). (8 pages)		
Regulatory requirement: 49 CFR 173.24a	**Action required/by whom**	**Packaging category--miscellaneous**
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(3) *Securing and cushioning*. Inner packagings or	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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.		
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure. For specific vibration test data, refer to Appendix E, Table E-7.
(b) Non-bulk packaging filling limits.		
(1) A single or composite non-	Designer to do and shipper responsibility to ensure that the	Shipper responsibility to ensure.

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:	material being shipped falls within the envelope of acceptable materials based on design and testing. Type A packagings are not required to be marked with specific gravity.	
(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;	This is not applicable as a Type A packaging does not incorporate packing groups.	
(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	This is not applicable as a Type A packaging does not incorporate packing groups.	
(iii) A Packing	This is not applicable as a Type A	

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.	packaging does not incorporate packing groups.	
(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 that 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:	Designer to do and shipper responsibility to ensure that the material being shipped falls within the envelope of acceptable materials based on design and testing.	Shipper responsibility to ensure.

(i) A single or composite non-bulk packaging that 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.	This not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	
(ii) A single or composite non-bulk packaging that 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.	This is not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	
(iii) A single or composite non-bulk packaging that is tested and marked for Packing Group II liquid hazardous materials may be	This is not applicable to Type A packagings as Type A packagings do not incorporate packing groups.	

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, of 1.2 if not marked.		
(4) Packagings tested as prescribed in section 178.605 or 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 confirms to one of the following:	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	Shipper responsibility to ensure.
(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	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	

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	This is not applicable to Type A packaging. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	
(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. Shipper responsibility to ensure that the Type A packaging is used with the designed limitations.	
(5) No hazardous material may remain on the outside of a package after filling.	This is modified for a Type A packaging (see 49 CFR 173.443). Shipper responsibility to ensure.	Shipper responsibility to ensure.
(c) Mixed contents.		
(1) An outer non-bulk packaging may contain more than one hazardous material only when--	For entire subsection (c), designer to do and shipper responsibility to ensure. For Type A packagings that are to contain other nonradioactive material, the package must meet both Type A and the required performance requirements.	Shipper responsibility to ensure.
(i) The inner and outer packagings used for each hazardous material conform to the relevant packaging sections of this part applicable to		Shipper responsibility to ensure.

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;		Shipper responsibility to ensure.
(iii) Corrosive materials (except ORM-D) in bottles are further packed in securely closed inner receptacles before packing in outer packagings; and		Shipper responsibility to ensure.
(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.		Shipper responsibility to ensure.
(2) A packaging containing inner packagings of	Shipper responsibility to ensure.	Shipper responsibility to ensure.

Division 6.2 materials may not contain other hazardous materials, except dry ice.		
(d) Liquids must not completely fill a receptacle at a temperature of 55 °C (131 °F) or less.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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Table H-1. Steel Drums--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). Post-HM-181 (Post-October 1994).		
Regulatory requirement: 49 CFR 173.24b	**Action required/by whom**	**Packaging category--steel drums**
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

be left in the shell to provide the required outage.		
(3) Bulk packagings for materials poisonous by inhalation. For a material that meets the definition of poisonous by inhalation (see section 178.1 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 (105 °F) for insulated tanks.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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 = 20). Elongation values used must be determined from a 50-mm or 2-in. test specimen.		

(c) Air pressure in excess of ambient atmospheric pressure may not be used to load or unload any lading that may create an air-enriched mixture within the flammability range of the lading in the vapor space of the tank.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(d) A bulk packaging may not be loaded with a hazardous material that:	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.		

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Table H-2. Steel Boxes--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). Post-HM-181 (Post-October 1994).		
Regulatory requirement: 49 CFR 173.24b	**Action required/by whom**	**Packaging category--steel boxes**
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

be left in the shell to provide the required outage.		
(3) Bulk packagings for materials poisonous by inhalation. For a material that meets the definition of poisonous by inhalation (see section 178.1 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 (105 °F) for insulated tanks.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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 = 20). Elongation values used must be determined from a 50-mm or 2-in. test specimen.		

(c) Air pressure in excess of ambient atmospheric pressure may not be used to load or unload any lading that may create an air-enriched mixture within the flammability range of the lading in the vapor space of the tank.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(d) A bulk packaging may not be loaded with a hazardous material that:	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.		

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Table H-3. Wooden Boxes--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). Post-HM-181 (Post-October 1994).		
Regulatory requirement: 49 CFR 173.24b	**Action required/by whom**	**Packaging category--wooden boxes**
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

be left in the shell to provide the required outage.		
(3) Bulk packagings for materials poisonous by inhalation. For a material that meets the definition of poisonous by inhalation (see section 178.1 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 (105 °F) for insulated tanks.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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 = 20). Elongation values used must be determined from a 50-mm or 2-in. test specimen.		

(c) Air pressure in excess of ambient atmospheric pressure may not be used to load or unload any lading that may create an air-enriched mixture within the flammability range of the lading in the vapor space of the tank.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(d) A bulk packaging may not be loaded with a hazardous material that:	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.		

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Table H-4. Fiberboard Containers--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). Post-HM-181 (Post-October 1994).		
Regulatory requirement: 49 CFR 173.24b	**Action required/by whom**	**Packaging category--fiberboard containers**
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

be left in the shell to provide the required outage.		
(3) Bulk packagings for materials poisonous by inhalation. For a material that meets the definition of poisonous by inhalation (see section 178.1 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 (105 °F) for insulated tanks.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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 = 20). Elongation values used must be determined from a 50-mm or 2-in. test specimen.		

(c) Air pressure in excess of ambient atmospheric pressure may not be used to load or unload any lading that may create an air-enriched mixture within the flammability range of the lading in the vapor space of the tank.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(d) A bulk packaging may not be loaded with a hazardous material that:	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.		

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Table H-5. UF_6--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). Post-HM-181 (Post-October 1994).		
Regulatory requirement: 49 CFR 173.24b	**Action required/by whom**	**Packaging category--UF_6**
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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,	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

vacant space must be left in the shell to provide the required outage.		
(3) Bulk packagings for materials poisonous by inhalation. For a material that meets the definition of poisonous by inhalation (see section 178.1 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 (105 °F) for insulated tanks.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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,	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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 = 20). Elongation values used must be determined from a 50-mm or 2-in. test specimen.		

(c) Air pressure in excess of ambient atmospheric pressure may not be used to load or unload any lading that may create an air-enriched mixture within the flammability range of the lading in the vapor space of the tank.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(d) A bulk packaging may not be loaded with a hazardous material that:	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.		

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Table H-6. Liquid and Gas Packagings--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). Post-HM-181 (Post-October 1994).		
Regulatory requirement: 49 CFR 173.24b	**Action required/by whom**	**Packaging category--liquid and gas**
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

be left in the shell to provide the required outage.		
(3) Bulk packagings for materials poisonous by inhalation. For a material that meets the definition of poisonous by inhalation (see section 178.1 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 (105 °F) for insulated tanks.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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 = 20). Elongation values used must be determined from a 50-mm or 2-in. test specimen.		

(c) Air pressure in excess of ambient atmospheric pressure may not be used to load or unload any lading that may create an air-enriched mixture within the flammability range of the lading in the vapor space of the tank.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(d) A bulk packaging may not be loaded with a hazardous material that:	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.		

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Table H-7. Miscellaneous Packagings--Compliance with Additional General Requirements for Bulk Packagings (49 CFR 173.24b). Post-HM-181 (Post-October 1994).		
Regulatory requirement: 49 CFR 173.24b	**Action required/by whom**	**Packaging category--miscellaneous**
(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.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

be left in the shell to provide the required outage.		
(3) Bulk packagings for materials poisonous by inhalation. For a material that meets the definition of poisonous by inhalation (see section 178.1 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 (105 °F) for insulated tanks.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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 = 20). Elongation values used must be determined from a 50-mm or 2-in. test specimen.		

(c) Air pressure in excess of ambient atmospheric pressure may not be used to load or unload any lading that may create an air-enriched mixture within the flammability range of the lading in the vapor space of the tank.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(d) A bulk packaging may not be loaded with a hazardous material that:	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(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.		

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Table J-1. Specification 2E; inside polyethylene bottle, 49 CFR 178.24a (pre HM-181, October 1989)

§178.24a-1 General requirements.

(a) Each bottle must meet the applicable requirements of §173.24 of this chapter.

(b) [Reserved]

§178.24a-2 Rated capacity.

(a) Maximum capacity not to exceed 5 quarts.

(b) [Reserved]

§178.24a-3 Materials of construction.

(a) Each bottle shall be made of a blow-molding grade of polyethylene resin which has not been used previously (except for regrind from the same production process) and shall be constructed so that it will maintain its shape when standing empty and open.

(b) Wall thickness must not be less than 0.008 inch (0.2 millimeters).

§178.24a-4 Closure.

(a) Closing devices must provide a tight seal. Vented closures are not authorized unless other wise provided for in Part 173 of this chapter.

(b) [Reserved]

§178.24a-5 Tests.

(a) Each bottle must be capable of withstanding the prescribed tests without breaking or leaking.

(b) The test prescribed in paragraph (d)(1) of this section must be made on at least three random sample bottles for each 1,000 bottles produced by each blow-molding machine. The test must be performed at the start of initial production from each blow-molding machine and upon any change in type of polyethylene or process method.

