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Mr. John Reeves
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Dear Mr. Reeves:

The documents entitled "Documentation and Verification Required for Type A Packaging Use" (WMTS-IP/7A-002, Rev. 0) and "Methodology for Identification of Testing to Conduct on Type A and Industrial Packagings" (WMTS-IP/7A-003, Rev. 0) are approved.

If you have any questions, please contact me at 301-903-5078.

Sincerely,

Michael E. Wangler, Director
Package Approval and Safety Program
Office of Safety, Health and Security, EM-5

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LIST OF TERMS

Bq/g	becquerels per gram
Ci	curie
cm	centimeter
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
ft	foot
g-cal/cm^2	gram-calories per square centimeter
g-moles/ft^3	gram-moles per cubic foot
IAEA	International Atomic Energy Agency
IATA	International Air Transport Association
in.	inch
kg	kilogram
kPa	kilopascal
lb	pound
lb/in^2	pounds per square inch
LSA	low specific activity
m	meter
µCi/g	microcuries per gram
NRC	U.S. Nuclear Regulatory Commission
psia	pounds per square inch, absolute
RAMPAC	Radioactive Materials Packaging
SCO	surface contaminated objects
STP	standard temperature and pressure
TBq	terabecquerel
W/m^2	watts per square meter

DOCUMENTATION AND VERIFICATION REQUIRED FOR TYPE A PACKAGING USE

1.0 INTRODUCTION

1.1 PURPOSE

This document was approved by the U.S. Department of Energy (DOE), Office of Safety, Health and Security (EM-5), as WMTS-IP/7A-002, Rev. 0, *Documentation and Verification Required for Type A Packaging Use* (Kelly and O'Brien 2000). This document is being released into the Fluor Hanford engineering document system and requires identification as being a Hanford (HNF) document for publication onto the Internet. This document is available in PDF format and may be found by accessing the Radioactive Materials Packaging (RAMPAC) web page located on the World Wide Web at the following address:

http://www.rampac.com/

This document furnishes knowledge and methods for verifying compliance with the U.S. Department of Transportation (DOT) packaging requirements for shipping Type A quantities of radioactive material. The primary emphasis is on the requirements identified in Title 49 of the *Code of Federal Regulations* (49 CFR) 173.415(a). This section of the regulations states, "Each offeror of a Specification 7A package must maintain on file for at least one year after the latest shipment, and shall provide to DOT on request, complete documentation of tests and an engineering evaluation or comparative data showing that the construction methods, packaging design, and materials of construction comply with that specification." This document does not provide guidance for the use of packagings for Type A quantities of fissile materials.

1.2 SCOPE

This document identifies methods for establishing the need for a Type A packaging and identifies sources of information for guidance on the proper shipment. Users of this document will learn to:

1. Identify an acceptable packaging for the material to be shipped
2. Verify that a packaging is properly tested and evaluated
3. Verify that documentation for the packaging is acceptable
4. Ensure the packaging is properly loaded.

1.3 APPROACH

This guidance document is based upon the premise that it is not sufficient merely to comply with packaging regulations. Compliance must be shown. A common approach for showing compliance is to use a checklist. This allows the performer to confirm completion of specific activities as they are completed. An example checklist and guidance for its use are provided in this document. The checklist is presented in the appendix.

1.4 DEFINITIONS

The meaning of the terms in this document follows the definitions identified in 49 CFR 100 through 185. The following definitions identify the usage of specific terms not covered in the regulations.

Material custodian means the person assigned responsibility for custody of the material.

Package (or packaging) engineer means a person understanding the packaging portions of the transportation regulations and having specialized knowledge about packagings for hazardous materials.

Shipper means a person signing the certification statement on the shipping papers.

Specialist (or transportation specialist) means a person having detailed knowledge about transportation regulations and package selection for hazardous materials.

1.5 RESPONSIBILITIES

1.5.1 Shipper (Offeror)

Requirements for hazardous materials shippers are established in 49 CFR 173.22. Those requirements direct a shipper to offer radioactive material for transportation in a packaging meeting the requirements identified in 49 CFR 173, Subpart I. The package must be prepared for shipment by classing and describing the hazardous material in accordance with 49 CFR 172 and 173. In addition, the shipper must determine that the packaging is an authorized packaging per the applicable requirements identified in 49 CFR 173 and must ensure that the package has been manufactured, assembled, and marked in accordance with the applicable requirements identified within 49 CFR 173, 178, and 179. Section 4.2, “Identification of Split in Responsibilities for Meeting Packaging Requirements,” identifies the complex relationship existing between the shipper and the packaging manufacturer. The shipper is advised to become familiar with the information in that section before selecting a packaging for use.

1.5.2 Manufacturer

In 49 CFR 178 the DOT assigns most of the responsibility for packaging integrity to the packaging manufacturer and some to the person using the package. Understanding this division of responsibility between manufacturer and shipper is essential when supplying a Type A packaging for use. If the responsibilities are not clearly understood by both the manufacturer and the shipper, the shipper might be led to believe that some requirements are met when they are not. In 49 CFR 178.2(c) the responsibility is placed on the manufacturer and subsequent distributors to supply a written notification to the person to whom the packaging is transferred. This notification must identify all packaging requirements not met at the time of transfer and the type and dimensions of any closures, including gaskets, needed to satisfy performance test requirements. Section 4.2, "Identification of Split in Responsibilities for Meeting Packaging Requirements," identifies the complex relationship established between the packaging manufacturer and the shipper that the notification is intended to clarify. The manufacturer is advised to become familiar with the information in that section before designing a packaging and preparing a notification.

2.0 VERIFYING THE NEED FOR A TYPE A PACKAGING

This section identifies the information needed to show that a Type A package is the proper packaging for the material being shipped. Selection of an acceptable packaging requires proper material identification and material classification.

2.1 CONTENTS CHARACTERIZATION

Material identification consists of determining the radiological, physical, thermal, and chemical characteristics of the material being shipped. The information is needed when designing or selecting a packaging. The information is used to ensure a safe packaging-load combination meeting all regulatory requirements. A checklist for use in ensuring that all characteristics are considered is provided in the appendix.

DOT-7A, Type A packagings are qualified for transporting Type A quantities of radioactive material. The material, besides meeting the Type A quantity limits, must be compatible with the packaging. Characterization of the contents for compatibility with the selected packaging is an important aspect of the shipment and is primarily the responsibility of the shipper. Designing a new packaging also requires characterization of the design load if the packaging is to fit the need.

The following subsections identify the regulatory drivers for the identification of material characteristics. In addition, they identify the importance of some characteristics to packaging design and selection.

2.1.1 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
173.435	Table A_1 and A_2 values for radionuclides
173.441	Radiation level limitations

173.453 Fissile materials--exceptions

173.459 Mixing of fissile material packages.

Addressing these packaging design requirements requires the development of a design basis list of the isotopes. The list should identify the radioisotopes present in the contents and their expected quantity on a per-loaded-package basis (radionuclides inventory). This design basis list may not reflect the actual contents shipped, but should establish bounding values on actual contents for design purposes. For packaging selection, the list of radionuclides should reflect those present in the actual load. If fissile radionuclides are present, the fissile classification should be shown.

Important parameters for both packaging design and selection are (1) the radionuclides, (2) activity per radioisotope, (3) the total activity allowed in the packaging, and (4) radiation level limits. This information is needed to determine if the Specification 7A (DOT-7A, Type A) packaging is acceptable packaging and to identify levels of shielding and containment required.

Section 1.0 of the appendix provides a reminder of what information is needed. Also, the checklist provides space in which to record the collected information.

2.1.2 Physical Form

The physical form of the material has a direct and indirect effect on the applicability of some requirements. For example, the form affects the density of the material, which affects the gross weight, which affects the requirements invoked for package handling features.

Physical form is very important when determining the containment level required by the load. The ability of the packaging to contain the material being shipped is dependent on particle size and the ability to flow. Usually, containment is simplest for “special form” materials. See definition in Section 4.1.1.5, “49 CFR 173.403, Definitions.” Special form material must satisfy several defined conditions, but it is typically either a single solid piece or is contained in a sealed capsule that can be opened only by destroying the capsule.

The complexity of containing solids increases as the particle size gets smaller. In the U.S. Department of Energy’s (DOE) DOT-7A test and evaluation document (DOE 1996 and DOE 1998), solid materials are classed into one of three material 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 (from the smallest physically possible particle size to the largest particle that will fit within the packaging).

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

  A packaging qualified for these contents is expected to contain contents of a corresponding particulate size, such as soil or construction debris. Materials, such as 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 of contamination, see 49 CFR 173.443, "Contamination control")

  A packaging qualified for these contents is expected to contain objects meeting the following or similar conditions:

  - 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.

Form Number 1 material requires a containment boundary that will retain the smallest size possible for the material being shipped, one molecule. Form Number 2 material requires a boundary that will retain the smallest size particle possible for the form of material; e.g., a grain of sand. Form Number 3 requires a containment that will retain the smallest object that will be shipped in the package. The containment boundary for all three material forms must retain the material not only during shipment but also when subjected to the packaging testing requirements.

Following the smallest size solids are liquids. Liquids flow and often result in gas generation that provides a driving force that can promote flow. Gases are the hardest physical form to contain. In general, packagings intended to transport liquids and gases require a containment boundary and closure built to close tolerances and having little movement during use. Containment for liquids and gases is made even more difficult as they are required to withstand more severe test conditions than those designed for solids. (See Section 4.1.2.1, “49 CFR 173.466, Additional tests for Type A packagings designed for liquids and gases.”)

Section 1.2, “Physical Form,” of the appendix provides space for recording the information on the physical form of the material making up the load. The checklist also reminds the user of the importance of checking for the possibility of the material undergoing physical phase changes.

2.1.3 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. However, for any heat-generating contents, the decay heat and other sources should be calculated and documented. The ability of the package design to handle the heat load should be analyzed to ensure no problems exist. If the load has other sources of thermal energy, they should be identified.

Section 1.3, “Thermal,” of the appendix provides space for recording the thermal load resulting from decay heat. Space is also provided for identifying other sources of thermal energy contained in the load.

2.1.4 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)	Chemical or galvanic 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 to degrade it. Also, the contents must not possess or develop chemical conditions that could lead to pressurization beyond the design specification or an explosion.

The basic chemical makeup of the contents to be shipped must be understood to adequately design or select a packaging. All organic substances and the quantity expected to be present in a single package must be identified. Any materials that would be classed as hazardous materials if they were not radioactive material should be identified through a material safety data sheet or by their proper shipping name and identification number in accordance with the Hazardous Materials Table (49 CFR 172.101). Hazards such as pyrophoricity, corrosivity, or oxidizing properties are not unusual to find with radioactive materials. This information is helpful in identifying the secondary hazards associated with the package contents. The package

must provide protection from those subsidiary hazards. Also, any materials that will react with air or water in the event containment is lost must be identified, and the packaging must be compatible with the resulting products. Any nonradioactive material contents that meet the definition of a hazardous material in accordance with 49 CFR 173 must be identified. Nonradioactive hazardous materials must be packaged in accordance with the regulatory requirements for the material. This will require dual certification for the packaging. An example of a load requiring a dual-certified packaging is a radioisotope generator that is shipped with a bottle of acid in the same package.

The checklist in the appendix provides a reminder of the need for information on the chemical properties of the load. Space in which to record the information is provided in Section 1.3 of the checklist.

2.2 MATERIAL CLASSIFICATION

The information gathered during the characterization process is used when classifying the material for transportation. The material being shipped must be classified properly to be shipped in accordance with the DOT regulatory requirements. Material classification provides the information needed to identify DOT-approved packagings for use in shipping the identified material. A checklist is provided in the appendix.

When characterization of the material identifies the presence of radionuclides, the material must be classified for transportation. Classification will determine if the material is controlled as a hazardous material because of the radioactive material present. If the material is controlled because of the radioactivity present, then the quantity to be shipped in a single packaging must be identified. This information is needed to classify the material into one of the transportation categories. The following subsections discuss the classification of radioactive materials.

2.2.1 Is Material Radioactive?

An assessment is needed to decide if the material should be classed as radioactive for transportation. The following section in 49 CFR will help the shipper in this decision.

49 CFR 173.403 Definitions.

Section 49 CFR 173.403 of the regulations identifies what is considered a radioactive hazard for purposes of transportation. To decide if a material is radioactive for shipment, the shipper needs to know the concentration (specific activity) of radioactivity existing in the material to be shipped. This concentration is compared with the limit established by the DOT in the 49 CFR 173.403 definition for radioactive material. If the concentration of radioactivity in the material to be shipped is greater than 70 Bq/g (0.002 μCi/g), the material is classed as radioactive material for purposes of transportation. Note that it is the concentration (specific activity) of radioactivity in the material being shipped, not the (specific activity) of the radionuclides used in the classification process. For a definition of specific activity, see

Section 4.1.1.5, "49 CFR 173,403, Definitions." If the radioactivity does not exceed 70 Bq/g (0.002 μCi/g), the material is not a radioactive hazard for shipment. If the material meets another DOT hazard class, it must be shipped in accordance with the requirements for that hazard class. Section 2.1 of the appendix provides space for identifying the determination.

2.2.2 Is Material Nonfissile or Fissile Exempt?

During the selection of the proper shipping name, a determination of the fissile classification of the radioactive material needs to be made. The fissile radioisotopes are identified in 49 CFR 173.403. Packaging requirements vary for fissile and nonfissile materials. Fissile material packaging exemptions are identified in 10 CFR 71.53, "Fissile material exemptions." Some relief for shipping requirements is identified in 49 CFR 173.453, "Fissile material exceptions." This document does not provide guidance for the use of Type A fissile packagings. This document covers the nonfissile or fissile excepted Type A packagings authorized for use in 10 CFR 71. Section 2.2 of the appendix provides space for identifying the fissile classification.

2.2.3 Can Type A Quantity Limits Be Met?

If the material is classed as radioactive material for transportation, then the amount of material per package becomes important. The concentration, quantity, and the kind of radioactive material present in the load are used to select a proper shipping name for the material. Selection of the proper shipping name requires identifying, for each radionuclide present in the material, an A_1 and/or A_2 value. The choice of A_1 or A_2 values is dependent on the form of material being shipped. The use of the A_1 values requires the material meeting the DOT definition for special form. The A_1 or A_2 value determined for the load should be documented. Section 2.2 of the appendix provides space for recording the value. The A_1 and A_2 values are used for establishing the level of control applied to the hazards associated with the radioactive material. If more than one radionuclide is present in the material, the A_1 and A_2 values are applied to the mixture. The proper shipping names for radioactive materials are identified in the Hazardous Materials Table, 49 CFR 172.101. Definitions and limits required for selection of the proper shipping name are found in 49 CFR 173, Subpart I.

Sections from 49 CFR 173, Subpart I, that guide the selection process are:

173.403	Definitions
173.424	Excepted packages for radioactive instruments and articles
173.426	Excepted packages for articles containing natural uranium or thorium
173.427	Transport requirements for low specific activity (LSA) Class 7 (radioactive) materials and surface contaminated objects (SCO)

173.428	Empty Class 7 (radioactive) materials packaging
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
173.434	Activity-mass relationships for uranium and natural thorium
173.441	Radiation level limitations.