(c) The test prescribed in paragraph (d)(2) of this section must be made at least once each month on a minimum of three random sample bottles produced and upon any change in type of polyethylene or process method.

(d) Prescribed tests;

(1) The bottle, filled to 98 percent of capacity with water, must be dropped from a height of 4 feet onto a solid unyielding surface so as to drop diagonally on the top edge or any other part which is weaker.

(2) The bottle, filled to 98 percent of capacity with a liquid which is compatible with polyethylene and which is liquid at 0° F, must be dropped from a height of 4 feet onto a solid unyielding surface, on any part of the bottle. Immediately prior to the test, the bottle and its contents must have been at a temperature of 0° F or lower for at least 24 hours.

§178.24a-6 Marking.

(a) Marking must be as prescribed in §173.24 of this subchapter, except as follows:

(1) Marking must be by embossment in at least 1/16-inch figures for bottles of one quart or less capacity and at least 1/8-inch figures for bottles of more that one quart capacity as follows: “DOT-2E”, the minimum thickness of the polyethylene in thousands of inches (mils), and the year of manufacture (e.g., DOT-2E 15-69).

(2) [Reserved]

[Reserved]

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Table J-2. Specification 2N; inside containers, metal cans, 49 CFR 178.32 (pre HM-181, October 1989)

§178.32 Specification 2N; inside containers, metal cans.

§178.32-1 Size.

(a) Not over 14-pounds water capacity (388 cubic inches).
(b) [Reserved]

§178.32.2 Material.

Each can must be made of good quality tin plate with parts and dimensions in compliance with the requirements of the following table:

Maximum diameter of can (inches)	Minimum thickness of metal (inch)	
	In body	In heads
4 5/16	0.01134 (107 lb tin plate)	0.01305 (128 lb tin plate) [1]
6 11/16	0.01134 (107 lb tin plate)	0.01485 (148 lb tin plate) [2]
6 11/16	0.01405 (135 lb tin plate)	0.01405 (135 lb tin plate) [3]

[1] The minimum thickness of metal in each head may be 107 lb tin plate provided side seams are soldered and heads are attached to body sections by full double seams internally soldered.

[2] The minimum thickness of metal in each head may be 135 lb tin plate provided side seams are soldered and heads are attached to body sections by full double seams internally soldered.

[3] Top heads must be attached to body sections by full double seams with durable seaming compound, and bottom heads must be attached to body sections by soldering.

§178.32-3 Manufacture.

(a) Seams soldered or full double seam. Outside surface rustproofed by lacquer or equivalent.
(b) [Reserved]

§178.32-4 Test.

(a) When closed as for shipment, must be capable of standing 40-pound interior pressure without leakage.

(b) [Reserved]

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Table J-3. Specification 2R; inside containment vessel, 49 CFR 178.34 (pre HM-181, October 1989)

§178.34 Specification 2R; inside containment vessel.

§178.34-1 General requirements.

(a) Each vessel must be made of stainless steel, malleable iron, or brass, or other material having equivalent physical strength and fire resistance.

(b) Each vessel must meet all of the applicable requirements of §173.24(c) and (d) of this subchapter. Letters and numerals at least 6 millimeters (1/4-inch) in height are authorized for the marking of a vessel not exceeding 5 centimeters (2 inches) inside diameter.

§178.34-2 Manufacture.

The ends of the vessel must be fitted with screw-type closures or flanges (see §178.34-4), except that one or both ends of the vessel may be permanently closed by a welded or brazed plate. Welded or brazed side seams are authorized.

§178.34-3 Dimensions.

(a) The inside diameter of the vessel may not exceed 30 centimeters (12 inches) exclusive of flanges for handling or fastening devices and must have wall thickness and length in accordance with the following:

Inside diameter maximum		Threaded closure		Wall thickness minimum—Flanged closure	Length maximum	
Inches	Centimeters	Inches	Millimeters		Inches	Centimeters
2	5	3/32	2.5	Not less than that prescribed for schedule 40 pipe	16	41
6	15	1/8	3.2		72	183
12	30	¼	6.5		72	183

(b) [Reserved]

§178.34-4 Closure devices.

(a) Each closure device must be as follows:

(1) Screw-type cap or plug; number of threads per inch must not be less than United States standard pipe threads and must have sufficient length of

thread to engage at least 5 threads when securely tightened. Pipe threads must be luted with an appropriate non-hardening compound which must be capable of withstanding up to 149º C (300º F) without loss of efficiency. Tightening torque must be adequate to maintain leak tightness with the specific luting compound.

(2) An opening may be closed by a securely bolted flange and leak-tight gasket. Each flange must be welded or brazed to the body of the 2R vessel per (ANSI) Standard B16.5 or (AWWA) Standard C207-55, section 10. A torque wrench must be used in securing the flange with a corresponding torque of no more than twice the force necessary to seal the selected gasket. Gasket material must be capable of withstanding up to 149º C (300º F) without loss of efficiency. The flange, whether of ferrous or nonferrous metal, must be constructed from the same metal as the vessel and must meet the dimensional and fabrication specifications for welded construction as follows:

(i) Pipe flanges described in Tables 13, 14, 16, 17, 20, 22, 23, 25, and 26 of ANSI B16.5.

(ii) For nominal pipe sizes 6, 8, 10, and 12 inches, AWWA Standard C207-55, Table 1, class B, may be used in place of the tables prescribed by paragraph (a)(2)(i) of this section.

(iii) Sizes under 6 inches, nominal pipe size, the following table with the same configuration as illustrated in AWWA C207-55, Table 1, class B may be used in place of paragraph (a)(2)(i) of this section.

Nominal pipe size		Flange O.D.		Number of bolts	Bolt circle diameter		Diameter of bolts		Flange thickness	
Inches	Centi-meters	Inches	Centi-meters		Inches	Centi-meters	Inches	Centi-meters	Inches	Centi-meters
2	5	6	15	4	4 ¾	11.8	½	1.2	5/8	1.6
2 ½	6.2	7	17.5	4	5 ½	13.8	½		5/8	
3	7.5	7 ½	18.8	4	6	15	½		5/8	
3 ½	8.8	8 ½	21.3	8	7	17.5	½		5/8	
4	10	9	22.5	8	7 ½	18.8	½		5/8	
5	12.6	10	25.4	8	8 ½	21.3	½		5/8	

(iv) Cast iron flanges prohibited.

(b) [Reserved]

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Table J-4. Specification 5C; steel barrels or drums, 49 CFR 178.83 (pre HM-181, October 1989)

§178.83 Specification 5C; steel barrels or drums.

Removable head containers not authorized.

§178.83-1 Compliance.

(a) Required in all details.

(b) [Reserved]

§178.83-2 Rated capacity.

(a) Rated capacity as marked, see §178.83-11(a)(3). Actual capacity of straight-sided containers shall be not less than rated (marked) capacity plus 2 percent, nor greater than rated capacity plus 2 percent plus 1 quart, except that for containers over 30 gallons marked capacity actual capacity shall be not less than rated capacity plus 2 percent, nor greater than rated capacity plus 2 percent plus 2 quarts; actual capacity of bilge-type containers must be not less than rated capacity; nor greater than rated capacity plus 2 percent plus 2 quarts.

§178.83-3 Composition.

(a) Steel must be, except for rolling hoops and chime reinforcement, as follows:

(b) All sheet metal, welding rod, closing devices, and samples taken from the welded portion of the finished container must be of Type 304, 18 chrome, 8 nickel alloy, with 0.08 percent carbon maximum, 18-20 percent chromium, 8-11 percent nickel, or other types of stainless steel or equivalent corrosion resistance and physical properties.

Type 304 or other grades of equivalent corrosion resistant steels in the as-welded condition are permissible for nitric acid concentrations up to and including 78 percent. For all concentrations of nitric acid the following are permissible:

(1) Type 304 heat-treated (quenches from 1900º F), or

(2) Stabilized Type 347 in the as-welded condition, or

(3) Stabilized Type 347 stress-relieved (1550º-1650º F), or

(4) Stabilized Type 347 heat-treated (quenches from 1900º F), or

(5) Other grades of equivalent corrosion resistance.

(d) All parts of any completed container exposed to lading must comply with the standard 65 percent boiling nitric acid test in that the limit of inches per month penetration in accordance with corrosion test as used in American Society of Testing

Materials Standard A-262-44-T shall be 0.0015 inch, this figure to be an average of five 48-hour tests.

§178.83-5 Seams.

(a) Body seams welded.
(b) Chime seams welded or double-seamed and welded.
(c) Flanges for closures welded in place.

§178.83-6 Chime reinforcement.

(a) Containers of 10 gallons capacity or over, with flanged head secured to body, to have chime reinforcement adequate for its protection.
(b) [Reserved]

§178.83-7 Parts and dimensions.