If the proper shipping name for the material to be placed in the package is “Radioactive Material n.o.s.,” “Radioactive Material Special Form n.o.s.,” or “Uranyl nitrate hexahydrate solution,” then the acceptable packaging is determined by the A_1 or A_2 value. To be shipped in a Type A packaging the quantity of radioactive material in the load must not exceed the A_1 or A_2 value set for the material form being shipped. While there is no lower limit for the A_1, and A_2 values in the Type A package, some loads may be shipped more efficiently in less than a Type A packaging if they meet one of the definitions for excepted shipments identified in 49 CFR 173.421, .424, .426, and .428.

Section 2.2 of the appendix provides a reminder of the need to determine the classification for the radioactive material. Space is provided for identifying the results of the determination and recording the proper shipping name.

3.0 PACKAGING SELECTION

This section identifies information that should be considered during design or selection of a packaging for a Type A quantity of radioactive material. The subsections provide a general description of the types of authorized packagings, identify physical characteristics that influence design or selection, and identify the impacts of the transportation mode on the design or selection. Sources of information on available packagings or packaging designs are identified to help in the process of choosing and finding an acceptable packaging.

3.1 AUTHORIZED TYPE A PACKAGES

Four packaging types are authorized In 49 CFR 173.415(a) for use in shipping Type A quantities of radioactive material. To assist in the packaging selection process, a general description of the four packaging types is provided below, along with a summation of conditions that influence their use. The packaging selection process is usually an iterative process consisting of an initial selection followed by an analysis of the ability of the packaging-load combination to meet the packaging requirement, followed by a repeat of the process if the packaging-load combination is not acceptable. The process is repeated until an acceptable packaging is identified. Section 3.1 of the appendix provides for identifying the type of packaging selected for use.

3.1.1 Specification 7A, General Packaging, Type A

The basic DOT specification for a Specification 7A, general packaging, Type A package is presented in 49 CFR 178.350. That specification requires that each packaging must meet all applicable requirements of 49 CFR 173, Subpart B, and be designed and constructed so that it meets the requirements of 49 CFR 173, Subpart I, Sections 173.403, 173.410, 173.412, 173.415, and 173.465. Each packaging built to Specification 7A, general packaging, Type A, must be marked on the outside "USA DOT 7A Type A" and "Radioactive Material."

Each offeror of a DOT-7A, Type A package must maintain on file for at least one year after the latest shipment, and shall provide to DOT on request, complete documentation of tests and an engineering evaluation or comparative data showing that the construction methods, packaging design, and materials of construction comply with that specification.

3.1.2 Other Type A Packagings

Type A packagings meeting the applicable standards for fissile materials in 10 CFR 71 and used in accordance with 49 CFR 173.471 are acceptable for use as a Type A packaging. Use of a certified packaging requires being registered to use the packaging and following all the applicable conditions of use.

3.1.3 Type B Packagings

Type B, B(U), or B(M) packagings meeting the applicable standards set forth in 10 CFR 71, certified by the U.S. Nuclear Regulatory Commission (NRC), and used in accordance with 49 CFR 173.471 are acceptable for use in shipping a Type A quantity of radioactive material. Use of a certified packaging requires being registered to use the packaging and following all the applicable conditions of use.

Alternately, an NRC-approved package may be shipped under the provisions of 49 CFR 173.415(a) as a DOT-7A, Type A package. In this instance, the shipper (if requested) must provide the 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 the DOT-7A, Type A packaging specification. The shipper is required to maintain this documentation on file for at least one year after the latest shipment.

The assumption should not be made that the Type B packaging documentation is adequate by itself to demonstrate compliance with the Type A packaging requirements. Differences in the application of the pass-fail criteria can result in undocumented performance requirements. Changes in radiation levels should be watched closely when the documentation is evaluated. In the recommendations of the International Atomic Energy Agency (IAEA) for Type A packagings, a 20% increase in the radiation level from the undamaged-to-damaged condition is identified as a significant change. The IAEA recommendations are found in *Regulations for the Safe Transport of Radioactive Material ST-1* (IAEA 1996). For the Type B package the changes in radiation levels due to normal conditions of transport may not be clearly identified. Also, any change in the way the package is used needs to be evaluated; e.g., a change in the authorized load. Thus, a radiographic source changer certified by the NRC for shipment of a specific radionuclide in special form could be used to ship a Type A quantity of a different nuclide provided the package is reevaluated under the provisions of 49 CFR 173.415(a). When an NRC-certified package is used as a DOT-7A, Type A package, the NRC package identification marking should be covered and new markings ("USA DOT 7A Type A" and "Radioactive Material") affixed to the package. In addition, the package should be marked with the name and address or symbol of the manufacturer (49 CFR 178.3).

3.1.4 Foreign-Made Packagings

Any foreign-made packaging that meets the standards in the *Regulations for the Safe Transport of Radioactive Material, 1985 Edition,* Safety Series No. 6 (As Amended 1990) (IAEA 1990), bears the marking "Type A," and was used for the import of Class 7 (radioactive) materials is authorized for use. Such packagings may be used for domestic and export shipment of Class 7 (radioactive) materials provided the offeror obtains the applicable documentation of tests and engineering evaluations and maintains the documentation on file in accordance with 49 CFR 173.415(a). These packagings must conform with requirements of the country of origin (as indicated by the packaging marking) and the IAEA regulations applicable to Type A packagings (IAEA 1990).

3.2 PHYSICAL CHARACTERISTICS OF THE LOAD

In Section 2.1, "Contents Characterization," the importance of collecting radiological, physical, thermal, and chemical data for use in selecting or designing a Type A package is presented. A few examples are presented in that section to demonstrate the importance of obtaining the information. This section identifies how to use the physical characteristics of the intended load when selecting or designing a packaging. Each of the following subsections looks at one of the radiological, physical, thermal, or chemical attributes and the impacts associated with those attributes that should be considered.

Section 3.2 of the appendix provides space for identifying information on the physical characteristics of the load. This section of the appendix provides space for identifying where information is to be found if Section 1.0 of the appendix has not been completed.

3.2.1 Radiation Type, Level, and Distribution

The radiation types most likely to influence packaging selection and design are as follows:

- The photon emissions, gamma and bremsstrahlung
- Particle emissions, neutrons, alpha, and beta.

The other radiation types must be considered, but will usually have little impact on shielding design or material selection.

When gamma and bremsstrahlung radiation are present, a packaging that provides dense shielding material is generally preferred. Common shielding materials are lead and steel. The shield must be designed to reduce the external radiation levels to those identified for general commerce or exclusive-use transportation. The limits are identified in 49 CFR 173.441, "Radiation level limitations." When designing a package, keeping the cavity provided for the load to a minimum will keep the overall weight of the packaging down. However, bremsstrahlung radiation results from the interaction of beta particles with dense materials. If the load results in the emission of many beta particles, the use of some low-density shield material, such as aluminum, before the dense shield may reduce the amount of dense shielding needed. This can result in a significant reduction in the overall weight.

The shielding for particles is generally lighter than that needed for the photon radiation. However, each of the particle types requires the consideration of different shielding materials. Usually the alpha particles are the easiest to shield against. A thin layer of almost any material will result in a very large reduction of the dose rate. Secondary radiation production from the stopping of the alpha particles is very small. Most energy goes into the production of ions.

Beta particles are a little more difficult to shield. Because the beta particle has less charge, it passes through the shield more than an alpha particle of equal energy. This results in the need for thicker shields. Beta particles also lose the most energy through ionization.