(a) Parts and dimensions as follows:

Marked capacity not over (gallons)	Type of container	Minimum thickness, uncoated sheets (gauge)		Rolling hoops		
		Body sheet	Head sheet	Type [1]	Minimum	
					Size (gauge or inch)	Weight (pounds per foot)
15	Straight side	20	20	None	--	--
30	do	18	18	I-bar	¾ x 1 ¼	1.25
55	do	16	16	I-bar [2]	¾ x 1 ¼	1.60
110	do	14	14	do [2]	¾ x 1 ¼	1.60
15	Bilge	16	16	None	--	--
30	do	14	16	do	--	--
55	do	13	14	do	--	--

[1] Rolling hoops may be of pliable solid rubber, metal, or other suitable material provided that equivalent protection to drum integrity is afforded.

[2] Stainless steel I-bar rolling hoops ¾ x 1 ¼ inches, weighing not less than 1.27 pounds per foot, are authorized.

(b) Steel sheets of specified gauges shall comply with the following:

Gauge No.	Nominal thickness [1] (inch)	Minimum thickness [1] (inch)
13	0.0897	0.0817
14	0.0747	0.0677
16	0.0598	0.0533
18	0.0478	0.0428

20	0.0359	0.0324

[1] Thickness shall be measured at any point on the sheet not less than 3/8 inch from an edge.

§178.83-8 Rolling hoops.

(a) Separate hoops to have tight fit on shell and be firmly secured in place. Beading under rolling hoops or spot welding not permitted.

(b) [Reserved]

§178.83-9 Closures.

(a) Adequate to prevent leakage; gaskets required. Closure must be of screw-thread type or fastened by screw-thread device. Unthreaded cap is authorized for containers of 12 gallons or less if cap is provided with outside sealing devices which cannot be removed without destroying the cap or sealing device.

(b) Closing part (plug, cap, plate, etc., see Note 1) must be of metal as thick as prescribed for head of container; this not required for containers of 12 gallons or less when the opening to be closed is not over 2.3 inches in diameter.

(c) For closure with threaded plug or cap, the seat (flange, etc.) for plug or cap must have 5 or more complete threads; 2 drainage holes of not over 5/16-inch diameter are allowed in that section of flange which extends inside the drum. Plug or cap must have sufficient length of thread to engage 5 threads when securely tightened with gasket in place. Except that for containers not over 15 gallons marked capacity the seat (flange, etc.) for plug or cap may have at least 3 complete threads and plug or cap sufficient length of thread to engage 3 threads when securely tightened with gasket in place.

(d) Openings over 2.3 inches are not permitted. Threads for plug or cap must be 8 or less per inch when over ¾ inch standard pipe size.

(1) Flanges with inside threads and plug must conform with the thread diameter and thread form shown in the following drawing (Figure 1, Figure 2, Figure 3, Figure 4)(other details shown on the drawing are recommended), or

(2) Eleven and one-half (11 ½) threads per inch, standard pipe size.

(e) Other types of closures are authorized if they perform without failure under the tests required by this section and a record of the test is retained during the period the closure is in use.

Note 1: This does not apply to cap seal over a closure which complies with all requirements.

§178.83-10 Defective containers.

(a) Leaks and other defects to be repaired by method used in constructing container, not by soldering.

(b) [Reserved]

§178.83-11 Marking.

(a) Each barrel or drum must be marked by embossing on a permanent head (or by embossing or die stamping on footring on drums equipped with footrings, or on metal plates securely attached to drum by brazing or welding not less than 20 percent of the perimeter of the plate) with clearly legible raised characters as

follows:

(1) DOT-5C.

(2) If the drum is manufactured of stainless steel, the type of steel used in the body and head sheets as identified by the American Iron and Steel Institute type number, and also the letters HT following the steel designation on barrels or drums subjected to stress relieving or heat treatment during manufacture (for example, 304, 316, 304 HT). This mark should be near the DOT mark.

(3) Name or symbol of person making the mark specified in paragraph (a)(a) of this section. A symbol, if used, must be registered with the Director, OHMT.

(4) The gauge of the metal in the thinnest part, the rated capacity in gallons, and the year of manufacture (for example, 18-55-83). When the gauge of the metal in the body differs from that in the heads, both must be indicated with a slanting line between them and with the gauge of the body indicated first (for example, 18/16-55-83 for body 18 gauge and head 16 gauge).

(b) For the purpose of this subchapter, the minimum character size specified in §173.24(c)(1)(iv) is waived.

§178.83-12 [Reserved]

§178.83-13 Type tests.

(a) Samples taken at random and closed as for use, shall withstand the prescribed tests without leakage. Each packaging design type must successfully pass the test before the packaging is used. The test must be repeated every 4 months. A packaging design type is defined by the design, size, material, thickness, and manner of construction, but may include various surface treatments. A type may also include packagings which differ from the design type only in their lesser design heights. The samples last tested must be retained until further tests are made, or for 1 year, whichever period is shorter. The type tests are as follows:

(1) Test by dropping, filled with water to 98 percent capacity, from height of 6 feet onto solid concrete so as to strike diagonally on chime, or when without chime seam, to strike on other circumferential seam; also additional drop test on any other parts which might be considered weaker than the chime. Closing devices and other parts projecting beyond chime or rolling hoops must also be capable of withstanding this test.

(2) Hydrostatic pressure test of 80 pounds per square inch sustained for 5 minutes.

(3) Periodic drop and hydrostatic tests are not required where container has satisfactorily met prescribed tests at the original start of production. Satisfactory test results must be obtained on samples of subsequent containers that have been altered I design or construction. Samples so tested must be retained until further tests are made or for one year, whichever period is shorter.

(b) [Reserved]

§178.83-14 Leakage test.

(a) Each container shall be tested, with seams under water or covered with soapsuds or heavy oil, by interior air pressure of at least 15 pounds per square inch. Equally efficient means of testing may be authorized upon approval by the Director, OHMT. Leakers shall be rejected or repaired and retested without failure.

(b) [Reserved]

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Table J-5. Specification 6C; steel barrels or drums, 49 CFR 178.99 (pre HM-181, October 1989)

§178.99 Specification 6C; steel barrels or drums.

Removable head containers which will pass all required tests are authorized.

§178.99-1 Compliance.

(a) Required in all details.

(b) Steel sheets of specified gauges shall comply with the following:

Gauge No.	Nominal thickness [1] (inch)	Minimum thickness [1] (inch)
14	0.0747	0.0677
15	0.0673	0.0603
16	0.0598	0.0533
18	0.0478	0.0428
20	0.0359	0.0324
22	0.0299	0.0269
[1] Thickness shall be measured at any point on the sheet not less than 3/8 inch from an edge.		

§178.99-2 Rated capacity.

(a) Rated capacity as marked, see §178.99-9(a)(3). Actual capacity of straight-sided containers shall be not less than rated (marked) capacity plus 2 percent, nor greater than rated capacity plus 2 percent plus 1 quart, except that for containers over 30 gallons marked capacity actual capacity shall not be less than rated capacity plus 2 percent, nor greater than rated capacity plus 2 percent plus 2 quarts; actual capacity of bilge-type containers must be not less than rated capacity, nor greater than rated capacity plus 2 percent plus 2 quarts.

§178.99-3 Composition.

(a) Sheets for body and heads to be low carbon, open hearth or electric steel.

§178.99-5 Parts and dimensions.

(b) Parts and dimensions as follows:

Marked capacity not over (gallons)	Authorized gross weight (pounds)	Type of container	Minimum thickness, uncoated sheets (gauge)		Rolling hoops		
			Body sheet	Head sheet	Type	Minimum	
						Size (gauge or inch)	Weight (pounds per foot)
5	80	Straight side	22	22	None	--	--
5 to 10	160	do	20	20	do	--	--
5 to 30	480	do	18	18	U	16	--
5 to 55	880	do	16	16	U	14	--
5 to 110	1,760	do	14	14	U	12	--
5 to 30	480	do	18	18	I-bar	¾ x 1 ¼	1.25
5 to 55	880	do	16	16	do	¾ x 1 ¼	1.25
5 to 110	1,760	do	14	14	I-bar	¾ x 1 ¼	1.60
5 to 33	480	Bilge	16	18	None	--	--
5 to 55	880	do	15	16	do	--	--

§178.99-6 Rolling hoops.

(a) Separate hoops to have tight fit on shell and be firmly secured in place. Beading under rolling hoops not permitted. Attachment to drum body by spot welding except for continuous resistance method, not permitted. Welding of I-bar type directly to body of drum in any manner not permitted.

§178.99-7 Closures.

(a)

Adequate to prevent leakage; gaskets required. Closures must be of screw-thread type or secured by positive fastening. Closing part (plug, cap, plate, etc., see Note 1) must be of metal as thick as prescribed for head of container; this not required for containers of 12 gallons or less when the opening to be closed in not over 2.3 inches in diameter. If unthreaded cap is used it must be provided with outside sealing device which cannot be removed without destroying the cap or sealing device.

Note 1: This does not apply to cap seal over a closure which complies with all requirements.

§178.99-8 Defective containers.

(a) Leaks and other defects to be repaired by method used in constructing container, not by soldering.

§178.99-9 Marking.

(a) Each barrel or drum must be marked by embossing on a permanent head (or by embossing or die stamping on footring on drums equipped with footrings, or on metal plates securely attached to drum by brazing or welding not less than 20 percent of the perimeter of the plate) with clearly legible raised characters as follows:

(1) DOT-6C * * *; stars to be replaced by the authorized gross weight (for example DOT-6C880, etc.).

(2) If the drum is manufactured of stainless steel, the type of steel used in the body and head sheets as identified by the American Iron and Steel Institute type number, and also the letters HT following the steel designation on barrels or drums subjected to stress relieving or heat treatment during manufacture (for example 304, 316, 304 HT). This mark should be near the DOT mark.

(3) Name or symbol of person making the mark specified in paragraph (a)(1) of this section. A symbol, if used, must be registered with the Director, OHMT.

(4) The gauge of the metal in the thinnest part, the rated capacity in gallons, and the year of manufacture (for example, 18-55-83). When the gauge of the metal in the body differs from that in the heads, both must be indicated with a slanting line between them and with the gauge of the body indicated first (for example, 18/16-55-83 for body 18 gauge and head 16 gauge).

(b) For the purpose of this subchapter, the minimum character size specified in §173.24(c)(1)(iv) is waived.

§178.99-10 [Reserved]

§178.99-11 Type tests.

(a) Samples taken at random and closed as for use, shall withstand the prescribed test without leakage. Each packaging design type must successfully pass the test before the packaging is used. The tests must be repeated every 4 months. A packaging design type is defined by the design, size, material, thickness, and manner of construction, but may include various surface treatments. A type may also include packagings which differ from the design type only in their lesser design heights. The samples last tested must be retained until further tests are made, or for 1 year whichever period is shorter. The type tests are as follows:

(1) Test by dropping, filled with dry, finely powdered material to the authorized gross weight, from height of 4 feet onto solid concrete so as to strike diagonally on top chime, or when without chime seam, to strike on other circumferential seam; also additional drop test on any other parts which might be considered weaker than the chime. Closing devices and other parts projecting beyond chime or rolling hoops must also be capable of withstanding this test.

(2) Hydrostatic pressure test of 30 pounds per square inch sustained for 5 minutes. Leakage through closure shall not constitute failure.

§178.99-12 Leakage test.

(a) Each container shall be tested, with seams under water or covered with soapsuds or heavy oil, by interior air pressure of at least 15 pounds per squire inch. Equally efficient means of testing may be authorized upon approval by the Director, OHMT.

Leakers shall be rejected or repaired and retested without failure. Removable head containers need not be tested with heads in place except that samples taken at random and closed as for use, or each type and size, must be tested at start of production and repeated every 4 months. Samples last tested must be retained until further tests are made of for 1 year.

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Table J-6. Specification 17C; steel drums, 49 CFR 178.115
(pre HM-181, October 1989)

§178.115 Specification 17C; steel drums.

Single trip container. Removable head containers which will pass all required tests are authorized.

§178.115-1 Compliance.

(a) Required in all details.
(b) [Reserved]

§178.115-2 Rated capacity.

(a) Rated capacity as marked, see §178.115-10(a)(3). Minimum actual capacity of containers shall be not less than rated (marked) capacity plus 4 percent. Maximum actual capacity shall not be greater than rated (marked) capacity plus 5 percent or rated (marked) capacity plus 4 percent plus 1 quart whichever is the greater.
(b) [Reserved]

§178.115-3 Composition.

(a) Sheets for body and heads to be low carbon, open hearth or electric steel.
(b) [Reserved]

§178.115-5 Seams.

(a) Body seams welded.

§178.115-6 Parts and dimensions.

(a) Parts and dimensions as follows:

Marked capacity not over (gallons)	Type of container	Minimum thickness, uncoated sheets (gauge)		Rolling hoops		
		Body sheet	Head sheet	Type [1]	Minimum	
					Size (gauge or inch)	Weight (pounds per foot)
5 [3]	Straight side	[1] 24	[3] 24	None	--	--
10	do	20	20	do	--	--

30	do	18	18	([1])	--	--
55	do	16	16	([1, 2])	--	--

[1] Rolled or swedged-in hoops.

[2] Each removable head drum body must have three rolled or swedged-in hoops with the centerline of one not more than 3 inches from the top curl.

[3] A drum of 5 ¼ gallons marked capacity is authorized for shipment of the commodity specified in §173.353(d) of this chapter.

(b) Steel sheets of specified gauges shall comply with the following:

Gauge No.	Nominal thickness [1] (inch)	Minimum thickness [1] (inch)
16	0.0598	0.0533
18	0.0478	0.0428
20	0.0359	0.0324
24	0.0239	0.0209

[1] Thickness shall be measured at any point on the sheet not less than 3/8 inch from an edge.

§178.115-7 Convex heads.

(a) Convex (crowned) heads, not extending beyond level of chime, required for drums of 25 gallons capacity or over; minimum convexity of 3/8-inch required.

(b) [Reserved]

§178.115-8 Closures.

(a) Adequate to prevent leakage; gaskets required.

(b) Closing part (plug, cap, plate, etc., see Note 1) must be of metal as thick as prescribed for head of container; this not required for containers of 12 gallons or less when the opening to be closed is not over 2.7 inches in diameter. If unthreaded cap is used it must be provided with outside sealing devices which cannot be removed without destroying the cap or sealing device.

(c) For closure with threaded plug or cap, the seat (flange, etc.) for plug or cap must have 3 or more complete threads; two drainage holes of not over 5/16-inch diameter are allowed. Plug or cap must have sufficient length of thread to engage 3 threads when tightened with gasket in place. Other types of closures are authorized if they perform without failure under the tests required by this section and a record of the tests is retained during the period the closure is in use.

(d) Full removable head drums over 5 gallons capacity must be closed by means of 12 gauge bolted ring with drop forged lugs, one of which is threaded, and having 3/8-inch bolt and nut for drums not over 30 gallons capacity and 5/8-inch bolt and nut for drums over 30 gallons capacity. Five gallon drums must be of lug type closure with cover having at least 16 lugs. Other types of closures are authorized if they perform without failure under the tests required by this section and a record of the

tests is retained during the period the closure is in use.

Note 1: This does not apply to cap seal over a closure which complies with all requirements.

§178.115-9 Defective containers.

(a) Leaks and other defects to be repaired by method used in constructing container, not by soldering.

(b) [Reserved]

§178.115-10 Marking.

(a) Each drum must be marked by embossing on a permanent head (or by embossing or die stamping on footrings on drums equipped with footrings, or on metal plates securely attached to drum by brazing or welding not less than 20 percent of the perimeter of the plate) with clearly legible raised characters as follows:

(1) DOT-17C and the letters STC located near the DOT mark to indicate a single-trip drum.

(2) If the drum is manufactured of stainless steel, the type of steel used in the body and head sheets as identified by the American Iron and Steel Institute type number, and also the letters HT following the steel designation on barrels or drums subjected to stress relieving or heat treatment during manufacture (for example, 304, 316, 304 HT). This mark should be near the DOT mark.

(3) Name or symbol of person making the mark specified in paragraph (a)(1) of this section. A symbol, if used, must be registered with the Director, OHMT.

(4) The gauge of the metal in the thinnest part, the rated capacity in gallons, and the year of manufacture (for example, 18-55-83). When the gauge of the metal in the body differs from that in the heads, both must be indicated with a slanting line between them and with the gauge of the body indicated first (for example, 18/16-55-83 for body 18 gauge and head 16 gauge).

(b) For the purpose of this subchapter, the minimum character size specified in §173.24(c)(1)(iv) is waived.

§178.115-11 [Reserved]

§178.115-12 Type tests.

(a) Samples taken at random and closed as for use, shall withstand the prescribed tests without leakage. Each packaging design type must successfully pass the tests before the packaging is used. The tests must be repeated every 4 months. A packaging design type is defined by the design, size, material, thickness, and manner of construction, but may include various surface treatments. A type may also include packagings which differ from the design type only in their lesser design heights. The samples last tested must be retained until further tests are made, or for 1 year, whichever period is shorter. The type tests are as follows:

(1) Test by dropping, filled with water to 98 percent capacity, from height of

4 feet onto solid concrete so as to strike diagonally on chime, or when without chime seam, to strike on other circumferential seam; also additional drop test on any other parts which might be considered weaker than the chime. Closing devices and other parts projecting beyond chime or rolling hoops must also be capable of withstanding this test.

(1) Hydrostatic pressure test of 40 pounds per square inch sustained for 5 minutes; except that full removable head drums must sustain 20 pounds per square inch.

(b) [Reserved]

§178.115-13 Leakage test.

(a) Each container shall be tested, with seams under water or covered with soapsuds or heavy oil, by interior air pressure of at least 15 pounds per square inch. Equally efficient means of testing may be authorized upon approval by the Director, OHMT. Leakers shall be rejected or repaired and retested without failure. Removable head containers need not be tested with heads in place except that samples taken at random and closed as for use, of each type and size, must be tested at start of production and repeated every 4 months. Samples last tested must be retained until further tests are made or for 1 year.

[Reserved]

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Table J-7. Specification 17H; steel drums, 49 CFR 178.118
(pre HM-181, October 1989)

§178.118 Specification 17H; steel drums.

Single trip container. Removable head required.

§178.118-1 Compliance.

(a) Required in all details.
(b) [Reserved]

§178.118-2 Rated capacity.