Increasing the density of the beta shield to reduce its thickness can be counter productive. As the density of the shield material increases, beta particles begin to lose energy through a process known as bremsstrahlung. Bremsstrahlung is the production of photon radiation, high-energy X-rays, when a beta particle undergoes rapid acceleration as it passes in the vicinity of a nucleus. In general, aluminum is the most dense material recommended for shielding beta particles.

Neutrons require shielding that is very different from that used for other particles. This results from the particles having no electrical charge. The use of a neutron shielding expert is highly recommended when selecting or designing a packaging to transport a neutron-emitting material that results in a significant exposure potential. High-energy neutrons result in a higher dose per neutron flux than low-energy neutrons. Also, higher-energy neutrons are more difficult to stop than low-energy neutrons. To reduce the energy of high-energy neutrons, collisions with molecules of a mass close to the mass of the neutron are employed. This results in the use of materials containing a lot of hydrogen. Once the neutron energy is reduced, a material with a high probability of capturing the neutron can be employed to stop the neutron. Sometimes reducing the energy alone will provide enough reduction in the exposure rate.

While reducing the energy level of the neutrons does reduce the dose rate, with some materials, the placement of the shielding material may be important. The placement is important as some materials capture the low-energy neutrons and produce additional high-energy neutrons. When this is the case, one should definitely seek the help of an expert when selecting or designing a shield. Because this document does not cover fissile packages, no discussion of the effects of the shield on criticality will be presented.

Besides using the information on the types of radiation present in the load to design shielding, this information is used when selecting or designing the packaging. The interaction of the radiation with the materials of construction must be considered. For example, the energy deposited into some plastic materials results in a cross linking of the polymer chains that results in the material becoming brittle. All materials used in the containment boundary or other critical safety component should be evaluated for their ability to withstand exposure to radiation. When a material that suffers reduced performance ability with time is used in a packaging, that factor must be considered during design and use. For example, a gasket material may require a modified design to allow for the changes in material properties and require more frequent replacement.

It is recommended that the information on the radioactivity in the design load be documented. This information is also useful when evaluating the ability to ship a different load in the packaging. Use of the checklist in the appendix or a similar document is recommended. Section 3.2.1 of the appendix provides space for identifying the documentation and location of the information on the radiological characteristics of the load.

3.2.2 Weight/Density

A very basic characteristic common to solids, liquids, and gases is the mass of the load. The more massive the load, the stronger the package must be to withstand both transportation

and the "normal condition of transport tests" imposed by the regulations. The density of the material also has an influence on the package. For a given mass, as the density of the load decreases, the volume required to confine or contain the load increases. As the volume increases, the dimensions of the package also increase. For a material requiring dense shielding, this can result in very large increases in the mass of the packaging. For loads where shielding is not significant, the increases in the packaging's dimension may still result in the need for additional structural strength. When selecting a package for a dense load, the resulting configuration should not negate the tests and/or evaluations conducted for a less dense material or vice versa. Meeting the weight restrictions of the package may not be sufficient. Loading the packaging with more or less dense material than that used to test or evaluate the packaging can result in a shifting of the energy deposition that results in packaging failure.

It is recommended that the mass or weight and density be identified for the load used when testing and evaluating the packaging. The information will be useful when the mass or density of the load is changed.

For a packaging that uses internal shock-absorbing material, how the load interacts with the energy-absorbing materials should be watched. With materials that crush, if the load has a different mass or density, failures could result. For example, if the load is more dense than the tested configuration, additional crush could result in a failure to meet radiation limits. During one Type A package test, failure of a containment boundary was observed for a packaging where the mass per unit area of crush was decreased. The larger surface area contacting the crush material resulted in the energy being transmitted to the closure rather than being absorbed in crushing the cushioning. The transmitted energy was enough to dislodge the closure, resulting in failure of the containment boundary.

Section 1.2.1 of the appendix provides space for recording information on the weight and density of the load. Section 3.2.2 of the appendix provides space for identifying where the information is documented and located if Section 1.2.1 is not used.

3.2.3 Physical Phase, Solid, Liquid, or Gas

The physical phase of the material can profoundly affect the ability of the packaging to meet regulatory requirements. The possibility of a phase change over the range in temperature that the package must perform should be watched. Uranium hexafluoride (UF6) is an example of a solid that can have phase changes over the required temperature range.

For solids, the influence of the size of the solid material on the containment boundary is pointed out in Section 2.0. The size and shape of the solid particles can affect how the load interacts with the containment boundary at impact. Granular materials can result in shifting some impact energy. The energy will be shifted at an angle away from the line of impact. This results in less energy dissipation at the point of impact and more at other points on the containment boundary. Another feature of a solid that must be considered is shape. For example, a motor has a large mass and a shaft protruding from the body. That protrusion results in small surface areas that may carry the total mass of the motor. If the motor is not properly

blocked and braced within the package, the concentrated load on the end of the shaft could result in packaging failure. When selecting a packaging from existing packagings, the testing and evaluations should always be reviewed to determine how the packaging was loaded. If the new loading is different, the packaging should be either retested or evaluated. Going from a load that exhibits fluid properties to one that exhibits the properties of a solid should be looked at as closely as a change in the other direction. Also, care should be taken when a packaging designed for liquids is used with a solid load. The package must not be loaded in a way that would result in failure if the testing were conducted.

For liquids, the package must meet additional design and performance requirements. When designing containment, it is important to remember that liquids, like granular solids, can shift some impact energy at angles to the line of impact traveled by the center of gravity. Also, crushing of the containment can result in pressurization due to the volume reduction. The pressurization, coupled with the dissipation of impact energy, can result in loss of closure. Packages for liquids must have either two containment boundaries, or one containment boundary surrounded with absorbent material. The amount of absorbent material must be capable of absorbing twice the liquid present in the package. Caution must be used in determining the amount and the placement of the absorbent. Accurate absorbent values are required for the material being shipped. Just because the absorbent will meet the requirements for one liquid does not indicate the same ability for a different liquid. If information is not available for the material to be shipped, tests and/or evaluations should be conducted. When using absorption data, how the data was obtained should be determined. Most data will be based on testing that resulted in the maximum absorption. In most packagings the absorbent material will not be under the same conditions that were used for testing and evaluating the capacity of the absorbent. A check should be made of the influence of the load on the absorbent material that results from the internal parts of the packaging and from the damage experienced during testing or evaluation. Usually squeezing the material will result in less absorption. Also, a check should be made that there is enough absorbent in paths that will be followed by the liquid. Twice the absorbent necessary on the bottom of a packaging will not do much good when the packaging is setting on its top.

With liquid packagings, the ability of the containment to withstand a change in phase and volume should be determined. Most water-based liquid will freeze. Freezing of water results in an expansion of the material. Other liquids may go to a gas phase. It is important to provide for expansion and contraction of the load. It should be remembered that the ability of a containment vessel to withstand an internal pressuring load does not show it will withstand an external loading. A packaging filled and sealed in a reduced-pressure atmosphere or while warm can experience greater pressure on the outside than exists inside.

For gases, like liquids, there are additional design and performance requirements to be met by the packaging. Double containment and absorbents are not required, but a stronger packaging is required. The need for a stronger packaging results from the necessity to withstand large impact loads and the pressure that results from containing a compressed gas. A packaging for containing gas requires additional attention to closures. Not only must the closures seal tightly, they must be protected from damage. The need for closure protection results not only

from the need to retain the material but also from a desire to avoid the hazards associated with the sudden release of energy that results when a valve is broken from a compressed gas cylinder.

When selecting a packaging for gas, the maximum pressure differentials that the package will experience should be considered. If the package can experience a pressure on the outside that is greater than the internal pressure, one must ensure that the package will not fail.