(a) Rated capacity as marked, see §178.118-10(a)(3). Minimum actual capacity of containers shall be not less than rated (marked) capacity plus 4 percent. Maximum actual capacity shall not be greater than rated (marked) capacity plus 5 percent or rated (marked) capacity plus 4 percent plus 1 quart whichever is the greater.
(b) [Reserved]

§178.118-3 Composition.

(a) Sheets for body and heads to be low carbon, open hearth or electric steel.
(b) [Reserved]

§178.118-5 Seams.

(a) Body seams welded.
(b) [Reserved]

§178.118-6 Parts and dimensions.

(a) Parts and dimensions as follows:

Marked capacity not over (gallons)	Type of container	Minimum thickness, uncoated sheets (gauge)			Rolling hoops		
		Body sheet	Bottom head sheet	Removable head sheet	Type	Minimum	
						Size (gauge or inch)	Weight (pounds per foot)
5	Straight side	24	24	20	None	--	--

30	do	18	18	18	([1])	--	--
55	do	18	18	[3] 14	([2])	--	--

[1] Rolled or swedged-in hoops.

[2] Each drum must have three rolled or swedged-in hoops, one to be placed in the body near the top curl.

[3] 16 gauge authorized provided there is at least one corrugation in the removable head near the periphery. 18 gauge authorized provided (1) there are at least two corrugations in the removable head near the periphery, (2) the manufacturer or assembler provides to the Director, OHMT, evidence of satisfactory performance of testing or the complete package design conducted in accordance with this section, and (3) the director issues a registration number which the manufacturer or assembler concerned durably marks on the removable head and its corresponding ring-closure device.

(a) Steel sheets of specified gauges shall comply with the following:

Gauge No.	Nominal thickness [1] (inch)	Minimum thickness [1] (inch)
14	0.0747	0.0677
16	0.0598	0.0533
18	0.0478	0.0428
20	0.0359	0.0324
24	0.0239	0.0209

[1] Thickness shall be measured at any point on the sheet not less than 3/8 inch from an edge.

§178.118-7 Convex heads.

(a) Convex (crowned) heads, not extending beyond level of chime, required for drums of 25 gallons capacity or over; minimum convexity of 3/8-inch required.

(b) [Reserved]

§178.118-8 Closures.

(a) Adequate to prevent leakage; gaskets required.

(b) Drums over 5 gallons capacity must be closed by means of 12 gauge bolted ring with drop forged lugs, one of which is threaded, and having 3/8 inch bolt and nut for drums not over 30 gallons capacity and 5/8 inch bolt and nut for drums over 30 gallons capacity. Five gallon drums must be of lug type closure with cover having at least 16 lugs. Other types of closures are authorized if they perform without failure under the tests required by this section and a record of the test is retained during the period the closure is in use.

(c) For closure with threaded plug or cap, the seat (flange, etc.) for plug or cap must have 3 or more threads; two drainage holes of not over 5/16-inch diameter are allowed. Plug or cap must have sufficient length of thread to engage 3 threads when screwed home with gasket in place: *Provided*, That for containers having a capacity of 12 gallons and less the seat (flange, etc.) for plug, or cap, must have two or more complete threads and plug, or cap, must have sufficient length of thread to engage

two threads when screwed home with gasket in place.

(1) Other types of closures are authorized if they perform without failure under the tests required by this section and a record of the tests is retained during the period the closure is in use.

§178.118-9 Defective containers.

(a) Leaks and other defects to be repaired by method used in constructing container, not by soldering.

(b) [Reserved]

§178.118-10 Marking.

(a) Marking requirements for new or altered drums are as follows: *New drums.* Marking on each drum by embossing on the permanent head, with raised marks, or by embossing or die stamping on footring (if equipped), or on metal plates securely attached to drum by brazing or welding not less than 20 percent of the perimeter. *Altered drums.* Drums which have been altered to Specification 17H from an all 18-gauge tight head drum may be embossed on the body of the drum, no more than six inches from top curl.

(1) DOT-17H and the letters STC located near the DOT mark to indicate a single-trip drum.

(2) If the drum is manufactured of stainless steel, the type of steel used in the body and head sheets as identified by the American Iron and Steel Institute type number, and also the letters HT following the steel designation on barrels or drums subjected to stress relieving or heat treatment during manufacture (for example, 304, 316, 304 HT). This mark should be near the DOT mark.

(3) Name or symbol of person making the mark specified in paragraph (a)(1) of this section. A symbol, if used, must be registered with the Director, OHMT.

(4) The gauge of the metal in the thinnest part, the rated capacity in gallons, and the year of manufacture (for example, 18-55-83). When the gauge of the metal in the body differs from that in the heads, both must be indicated with a slanting line between them and with the gauge of the body indicated first (for example, 18/16-55-83 for body 18 gauge and head 16 gauge).

(b) For the purpose of this subchapter, the minimum character size specified in §173.24(c)(1)(iv) is waived.

§178.118-11 [Reserved]

§178.118-12 Type tests.

(a) Samples taken at random and closed as for use, shall withstand the prescribed tests without leakage. Each packaging design type must successfully pass the tests before the packaging is used. The tests must be repeated every 4 months. A packaging design type is defined by the design, size, material, thickness, and manner of construction, but may include various surface treatments. A type may also include packagings which differ from the design type only in their lesser design heights. The samples last tested must be retained until further tests are made, or for 1 year, whichever period is shorter. The type tests are as follows:

(1) Test by dropping, filled with water to 98 percent capacity, from height of 4 feet onto solid concrete so as to strike diagonally on chime, or when without chime seam, to strike on other circumferential seam; also additional drop test on any other parts which might be considered weaker than the chime. Closing devices and other parts projecting beyond chime or rolling hoops must also be capable of withstanding this test.

(2) Hydrostatic pressure test of 15 pounds per square inch sustained for 5 minutes.

(b) [Reserved]

§178.118-13 Leakage test.

(a) Each drum shall be tested, with seams under water or covered with soapsuds or heavy oil, by interior air pressure of at least 7 pounds per square inch for containers over 12 gallons capacity and at least 5 pounds for others. Equally efficient means of testing may be authorized upon approval by the Director, OHMT. Leakers shall be rejected or repaired and retested without failure. Drums need not be tested with heads in place, except that samples taken at random and closed as for use, of each type and size, must be tested at start of production and repeated every 4 months. Samples last tested must be retained until further tests are made or for 1 year.

[Reserved]

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Table J-8. Specification 12B; fiberboard boxes, 49 CFR 178.205 (pre HM-181, October 1989)

§178.205 Specification 12B; fiberboard boxes.

§178.205-1 Compliance.

(a) Required in all details.

(b) [Reserved]

§178.205-2 Definitions.

(a) Terms such as “200-pound test” mean minimum strength, Mullen or Cady test.

(b) “Joints” are where edges of parts of box, except recessed flanged heads, are connected together in setting up the box. Generally done by box maker.

(c) “Seams” are where edges of parts of box are visible, except joints, when box is closed.

§178.205-3 Classification of board.

(a) Fiberboard is hereby classified by strength, Mullen or Cady test (minimum), of completed board as in first column of the following table; weights specified in the table are the minimums authorized.

Classified strength [1] of completed board	Solid fiberboard--Minimum combined weight of component plies exclusive of adhesives (pounds per 1,000 sq. ft.)	Facings for corrugated fiberboard	
		Double faced—Minimum combined weight of facings (pounds per 1,000 sq. ft.)	Double wall—Minimum combined weight of facings including center liner (pounds per 1,000 sq. ft.)
175	149	75	--
200	190	84	92
275	237	138	110
325	237	138	110
350	283	180	126
375	283	180	180
400	283	180	180
450	283	180	180
[1] Mullen or Cady test (minimum).			

(b) [Reserved]

§178.205-4 Solid fiberboard.

(a) To be 3-ply or more; both outer plies water resistant.

(b) [Reserved]

§178.205-5 Corrugated fiberboard.

(a) Both outer facings water resistant; corrugated sheets must be at least 0.009-inch thick and weigh not less than 26 pounds per 1000 square feet; all parts must be securely glued together throughout all contact areas.

(b) [Reserved]

§178.205-6 Stitching staples.

Stitching staples must be made in such a configuration that their holding capability as installed will not be less than that of flat steel staples 3/32 x 0.019 inch in cross section and not less than 7/16-inch wide.

§178.205-7 Tape.

(a) Coated with glue at least equal to No. 1 ¾ Peter Cooper standard. Cloth tape of strength, across the woof, at least 70 units, Elmendorf test. Sisal tape of 2 sheets of No. 1 Kraft paper, total weight 80 pounds per ream (500 sheets, 24" x 36"); sheets to be combined with asphalt and reinforced by unspun sisal fibers completely embedded in the asphalt and extending across the tape, except as provided in §178.205-11(d). Other tapes of equal strength and efficiency are authorized.

(b) Tape for closure of slotted containers complying with the following requirements is authorized when applied as prescribed in §178.205-17(a)(3):

(1) Tape must be not less than 3 inches wide and shall be made of two sheets of 100 percent sulfate Kraft each not less than 30 pounds basis weight, reinforced with glass, sisal, or rayon fiber, combined with a laminant of asphalt or other material not affected by temperature extremes any more than would standard 180º F to 200º F softening point asphalt.

(2) Tape must be reinforced by lengthwise fibers spaced not more than an average of ½-inch apart, and by crosswise fibers spaced not less than an average of 2 per inch except that when a diamond pattern is employed for crosswise reinforcement, the spacing between the parallel sides of the diamond measured in the machine direction must be not more than 1 inch.

(3) Glass or sisal reinforced tape must have a minimum tensile strength in the machine direction of 75 pounds per inch of width and a minimum tensile strength in the cross direction of 45 pounds per inch of width; rayon reinforced tape must have a minimum tensile strength in the machine direction of 57 pounds per inch of width and a minimum tensile strength in the cross direction of 27 pounds per inch of width with elongation not exceeding 15 percent. Tensile tests on the finished product shall be made on a 3-inch width sample.

§178.205-8 Test.

(a) Acceptable board must have prescribed strength. Mullen or Cady test, after exposure for at least 3 hours to normal atmospheric conditions (50 to 70 percent relative humidity), under test as follows:

(1) Clamp board firmly in machine and turn wheel thereof at constant speed of approximately 2 revolutions per second.

(2) Six punctures required, 3 from each side; all results but one must show prescribed strength.

(3) Board failing may be retested by making 24 punctures, 12 from each side; when all results but 4 show prescribed strength the board is acceptable.

(4) For corrugated fiberboard, doublepop tests may be disregarded.

(b) [Reserved]

§178.205-9 Types authorized.

(a) To be of solid or corrugated fiberboard of the following types, or as specifically provided for in §178.205-19 to §178.205-37;

(1) Slotted box; three-piece box without recessed ends; three-piece box of solid fiberboard with recessed ends; double-slide box; triple-slide box; telescope box, with sections of equal depth, or with covers, top or bottom or both, with 3 inches overlap. (See §178.205-14 (d) for boxes with single-flap closures.)

(2) [Reserved]

§178.205-10 Forming.

(a) Parts must be cut true to size and so creased and slotted as to fit closely into position without cracking, surface breaks, separation of parts outside of crease, or undue binding.

(b) [Reserved]

§178.205-11 Joints.

(a) For solid and corrugated fiberboard slotted containers: Lapped 1 ½ inches from center of scoreline except as in §178.205-12; stitched at 2 ½ inch intervals and within 1 inch of each end of joint; body joint must be double-stitched (2 parallel stitches) at each end of joint over 18 inches long.

(b) For corrugated fiberboard slotted containers only: One butt joint taped (see §178.205-7) is authorized; 3-inch tape required for boxes over 30 pounds authorized gross weight and 2 inch tape for others.

(c) For triple and double slide boxes: Joints of all slides must be taped (see §178.205-7) for stitched; 3-inch tape required for boxes over 30 pounds authorized gross weight and 2-inch for others.

(d) For corrugated fiberboard only: One butt joint taped inside and outside with strips of one thickness of sulphate paper not less than 2 inches wide extending entire length of joint and firmly glued to box. For boxes not exceeding 65 pounds gross weight, outside strip of sulphate paper to be of basis weight not less than 60 pounds testing not less than 60 pounds and inside strip of sulphate paper to be of basis weight not less than 40 pounds testing not less than 40 pounds. For boxes exceeding 65 pounds gross weight, outside and inside with strips of sulphate paper which must each be of basis weight not less than 90 pounds testing not less than 90 pounds. Basis weight of paper shown is for 500 sheets, 24 x 36 inches.

(1) For glued lap joint, the sides of box forming joint must lap not less than 1¼” and be firmly glued throughout entire area of contact with a glue or adhesive which cannot be dissolved in water after the film application has

dried.

§178.205-12 Flanged heads.

(a) Must have 4 flanges, at least 1” long above fillet, on each head. Recessed flanged heads not authorized for boxes of corrugated fiberboard.

(b) [Reserved]

§178.205-13 Seams which are to be stitched.

(a) Overlap, if any, required to be at least 1 ½ inches from center of scoreline except as in §178.205-12.

(b) [Reserved]

§178.205-14 Flap closures.

(a) Fill-in pieces, of the same type fiberboard as used in construction of the container, are required where it is necessary to prevent an opening between the inner flaps, unless otherwise provided by paragraphs (b) and (c) of this section of by Part 173 of this chapter.

(b) If to be closed by adhesive, each inner flap must cover at least one-third of face; inner flaps must butt or have full overlap, or fill-in pieces must be used, unless otherwise provided by Part 173 of this chapter, except that fill-in pieces are not required when outer flaps have full overlap. Outer flaps must butt or have full overlap.

(c) In lieu of fill-in pieces between inner flaps which do not butt, the following is authorized when linings are not prescribed in §178.205-16.

(1) Top and bottom pads the same dimensions as interior of container of solid or corrugated fiberboard at least 125 pound test (Mullen or Cady).

(2) Minimum combined weight of facings for corrugated fiberboard pads must be at least 52 pounds per thousand square feet.

(3) Minimum combined weight of component plies for solid fiberboard pads must be at least 114 pounds per thousand square feet, exclusive of adhesives.

(4) Complete inner box or boxes.

(d) Single-flap closures are authorized for boxes with one dimension not over 2”; each flap must be scored and form one of the small faces of the box and lap at least 5” on one of the largest faces.

§178.205-15 Linings (when prescribed by §178.205-16).

(a) Of 1-piece to extend around 4 faces with joint at center of 1 face and with 4 flanges, at least 1 ½” long, on each end (corners may be mitered) to bend over the other 2 faces; also 2 pads to cover the other 2 faces. Pads may be omitted if closing flaps afford 3 thicknesses throughout face. For boxes with 1 dimension not over 3”, one of the widest flanges may be lengthened to cover entire face and lap 6” on the adjoining face and the other flanges and the pads may then be omitted.

(b) [Reserved]

§178.205-16 Authorized gross weight and parts required.

(a) The authorized gross weight (when packed) and the parts required are as follows:

Authorized gross weight (pounds)	Strength of fiberboard (minimum) Mullen or Cady test						
	Solid board			Doublefaced corrugated		Doublewall corrugated	
	Box	Lining [2]	Heads [1]	Box	Lining [2]	Box	Lining [2]
15	175	--	([3])	175	--	200	--
30	200	--	275	200	--	200	--
40	275	--	350	275	--	200	--
	--	--	--	200	175	--	--
55	325	--	([3])	325	--	275	--
65 [4]	375	--	([3])	375	--	--	--
	--	--	--	275	175	275	--
	275	175	350	200	200	--	--

[1] For recessed heads when used. In other cases same as for the box.

[2] As prescribed in §178.205-15. A complete box is acceptable in place of the lining.

[3] Recessed heads are not authorized.

[4] Except as otherwise authorized herein or by Part 173 of this chapter.

(b) Triple slide boxes authorized for gross weights as follows: Of board at least 175-pound test for 40 pounds; of board at least 200-pound test for 65 pounds.

§178.205-17 Closing for shipment.

(a) Slotted container, by coating with adhesive the entire contact surfaces of closing flaps and fill-in pieces where required or as prescribed in paragraph (a)(1), (2), or (3) of this section.

(1) By stitching with staples as prescribed by §178.205-6 at 2 ½-inch intervals along all seams (one 5-inch space allowed when necessary to permit use of stitching device); or with staples made of flat wire of hardness not less than equivalent of Rockwell B90; and not less than 0.037 inch thick and not less than 0.074 inch wide, with not less than 1 ¼ inch crown, may be spaced not more than 5 inches apart. Such staples may be used across center seam where outside flaps meet in lieu of on both sides of center seam but need only be used where outside flaps overlay inner flaps; or staples made of arcuate wire of hardness not less than equivalent of Rockwell B90, and not less than 0.027 inch thick and not less than 0.095 inch wide, with not less than 1 inch crown, may be spaced not more than 5 inches apart. Such stitches when spaced not more than 2 ½ inches apart may be used across center seam where outside flaps meet in lieu of on both sides of center seam but need only be used where outside flaps overlay inner flaps.

(2) For fiberboard boxes containing not more than 1 inside metal can not exceeding 1 gallon nominal capacity, and as otherwise authorized by Part

173 of this chapter, by application of 2 strips of pressure-sensitive tape not less than ½ inch in width, 1 strip to be placed approximately equal distance over the seam of abutting outer flaps, the other at a right angle to the first and spaced approximately equal distance on the closure face; strips must be of sufficient length to extend not less than 1 inch beyond score lines on side and end panels. Tape shall have a minimum tensile strength of 160 pounds per inch of width; minimum adhesion value of 18 ounces per inch of width; and minimum elongation of 12 percent at break, or having a minimum longitudinal tensile strength of not less than 240 pounds per inch of width; minimum adhesion value of 18 ounces per inch of width and a minimum elongation of 3 percent at break.

(3) For slotted containers only, reinforced tape complying with the requirements of §178.205-7(b) is authorized for application over the center seam only. Tape must extend over the ends of box not less than 2½ inches.

(4) All closing flaps may be firmly glued with a hot-melt adhesive of 100 percent solid content of thermoplastic material which will maintain bond at temperature ranging from 20º F below zero to 165º F above zero. Adhesive must be applied in not less than eight stripes (except as specified below) on each inner flap, each stripe having a minimum width of 3/16-inch after compression. Stripes may not be more than 1 ½ inches apart and not less than four stripes must be applied on each side of center seam on each inner flap for full length of flap overlap area with one stripe not more than ½-inch from each side of center seam. If less than eight such stripes are applied on each inner flap, adhesive must cover and securely bond not less than 25 percent of flap contact area with bonded areas extending to within ½-inch or less of center seam.