For both liquids and gases, the additional performance requirements are just that, additional. The packaging documentation should discuss both sets of performance requirements. This does not mean that the packaging must be tested to both free drops and both penetration drops, but all four must be covered in the evaluation. When selecting a packaging from existing packagings, the packaging should be tested and/or evaluated to meet all of the requirements.

It is recommended that the information on the physical properties of the load be documented. Section 1.2.2 of the appendix provides space to record the information on the physical properties of the material. Section 3.2.3 of the appendix provides space for identifying where the information is documented and located if Section 1.2.2 is not used. The information is a useful starting point when evaluating the packaging for a different load.

3.2.4 Gas Generation

Gas generation results from various processes; e.g., chemical reactions, biological decay, and radiolysis. Several hazards can result from gas generation, pressurization, and/or the generation of flammable mixtures. When designing or selecting a package, both the load and the material used for construction should be evaluated. The presence of organic and hydrogenous materials can result in significant gas generation in short periods. Not all reactions are linear, so care must be used during the evaluation.

The problem of flammable gas production can be addressed in a number of ways. Three common ways are venting, controlling the length of closure, and the addition of an inert atmosphere. The following discussion on hydrogen gas generation as a controlling parameter for radioactive shipments is from the NRC. On September 10, 1984, the NRC issued Information Notice No. 84-72, *Clarification of Conditions for Waste Shipments Subject to Hydrogen Gas Generation* (NRC 1984). The following generic requirements from that notice are included in certain certificates of compliance:

> *(1) For any package containing water and/or organic substances that could radiolytically generate combustible gases, it must be determined by tests and measurements of a representative package whether or not the following criteria are met over a period of time that is twice the expected shipment time:*
>
> > *(a) The hydrogen generated must be limited to a molar quantity that would be no more than 5% by volume (or equivalent limits for other inflammable gases) of the secondary container gas void, if*

present, at standard temperature and pressure (STP) (i.e., no more than 0.063 g-moles/ft^3 at 14.7 psia and 70°F), or

(b) The secondary container and cask cavity must be inerted with a diluent to ensure that oxygen must be limited to 5% by volume in those portions of the package that could have hydrogen greater than 5%.

For any package delivered to a carrier for transport, the secondary container must be prepared for shipment in the same manner in which determination for gas generation is made. The shipment period begins when the package is prepared (sealed) and must be completed within twice the expected shipment time.

(2) For any package containing materials with radioactivity concentration not exceeding that for low specific activity (LSA) material, and shipped within 10 days of preparation, or within 10 days after venting of drums or other secondary containers, the determination in (1) above need not be made, and the time restriction in (1) above does not apply.

The notice also points out that the generation of combustible gases is dependent on the waste form, radioactive concentration and isotope, free volume, total mass, and accumulated dose in the waste. This information should be considered when designing or selecting a Type A packaging.

For Type A packaging for solids, venting is a common practice. The vent openings must be small enough to prevent loss of material. One method of providing the small, opening pathway is the use of high-performance filters. Several companies make small filters capable of meeting Type A packaging performance requirements. When venting is used, care needs to be taken that the packages will not release enough gases into the surrounding area such that the gas generates a health or flammable hazard. If a package is used to ship solids that have the potential for gas generation and it is not vented, then the ability of the packaging to withstand the expected pressure and flammable levels should be evaluated. Also, if the package is to be opened after shipment, a safe method of pressure relief should be developed. Of note, pressure relief and venting methods should not result in a release of radioactive material to the environment.

For liquids, venting is not a common practice and is not recommended. When venting a liquid package, care must be taken to ensure venting occurs in all stable positions. This results from the likelihood of a single vent being blocked by the liquid load. If double containment is used, both containment boundaries must provide adequate venting. Any filters used would require a demonstration that they function after wetting with the material to be shipped. The most common practice for liquid packagings is to establish an administrative control over the time the package will remain sealed.

For gas packagings, gas generation is generally not a problem.

The maximum operating pressure for a packaging is defined in 49 CFR 173.403. The maximum normal operating pressure is defined as the maximum gauge pressure that would develop in a receptacle in a period of one year, in the absence of venting or cooling, under the heat conditions specified in 10 CFR 71.71(c)(1). In 10 CFR 71(c)(1) the heat condition is specified as an ambient temperature of 38 °C (100 °F) in still air and where insolation occurs according to Table 3-1.

Table 3-1. Insolation Data.

Form and location of surface	Total insolation for a 12-hr period (g-cal/cm^2)
Flat surfaces transported horizontally Base Other surfaces	None 800
Flat surfaces not transported horizontally	200
Curved surfaces	400

When designing or selecting a package, the worst-case gas generating load that is to be shipped in the packaging should be used to determine if this criterion is met.

Section 3.2.4 of the appendix provides space for identifying where the information on gas generation is documented and the location of the documentation. The information is a useful starting point when evaluating the packaging for a different load.

3.2.5 Thermal

Usually, a Type A quantity of radioactive material will not produce much heat. However, under some conditions, even a small heat input can result in high temperatures. The Type A package should be tested or evaluated to determine if temperatures resulting in failure can be reached. The regulations call for the package to meet this requirement over a temperature range of -40 °C (-40 °F) to 70 °C (158 °F). There are also temperature limits for the accessible surface of the package. The surface temperature must not exceed 50 °C (122 °F) when the package is in still air and shade with an ambient temperature of 38 °C (100 °F). If shipped exclusive use, the surface temperature must not exceed 85 °C (185 °F). If the Type A package is to be carried in general cargo without special provisions, there should be some heat output provisions. The heat output in watts should not exceed 0.1 times the minimum package dimensions in centimeters, or the average surface heat flux should not exceed 15 W/m^2, and the package should not be surrounded with packagings, such as bags, that would impede air flow.

Section 1.3 of the appendix provides space to record thermal information on the load. Section 3.2.5 of the appendix provides space for identifying the documentation of the ability of the packaging to handle heat and the location of that documentation.

3.2.6 Chemical

When a packaging is designed, care must be used in the selection of the materials of construction. The materials selected should be compatible with each other, besides being compatible with the load. Care must be taken to ensure the use of dissimilar material in the package does not result in a reaction that will result in packaging failure. For example, contact between copper and aluminum will result in electrolysis that can destroy the packaging.

When a packaging is designed or selected, care must be taken to ensure the load will not result in an adverse chemical reaction with the portions of the packaging it contacts. For example, one would not want to use stainless steel for a pressurized container for a load containing chlorine. Under these conditions, chloride-induced stress cracking can occur. The load should also be evaluated for chemical reactions that could result in the generation of conditions that could result in failure of the packaging; e.g., an exothermic reaction that could produce enough heat to fail the materials of construction. Consideration also must be given to the potential for air or moisture to enter the package and react with the load to produce a material that is not compatible with the materials of construction.

Section 1.4 of the appendix provides space for recording information on the chemical properties of the load. Section 3.2.6 of the appendix provides space for identifying the documentation that demonstrates the ability of the packaging to handle the chemical properties of the load and materials of construction and where the documentation is located.

3.3 IDENTIFICATION OF TRANSPORTATION MODE

This subsection identifies the different packaging requirements that exist due to the chosen transportation mode. Suggestions on meeting the requirements are provided. Except for transportation by air, the design and performance requirements are the same.

3.3.1 Air

Packages for shipment of liquid by air have several requirements that differ from those for shipment by other modes. Only one of the differences is identified in 49 CFR 173, Subpart I. That difference, found in 49 CFR 173.410(i)(3), applies to packages containing liquids. Packages for liquids must be able to withstand, without leakage, an internal pressure that results in a pressure differential of not less than 95 kPa (13.8 lb/in^2). This is a minimum pressure differential and may not be adequate for some loads. Of note, most DOT-7A, Type A packagings are only designed for a pressure differential of about 75 kPa (11.2 lb/in^2).