(5) For regular slotted containers, pressure-sensitive tape is authorized for application over the center seams only and extending not less than two inches over the ends of the box. Tape must be not less than 2 inches wide and have a plastic film backing of polyester, polypropylene, or equivalent material. Tape must have a minimum tensile strength of 45 pounds per inch of width in the machine direction and not less than 55 pounds per inch of width in the cross direction and may not be affected by temperature extremes normally encountered during transportation. Boxes closed by means of this pressure-sensitive tape must be capable of passing performance tests prescribed in §178.210-10.

(b) Double slide boxes or triple slide boxes, by coating the inner slides with adhesive, or by closing with reinforced tape capable of withstanding test prescribed by paragraph (b)(1) of this section; for single-flap closures as authorized for boxes with one dimension not over 2 inches, the flaps must be fastened to the body with adhesive.

(1) Boxes selected at random, containing dummy contents similar to that to be shipped and packed to authorized gross weight, closed with reinforced tape across the ends and onto opposite side panels at least 2 inches, must be capable of withstanding a drop on each end from a height of 4 feet onto solid concrete without closure failure.

(c) Fiberboard boxes with covers extending over sides but not to bottom, covers resting on walls of box, or telescope boxes of equal depth section, covers extending to bottom, must be secured by one of the following methods:

(1) By not less than three metal straps, one lengthwise and others at right angles thereto.

(2) When cover extends not less than 3 inches over the walls of the box, by coating with adhesive the entire contact area of the cover.

(3) Telescope boxes having equal depth sections may be closed by application of reinforced water activated tape or pressure sensitive tape under conditions and for commodities as prescribed in Part 173 of this chapter.

(d) When metal straps are specified, boxes must be strapped with the required number; size at least 5/8 inch x 0.015 inch.

§178.205-18 Marking.

(a) *On each container*. Symbol in rectangle as follows:

DOT-12B ***

(1) Stars to be replaced by authorized gross weight (for example, DOT-12B40, etc.).

(2) Name and address or symbol of person making the mark specified in paragraph (a)(1) of this section and located just above or below that mark. Symbol, if used, must be registered with the Director OHMT.

(3) When metal straps are prescribed, boxes must be marked " _____ (number) METAL STRAPS REQUIRED" just above or below the mark specified in this paragraph.

(4) Size of markings: Specification markings prescribed in paragraph (a)(1) of this section must be at least ½ inch high; other markings must be legible.

[Reserved]

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Table J-9. Specification 12C; fiberboard boxes, 49 CFR 178.206 (pre HM-181, October 1989)

§178.206 Specification 12C; fiberboard boxes.

§178.206-1 Compliance.

(a) Required in all details.
(b) [Reserved]

§178.206-2 Definitions.

(a) Terms such as “200-pound test” mean minimum strength, Mullen or Cady test.
(b) “Joints” are where edges of parts of box, except recessed flanged heads, are connected together in setting up the box. Generally done by box maker.
(c) “Seams” are where edges of parts of box are visible, except joints, when box is closed.

§178.206-3 Classification of board.

(a) Fiberboard is hereby classified by strength of completed board as in first column of the following table; weights specified in the table are the minimums authorized.

Classified strength [1] of completed board	Solid fiberboard--Minimum combined weight of component plies exclusive of adhesives (pounds per 1,000 sq. ft.)	Facings for corrugated fiberboard	
		Double faced—Minimum combined weight of facings (pounds per 1,000 sq. ft.)	Double wall—Minimum combined weight of facings including center liner (pounds per 1,000 sq. ft.)
175	149	75	--
200	190	84	92
275	237	138	110
350	283	180	126
[1] Mullen or Cady test (minimum).			

(b) [Reserved]

§178.206-4 Solid fiberboard.

(a) To be 3-ply or more; both outer plies water resistant.

(b) [Reserved]

§178.206-5 Corrugated fiberboard.

(a) Both outer facings water resistant; corrugated sheets must be at least 0.009-inch thick and weigh not less than 26 pounds per 1000 square feet; all parts must be securely glued together throughout all contact areas.

(b) [Reserved]

§178.206-6 Stitching staples.

Stitching staples must be made in such a configuration that their holding capability as installed will not be less than that of flat steel staples 3/32 x 0.019 inch in cross section and not less than 7/16-inch wide.

§178.206-7 Tape.

(a) Coated with glue at least equal to No. 1 ¾ Peter Cooper standard. Cloth tape of strength, across woof, at least 70 units, Elmendorf test. Sisal tape of 2 sheets of No. 1 Kraft paper, total weight 80 pounds per ream (500 sheets, 24 x 36 inches); sheets to be combined with asphalt and reinforced by unspun sisal fibers completely embedded in the asphalt and extending across the tape, except as provided in §178.206-11(d).

(b) Tape for closure of slotted containers complying with the following requirements is authorized when applied as prescribed in §178.206-17(a)(2):

(1) Tape must be not less than 3 inches wide and shall be made of two sheets of 100 percent sulfate Kraft each not less than 30 pounds basis weight, reinforced with glass, sisal, or rayon fiber, combined with a laminant of asphalt or other material not affected by temperature extremes any more than would standard 180º F to 200º F softening point asphalt.

(2) Tape must be reinforced by lengthwise fibers spaced not more than an average of ½-inch apart, and by crosswise fibers spaced not less than an average of 2 per inch except that when a diamond pattern is employed for crosswise reinforcement, the spacing between the parallel sides of the diamond measured in the machine direction must be not more than 1 inch.

(3) Glass or sisal reinforced tape must have a minimum tensile strength in the machine direction of 75 pounds per inch of width and a minimum tensile strength in the cross direction of 45 pounds per inch of width; rayon reinforced tape must have a minimum tensile strength in the machine direction of 57 pounds per inch of width and a minimum tensile strength in the cross direction of 27 pounds per inch of width with elongation not exceeding 15 percent. Tensile tests on the finished product shall be made on a 3-inch width sample.

§178.206-8 Test.

(a) Acceptable board must have prescribed strength. Mullen or Cady test, after exposure for at least 3 hours to normal atmospheric conditions (50 to 70 percent relative humidity), under test as follows:

(1) Clamp board firmly in machine and turn wheel thereof at constant speed of approximately 2 revolutions per second.

(2) Six punctures required, 3 from each side; all results but one must show prescribed strength.

(3) Board failing may be retested by making 24 punctures, 12 from each side; when all results but 4 show prescribed strength the board is acceptable.

(4) For corrugated fiberboard, doublepop tests may be disregarded.

§178.206-9 Types authorized.

(a) To be of solid or corrugated fiberboard of the following types:

(1) Slotted box; three-piece box without recessed ends; three-piece box of solid fiberboard with recessed ends; double-slide box; triple-slide box; telescope box, with sections of equal depth, or with covers, top or bottom or both, with 3 inches overlap. (See §178.206-14 (d) for boxes with single-flap closures.)

(b) [Reserved]

§178.206-10 Forming.

(a) Parts must be cut true to size and so creased and slotted as to fit closely into position without cracking, surface breaks, separation of parts outside of crease, or undue binding.

(b) [Reserved]

§178.206-11 Joints.

(a) For solid and corrugated fiberboard slotted containers: Lapped 1 ½ inches from center of scoreline except as in §178.205-12; stitched at 2 ½ inch intervals and within 1 inch of each end of joint; body joint must be double-stitched (2 parallel stitches) at each end of joint over 18 inches long.

(b) For corrugated fiberboard slotted containers only: One butt joint taped (see §178.206-7) is authorized; 3-inch tape required for boxes over 30 pounds authorized gross weight and 2 inch tape for others.

(c) For triple and double slide boxes: Joints of all slides must be taped (see §178.206-7) or stitched.

(d) For corrugated fiberboard only: One butt joint taped inside and outside with strips of one thickness of sulphate paper not less than 2 inches wide extending entire length of joint and firmly glued to box. For boxes not exceeding 65 pounds gross weight, outside strip of sulphate paper to be of basis weight not less than 60 pounds testing not less than 60 pounds and inside strip of sulphate paper to be of basis weight not less than 40 pounds testing not less than 40 pounds. For boxes exceeding 65 pounds gross weight, outside and inside with strips of sulphate paper which must each be of basis weight not less than 90 pounds testing not less than 90 pounds. Basis weight of paper shown is for 500 sheets, 24 x 36 inches.

(1) For glued lap joint, the sides of box forming joint must lap not less than 1¼” and be firmly glued throughout entire area of contact with a glue or adhesive which cannot be dissolved in water after the film application has dried.

§178.206-12 Flanged heads.

(a) Must have 4 flanges, at least 1” long above fillet, on each head. Recessed flanged heads not authorized for boxes of corrugated fiberboard.

(b) [Reserved]

§178.206-13 Seams which are to be stitched.

(a) Overlap, if any, required to be at least 1 ½ inches from center of scoreline except as in §178.206-12.

(b) [Reserved]

§178.206-14 Flap closures.