The remaining differences show up in 49 CFR 173.24, “General requirements for packagings and packages,” and 173.27, “General requirements for transportation by aircraft.” Subsection (g) in 49 CFR 173.24 states that a package being shipped by air must not be vented to reduce the internal pressure resulting from the evolution of gas from the contents. Subsection (c) in 49 CFR 173.27 states that a packaging must be designed and constructed to prevent leakage that may be caused by changes in altitude and temperature during transportation aboard aircraft.

The requirements for Type A packagings identified in 49 CFR 173, Subpart I, already address the temperature ranges and the need to withstand vibration. For most materials and loadings the required pressure differential will meet the requirements for shipment by aircraft. However, loads that generate internal pressure should be evaluated to determine if the packaging can withstand the pressure differential that could result from the maximum normal operating pressure and the reduced external pressure. Of note, when selecting a packaging, this requirement will make any vented DOT-7A, Type A package unacceptable for shipment by aircraft.

Subsection (d) in 49 CFR 173.27 establishes some specific conditions for use of several types of packaging closures. The conditions are that stoppers, corks, or other such friction-type closures must be held securely, tightly, and effectively in place by positive means. Each screw-type closure on any packaging must be secured to prevent closure from loosening due to vibration or substantial change in temperature. While stoppers and corks are not likely to be used on a Type A packaging, friction and screw type closures are common. When a packaging is used for shipment by aircraft, the closures must meet the identified conditions.

The requirements the packaging must meet are covered in Section 4.0, “Verifying Regulatory Compliance of Selected Packaging.” Section 3.2.7 of the appendix provides space for identifying information on the applicability of the requirements associated with transport by aircraft. Included is an area for identifying the need for a pressure differential greater than the minimum required for transporting liquids. Section 4.0 of the appendix provides space for recording information on the ability of the packaging to meet the additional design requirements for shipment by aircraft. Sections 4.1, 4.4, and 4.5 of the appendix provide space for identifying the documentation that shows the ability of the packaging to meet the additional requirements for shipment by aircraft and to identify where the documentation can be found.

3.3.2 Highway, Rail, or Vessel

Packaging design and selection requirements are the same in all three modes of transportation.

3.4 TYPE A PACKAGING REGISTERS

This subsection identifies sources of information on available packagings or packaging designs to aid in the process of finding and choosing an acceptable packaging.

3.4.1 DOE's Test and Evaluation Document

The DOE conducts, through several of its operating contractors, an evaluation and test program to qualify Type A radioactive material packagings per DOT Specification 7A, general packaging, Type A regulations. The DOE program is called the “DOT-7A Program.” The DOT-7A Program is administered by the DOE, Office of Safety, Health, and Security, at DOE Headquarters in Germantown, Maryland.

The *Test and Evaluation Document for DOT Specification 7A Type A Packaging*, DOE/RL-96-57 (DOE 1996 and DOE 1998), presents approximately 300 different packagings determined to meet the requirements for a DOT-7A, Type A packaging per 49 CFR 178.350. The document is broken out by packaging category; i.e., steel drums, steel boxes, wooden boxes, fiberboard containers, liquid and gas packagings, and miscellaneous packagings. Helpful design information is given for each of the referenced packagings. Appendices are provided that document how the referenced packaging meets design and test requirements for a DOT-7A, Type A packaging. All DOT-7A, Type A packagings presented in DOE (1996) were designed and evaluated in accordance with the requirements of 49 CFR 178.350 in effect on July 1, 1983, and are authorized for use after April 1, 1997. All DOT-7A, Type A packagings presented in DOE (1998) were designed and evaluated in accordance with the requirements of 49 CFR 178.350 in effect and authorized for use after April 1, 1997.

The specific packaging data contained in DOE (1996 and 1998) serve to meet the requirements of 49 CFR 173.415(a) for ". . . documentation of tests and an engineering evaluation or comparative data showing that the construction methods, packaging design, and materials of construction comply with that specification." when packagings are used as prescribed. However, shippers are cautioned that additional documentation will be needed to fulfill all of the requirements for a particular shipment. Most importantly, documentation will be needed 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.

DOE has, from the beginning, shared the information in DOE (1996 and 1998) with the radioactive materials shipping community throughout the world. Both volumes of the document are available on the World Wide Web via the following address:

http://www.hanford.gov/pss/t&p/dot7a/pdot7a.htm

This address is case sensitive. To access this document via the Internet, the address MUST be typed EXACTLY as shown above, or an error message will occur. It is highly recommended that Internet users mark this site.

Another route to take to access DOE's document via the Internet is to access the RAMPAC web page via the following address:

http://www.rampac.com/

The "RAMPAC Home Page" will appear, *proceed*, and a selection menu will be presented. DOE's Type A test and evaluation document will be listed as a selection item.

3.4.2 Vendor Catalogs

There are commercial organizations that manufacture packagings to 49 CFR 178 regulations. Some of these manufacturers publish catalogs of the packagings they offer. Other manufacturers produce packagings to customer-supplied designs.

Section 1.5 of this document discusses the responsibilities of the shipper and manufacturer as they apply to DOT-7A, Type A packagings. Many times shippers and manufacturers have a very poor understanding of these responsibilities. When a packaging is obtained from a commercial source, before acceptance and definitely before use, it is highly recommended that the documentation supplied by the manufacturer be checked against the documentation requirements identified in this document. See the recommendations on checking packaging documentation presented in Section 4.3.1, “Desktop Review.”

3.4.3 RAMPAC Database

The DOE RAMPAC database provides shippers of radioactive material with information on all nonclassified packages certified by the NRC and the DOE for the transport of radioactive materials. RAMPAC also contains information on U.S. and foreign packages certified by the DOT for import and export use. It is the only tool that contains and reports package information from all three federal agencies.

The RAMPAC contains information on more than 2000 radioactive material shipping packages. The information is taken directly from the certification documentation. Important characteristics for each package are stored in the database. These characteristics can be searched to identify packages that meet the database users’ requirements.

Access to the RAMPAC web site may be achieved via the following Internet address:

http://www.rampac.com/

The “RAMPAC Home Page” will appear, *proceed*, and a menu will appear for database access. First-time users need to complete a profile and obtain a password. For more information or assistance, RAMPAC support is identified at the bottom of the website page referenced above.

4.0 VERIFYING REGULATORY COMPLIANCE OF SELECTED PACKAGING

This section identifies the packaging requirements for verification and documentation of compliance. Types of acceptable documentation useful for proving compliance are identified. A checklist of requirements for DOT-7A Type A packagings is included as the appendix. The checklist includes space after the requirements to identify the documentation that demonstrates the requirement is met and the location of the documentation.

4.1 WHAT TO VERIFY

Four types of packagings are identified in 49 CFR 173.415(a) as authorized by the DOT for use as a Type A packaging. These four packaging types are identified in Section 3.1, “Authorized Type A Packages,” of this document.

In Section 3.1 of this document, it is identified that any foreign-made packaging meeting the standards in IAEA Safety Series 6 (IAEA 1990), bearing the marking "Type A," and used for the import of Class 7 (radioactive) materials is authorized for use. Such packagings may be used for domestic and export shipment of Class 7 (radioactive) materials, provided the offeror obtains the applicable documentation of tests and engineering evaluations and maintains the documentation on file in accordance with 49 CFR 173.415(a). These packagings must conform with requirements of the country of origin (as indicated by the packaging marking) and the IAEA regulations applicable to Type A packagings (IAEA 1990).

This document presents no specific information on what to verify in the documentation for a foreign packaging. The documentation, however, should contain similar information to that identified for DOT-7A, Type A packagings. One other piece of documentation to consider having for a foreign packaging is proof that the package was used for the import of Class 7 (radioactive) material.

In Section 3.1 of this document, it is identified that certified packagings must be used in accordance with the requirements identified for the package or be tested and/or evaluated for use as a DOT-7A, Type A package. Use of the certified packaging in compliance with the requirements includes the record-keeping requirements. No specific information on what to verify in the documentation of a certified packaging is presented in this document.

If a certified packaging is used as a DOT-7A, Type A packaging, then all of the documentation identified in 49 CFR 173.415(a) for a DOT-7A, Type A package must be available.

For a DOT-7A, Type A packaging 49 CFR 415(a) states, “Each offeror of a Specification 7A package must maintain on file for at least one year after the latest shipment, and shall provide to DOT on request, complete documentation of tests and an engineering evaluation or comparative data showing that the construction methods, packaging design, and materials of

construction comply with that specification . . . .” This requirement applies to all packagings being used as DOT-7A, Type A packages.

The following subsections identify the regulatory requirements associated with the design, selection, and use of a DOT-7A, Type A packaging and what should be verified.

Before starting into the requirements that apply to both the design and selection processes, there is one special note for those selecting a previously designed and built package.

NOTE: DOT-7A, Type A packagings designed in accordance with the requirements of 49 CFR 178.350 in effect on June 30, 1983, are no longer authorized for use. The fact that the packaging documentation is based on the requirements in effect on July 1, 1983, or later should be verified.

4.1.1 Regulatory Design Requirements

The following quotation identifies the starting point for identifying the regulatory design requirements for a DOT-7A, Type A packaging.

49 CFR 178.350 Specification 7A; general packaging, Type A.

(a) Each packaging must meet all applicable requirements of Subpart B of Part 173 of this subchapter and be designed and constructed so that it meets the requirements of sections 173.403, 173.410, 173.412, 173.415 and 173.465 of this subchapter for Type A packaging.

(b) Each Specification 7A packaging must be marked on the outside "USA DOT-7A, Type A" and "Radioactive Material."

The regulatory requirements identified in the above quotation are presented in the following subsections. The first four subsections identify the applicable design and selection requirements from 49 CFR 173, Subpart B. The last four subsections identify the design requirements identified in 49 CFR, Sections 173.403, 173.410, 173.412, and 173.465. The requirements of 49 CFR 173.415 are identified previously in Section 4.1. In the following subsections, the regulatory requirements are presented in bolded text. The discussion of the documentation required follows the requirements. The discussion is in normal text and double-indented.

To satisfy the documentation requirements of 49 CFR 173.415(a), some form of documentation should be available that shows consideration for each requirement identified in the following subsections. It is recommended that the documentation identify the requirement and follow with a statement that the requirement is met and how it is met. The statement can contain references to supporting documentation, such as engineering evaluations. When a requirement is not applicable, it is recommended that the evaluation that the requirement is not applicable be documented.

DOE (1996 and 1998) provide examples of the documentation needed to support the use of a DOT-7A, Type A packaging. The testing and evaluation document (DOE 1996 and 1998) follows the recommended format for the documentation of a DOT-7A, Type A packaging. The document provides enough detail to demonstrate compliance, but not necessarily enough to build a package. The information is generally based on a generic design load and points out the additional information needed for demonstrating compliance for a specific shipment. For many packagings identified in DOE (1996 and 1998), the design information was extracted from design drawings, sketches, engineering evaluations, design criterion, specifications, engineering reports, supplier catalogs, and other sources of information. The test results and the evaluation of the results are from test procedures, test reports, and evaluations.

When documentation, formatted as recommended in this document, is not available to support the use of a DOT-7A, Type A packaging, whatever documentation is available should be collected. The documentation is likely to take the form of the document types used to obtain the information found in DOE (1996 and 1998). When documents are used to support a package, the user should ensure the information contained in the documents can be shown to apply to the package.

The checklist in the appendix identifies each of the requirements discussed in the following sections. After each requirement on the checklist, space is provided for identifying the documentation in which compliance with the requirements is demonstrated. Use of the checklist when designing or selecting a packaging will reduce the risk of missing a requirement.

4.1.1.1 49 CFR 173.24, General requirements for packagings and packages. Many requirements of this section are duplicated by the requirements in 49 CFR 173, Subpart I, or are not applicable to DOT-7A, Type A packaging. When a requirement is judged to be duplicated in 49 CFR 173, Subpart I, it is recommended that the judgment be documented and that the documentation showing that the requirement is met be identified. When a requirement is not applicable, it is recommended that the evaluation that the material is not applicable be documented.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for the design documentation for the packaging to show evidence of compliance. The various types of documents likely to contain the needed information are identified in Section 4.1.1, “Regulatory Design Requirements.”

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

(a)(1) Bulk and non-bulk packagings;

(a)(2) New packagings and packagings which are reused; and

(a)(3) Specification and non-specification packagings.

All Type A packages fall into one or more of the identified packaging types; therefore, the provisions of the section apply. Some form of documentation that the provisions of 49 CFR 173.24 were evaluated during design process is required.

Documentation of consideration during the packaging selection process is required. A DOT-7A, Type A package is comprised of the packaging and the contents. Changing the contents can change the performance of the packaging. At a minimum, documentation showing that the planned packaging-load combination is bound by the design packaging-load combination is required. When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for the design documentation for the packaging to show evidence of compliance. Documentation for this general requirement may exist only in the application of the other requirements found in 49 CFR 173.24.

(b) Each package used for the 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--

(b)(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;

For DOT-7A, Type A packages, documentation of the ability of the package to meet the more severe requirements of 49 CFR 173.410, .412, .415, .465, and when applicable .466, can serve as documentation that this requirement is met.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for the design documentation for the packaging to show evidence of compliance. Documentation for this specific requirement may exist only in the application of the specific requirements found in 49 CFR 173.410, .412, .415, .465, and when applicable .466.

(b)(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;

For DOT-7A, Type A packages, documentation of the ability of the package to meet the more severe requirements of 49 CFR 173.410, .412, .415, .465, and when applicable .466, can serve as documentation that this requirement is met.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for the design documentation for the packaging to show evidence of compliance. Documentation for this specific requirement may exist only in the application of the specific requirements found in 49 CFR 173.410, .412, .415, .465, and when applicable .466.

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

For DOT-7A, Type A packages, documentation of the ability of the package to meet the more severe requirements of 49 CFR 173.410, .412, .415, .465, and when applicable .466, can serve as documentation that this requirement is met.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for the design documentation for the packaging to show evidence of compliance. Documentation for this specific requirement may exist only in the application of the specific requirements found in 49 CFR 173.410, .412, .415, .465, and when applicable .466. What the packaging was originally designed to withstand should be checked. If necessary, the documentation should be reevaluated and the differences documented.

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

(c)(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

(c)(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.

DOT-7A, Type A packagings are authorized for Type A quantities of radioactive materials. The documentation to show that the package meets the applicable DOT-7A, Type A packaging requirements must be in the possession of the shipper at the time of shipment.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for the design documentation for the packaging to show evidence of compliance. The

material classification and the ability of the packaging to retain the material being shipped should be documented.

(d) Specification packagings and UN standard packagings manufactured outside the U.S.

(d)(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.

DOT-7A, Type A packagings are authorized specification packaging. The documentation to show that the package meets the applicable DOT-7A, Type A packaging requirements must be in the possession of the shipper at the time of shipment.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for the design documentation for the packaging to show evidence of compliance. The manufacturer of the Type A packaging should supply the documentation of the requirements that are met and a notification of those requirements that remain to be completed. The user should prepare documentation of completion of the requirements identified on the notification.