(a) Fill-in pieces, of the same type fiberboard as used in construction of the container, are required where it is necessary to prevent an opening between the inner flaps, unless otherwise provided by Part 173 of this chapter.

(b) If to be closed by adhesive, each inner flap must cover at least one-third of face; inner flaps must butt or have full overlap, or fill-in pieces must be used, unless otherwise provided by Part 173 of this chapter, except that fill-in pieces are not required when outer flaps have full overlap. Outer flaps must be reasonably close together at the center seam or have full overlap.

(c) In lieu of fill-in pieces between inner flaps which do not butt, the following is authorized when linings are not prescribed in §178.206-16.

(1) Top and bottom pads the same dimensions as interior of container of solid or corrugated fiberboard at least 125 pound test (Mullen or Cady).

(2) Minimum combined weight of facings for corrugated fiberboard pads must be at least 52 pounds per thousand square feet.

(3) Minimum combined weight of component plies for solid fiberboard pads must be at least 114 pounds per thousand square feet, exclusive of adhesives.

(4) Complete inner box or boxes.

(d) Single-flap closures are authorized for boxes with one dimension not over 2”; each flap must be scored and form one of the small faces of the box and lap at least 5” on one of the largest faces.

§178.206-15 Linings (when prescribed).

(a) Of 1 piece to extend around 4 faces with joint at center of 1 face and with 4 flanges, at least 1 ½” long, on each end (corners may be mitered) to bend over the other 2 faces; also 2 pads to cover the other 2 faces. Pads may be omitted if closing flaps afford 3 thicknesses throughout face. For boxes with 1 dimension not over 3”, one of the widest flanges may be lengthened to cover entire face and lap 6” on the adjoining face and the other flanges and the pads may then be omitted.

(b) [Reserved]

§178.206-16 Authorized gross weight and parts required.

(a) The authorized gross weight (when packed) and the parts required are as follows:

Authorized gross weight (pounds)	Strength of fiberboard (minimum) Mullen or Cady test						
	Solid board			Doublefaced corrugated		Doublewall corrugated	
	Box	Lining [2]	Heads [1]	Box	Lining [2]	Box	Lining [2]
30	175	--	200	175	--	200	--
40	200	--	275	200	--	200	--

	--	--	350	[3] 275	--	--	--
65 [4]	275	--	--	200	175	275	--

[1] For recessed heads when used. In other cases same as for box.

[2] As prescribed in §178.206-15. A complete box is acceptable in place of the lining.

[3] Facings at least 138 pounds per thousand square feet or inner facing at least 42 pounds and outer facing at least 90 pounds per thousand square feet.

[4] Except as otherwise authorized by Part 173 of this chapter.

(b) Triple slide boxes authorized for gross weights as follows: Of board at least 75-pound test for 40 pounds; of board at least 200-pound test for 65 pounds.

§178.206-17 Closing for shipment.

(a) Slotted container, by coating with adhesive the entire contact surfaces of closing flaps and fill-in pieces where required or as prescribed in paragraph (a)(1), (2), or (3) of this section.

(1) By stitching with staples as prescribed by §178.206-6 at 2 ½-inch intervals along all seams (one 5-inch space allowed when necessary to permit use of stitching device); or with staples made of flat wire of hardness not less than equivalent of Rockwell B90; and not less than 0.037 inch thick and not less than 0.074 inch wide, with not less than 1 ¼-inch crown, may be spaced not more than 5 inches apart. Such staples may be used across center seam where outside flaps meet in lieu of on both sides of center seam but need only be used where outside flaps overlay inner flaps; or staples made of arcuate wire of hardness not less than equivalent of Rockwell B90, and not less than 0.027 inch thick and not less than 0.095 inch wide, with not less than 1 inch crown, may be spaced not more than 5 inches apart. Such stitches when spaced not more than 2 ½ inches apart may be used across center seam where outside flaps meet in lieu of on both sides of center seam but need only be used where outside flaps overlay inner flaps.

(2) For fiberboard boxes containing not more than 1 inside metal can not exceeding 1 gallon nominal capacity, by application of 2 strips of pressure-sensitive tape not less than ½ inch in width, 1 strip to be placed approximately equal distance over the seam of abutting outer flaps, the other at a right angle to the first and spaced approximately equal distance on the closure face; strips must be of sufficient length to extend not less than 1 inch beyond score lines on side and end panels. Tape shall have a minimum tensile strength of 160 pounds per inch of width; minimum adhesion value of 18 ounces per inch of width; and minimum elongation of 12 percent at break, or having a minimum longitudinal tensile strength of not less than 240 pounds per inch of width; minimum adhesion value of 18 ounces per inch of width and a minimum elongation of 3 percent at break.

(3) For slotted containers only, reinforced tape complying with the requirements of §178.206-7(b) is authorized for application over the

center seam only. Tape must extend over the ends of box not less than 2½ inches.

(b) Double slide boxes or triple slide boxes, by coating the inner slides with adhesive for boxes with one dimension not over 2 inches, the flaps must be fastened to the body with adhesive.

(c) Fiberboard boxes with covers extending over sides but not to bottom, covers resting on walls of box, or telescope boxes of equal depth section, covers extending to bottom, must be secured by one of the following methods:

(1) By not less than three metal straps, one lengthwise and others at right angles thereto.

(2) When cover extends not less than 3 inches over the walls of the box, by coating with adhesive the entire contact area of the cover.

(d) When metal straps are specified, boxes must be strapped with the required number; size at least 5/8 inch x 0.015 inch.

§178.206-18 Marking.

(a) On each container. Symbol in rectangle as follows:

DOT-12C ***

(1) Stars to be replaced by authorized gross weight (for example, DOT-12C65, etc.).

(2) Name and address or symbol of person making the mark specified in paragraph (a)(1) of this section and located just above or below that mark. Symbol, if used, must be registered with the Director OHMT.

(3) When metal straps are prescribed, boxes must be marked " _____ (number) METAL STRAPS REQUIRED" just above or below the mark specified in this paragraph.

(4) Size of markings: Specification markings prescribed in paragraph (a)(1) of this section must be at least ½ inch high; other markings must be legible.

[Reserved]

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Table J-10. Specification 55; metal-encased, lead or uranium metal-shielded, radioactive materials container, 49 CFR 178.250 (pre HM-181, October 1989)

§178.250 Specification 55; metal-encased, lead or uranium metal-shielded, radioactive materials container.

§178.250-1 Compliance.

(a) Required in all details.

§178.250-2 Requirements for design and construction.

(a) Lead or uranium metal shield to be encased in mild steel or equally fire-resistant metal of minimum wall thicknesses as follows:

(1) One-eighth inch (1/8”) thick for not more than 6 inches of lead or uranium metal (see Note 1).

(2) One-fourth inch (1/4”) thick for more than 6 inches of lead or uranium metal (see Note 1).

Note 1: Thickness of lead to be measured from outer edge of source cavity to nearest point on outer container wall.

(b) Lead or uranium metal shield to be completely encased so that molten lead or uranium metal will not flow away or lose its shielding efficiency if involved in a fire. The shield must be supported in the outer container in such manner that it cannot change position under any ordinary conditions. Parts of the shield must be so designed that radiation cannot be “beamed” at point where sections join (offset design required).

(c) Containers weighing more than 500 pounds must be fitted with skids or otherwise designed so that excessive weight will be prevented on small areas of car or truck floors.

(d) Containers weighing more than 500 pounds must be provided with hooks, handles, skids, or other devices to facilitate handling.

(e) Containers must be of such size and design as are necessary to reduce the radiation from the container to within the limits prescribed in §173.393.

(f) Containers constructed with tubing for drainage purpose must have the opening exterior to the shipping container plugged or capped. Drain lines must be plugged or capped with a material which will have a melt-point at or below that of lead, for

example, lead, hard rubber or plastic.

§178.250-3 Welding and brazing.

(a) When used to join parts of the container must be performed in a workmanlike manner and shall provide a joint efficiency of not less than 85 percent. The melting point of brazing material must be in excess of 1000º F.

§178.250-4 Closures.

(a) Closure must be by positive fastening device capable of withstanding severe impacts without failure.

(b) Lead or uranium metal shielding forming part of closing device must be completely encased in mild steel or equally fire-resistant metal.

(c) Closure must be of off-set design where inserted into other parts of the container.

(d) A means must be provided on the closure to accommodate a seal of a type that must be destroyed if container is opened for any purpose.

§178.250-5 Marking.

(a) Marking on each container in an unobstructed area, by embossing or die-stamping on the container, or on a metal plate attached to the container by welding or brazing, in letters and figures at least ¼" in height, as follows:

(1) DOT-55 *** (stars to be replaced by the tare weight of the container (for example: DOT-55 850)). These marks shall be understood to certify that the container complies with all specification requirements.

(2) The words "RADIOACTIVE MATERIAL."

(3) Name or symbol (letters) of maker or user assuming responsibility for compliance with specification requirements; this must be recorded with the Bureau of Explosives.

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Table G-6. Liquid and Gas Packagings--Compliance With Vibration Standard (49 CFR 178.608).

Specific packaging	No. tested	Weight kg (lb)	Contents	Results	Comments

NOTE: Packaging category compliance information will be added for this packaging type upon completion of testing for this packaging type.

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