(d)(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:

(d)(2)(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;

(d)(2)(ii) The packaging is capable of passing the prescribed tests in part 178 of this subchapter applicable to that standard; and

(d)(2)(iii) The competent authority of the country of manufacture provides reciprocal treatment for UN standard packagings manufactured in the U.S.

These requirements do not apply to packaging designed and manufactured in the U.S. When using foreign-made Type A packaging, the packaging must meet the additional, more stringent requirements identified in 49 CFR 173.415(d). Documentation that those requirements are met can serve to document that the above requirements are met. Documentation of the use of that documentation is recommended.

(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.

When designing a DOT-7A, Type A packaging, the fact that the packaging will withstand the corrosivity of the load should be documented. It should also be documented that the packaging will not suffer adversely from permeability, softening, premature aging, and embrittlement of the materials of construction. A clear statement of the ability of the packaging to meet the requirements is recommended.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of compatibility in the design documentation for the packaging. The information is likely to be found in an engineering evaluation and design criteria documents. If the planned load is not bound by the design load, an evaluation of compatibility with the packaging must be documented. Documentation of all evaluations is recommended.

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

When designing a DOT-7A, Type A packaging, the fact that the packaging will not suffer any significant chemical or galvanic reactions should be documented. The documentation should discuss reactions between materials of construction and between materials of construction and the load. A clear statement of the ability of the packaging to meet the requirements is recommended.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of chemical and galvanic reactions in the design documentation for the packaging. If the planned load is not bound by the design load, an evaluation of compatibility with the packaging must be documented. Documentation of all evaluations is recommended.

(e)(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.

(e)(3)(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 a temperature no lower than--

(e)(3)(ii)(A) 18 °C (64 °F) for 180 days in accordance with Test Method 1 in appendix B of this part;

(e)(3)(ii)(B) 50 °C (122 °F) for 28 days in accordance with Test Method 2 in appendix B of this part; or

(e)(3)(ii)(C) 60 °C (140 °F) for 14 days in accordance with Test Method 3 in appendix B of this part.

(e)(3)(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.

When the design of a DOT-7A, Type A packaging uses a plastic receptacle to hold the radioactive material, the user should ensure that the material is compatible with the lading. Many plastic materials become embrittled when exposed to radiation. When the packaging is used to transport liquids, that the packaging was tested and meets the identified conditions should be documented. The documentation should identify the materials tested. A clear statement of the ability of the packaging to meet the requirements is recommended.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for discussions of embrittlement and permeation in the design documentation for the packaging. Because the liquids to be shipped are not always known, the permeation requirement is often left for the shipper to document. The information is likely to be found in test reports, engineering evaluations, product information bulletins, and supplier catalogues. If the container is a commercial product, the manufacturer may have some compatibility documentation available. If the planned load is not bound by the design load, an evaluation of compatibility with the packaging must be documented. Documentation of all evaluations is recommended.

(e)(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--

(e)(4)(i) Combustion or dangerous evolution of heat;

(e)(4)(ii) Evolution of flammable, poisonous, or asphyxiant gases; or

(e)(4)(iii) Formation of unstable or corrosive materials.
(e)(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.

When designing a DOT-7A, Type A packaging, the user should look also at the secondary hazards associated with the radioactive hazard. The fact that the design load does not result in producing the identified hazardous conditions should be documented. The requirement to retain liquids that result from solids should be evaluated over the temperature range identified for Type A packagings in 49 CFR 173.412(c).

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for discussions of compatibility of mixed contents and phase changes of materials in the design documentation for the packaging. The information is likely to be found in the design criterion, engineering evaluations, test reports, information bulletins, and supplier catalogs. If the planned load is not bound by the design load, an evaluation that the load will not result in the production of the identified hazards must be documented. Documentation of all evaluations is recommended.

(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--

(f)(1)(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

(f)(1)(ii) The closure is secure and leakproof.

(f)(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.

When designing a DOT-7A, Type A packaging, the fact that the identified closure requirements are met should be documented. Some parts of the previously stated requirements can be demonstrated by showing that the closure meets a more stringent requirement from 49 CFR 173, Subpart I.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of the closures in the design documentation for the packaging. The information is likely to be in documents such as design criterion, test reports, and

engineering evaluation documents. It should be verified that the planned load is bound by the design load. If the load is not bound, the closure's ability to meet the requirements for the new load should be evaluated or tested. The evaluation or test should be documented.

(g) Venting. Venting of packagings, to reduce internal pressure which may develop by the evolution of gas from the contents, is permitted only when--

(g)(1) Transportation by aircraft is not involved;

(g)(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;

(g)(3) The packaging is designed so as to preclude an unintentional release of hazardous materials from the receptacle; and

(g)(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.

Venting of DOT-7A, Type A packagings is acceptable. If venting is used, the design documents must show that the conditions identified above are met. It should be noted that a packaging designed for transport by aircraft must not be vented.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of venting in the design documentation for the packaging. Information on venting is likely to be found in drawings, sketches, specifications, engineering evaluations, design criterion, and test reports. If the planned load is not bound by the design load, an evaluation of the ability of the packaging-load combination to meet the requirement must be documented.

For additional information on venting, see the discussion in Section 3.2.4, "Gas Generation."

(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 packagings are specified in §173.24a(d) and §173.24b(a), respectively.

When designing a DOT-7A, Type A packaging, room must be allowed for expansion and contraction of the load. The design documentation should identify how the above requirement is met.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of filling in the design documentation for the packaging. Information is likely to be found in engineering evaluations, operating instructions, and DOT-mandated notifications. If the planned load is not bound by the design load, an evaluation of the ability of the packaging-load combination to meet the requirement must be documented.

For additional information on filling, see the discussion in Section 4.1.1.7, 49 CFR 173.412, "Additional design requirements for Type A packages."

(h)(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 packaging.

The above requirement is not directly applicable to a DOT-7A, Type A package. However, when designing a DOT-7A, Type A package, one should consider the use of the design requirements associated with the secondary hazards.

(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.

When designing a DOT-7A, Type A package for transportation by aircraft, the fact that it meets the requirements identified in 49 CFR 173.24, 173.24a, 173.24b, 173.27, and Subpart I should be documented. Also, one should consider the need to document that the packaging meets the requirements in the *Dangerous Goods Regulations* issued by the International Air Transport Association (IATA 2000).

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of shipment by aircraft in the design documentation for the packaging. Information is likely to be found in design criterion and specification documents. If the planned load is not bound by the design load documentation, documentation for the ability of the planned packaging-load combination to meet the air requirements is required. Documentation of all evaluations is recommended.

4.1.1.2 49 CFR 173.24a, Additional general requirements for non-bulk packagings and packages. Many requirements of this section are duplicated by the requirements in 49 CFR 173, Subpart I, or are not applicable to DOT-7A, Type A packaging. When a requirement is judged to

be duplicated in 49 CFR 173, Subpart I, it is recommended that the judgment be documented and that the documentation showing that the requirement is met be identified. When a requirement is not applicable, it is recommended that the evaluation that the material is not applicable be documented.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look at the design documentation for the packaging for evidence of compliance. The various types of documents likely to contain the needed information are identified in Section 4.1.1, "Regulatory Design Requirements."

(**a) Packaging design. Except as provided in §172.312 of this subchapter:**

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

When designing a DOT-7A, Type A packaging for use in shipping liquids and the packaging design meets the definition of a combination packaging, one should design the packaging such that the closures are upright when the packaging is in the transport position. That design feature should be documented.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of combination packagings and/or closures in the design documentation for the packaging. Sketches, drawings, and operating instructions may also provide documentation of compliance. The user should ensure that closures are upright when a combination packaging is selected for use.

(a)(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.

When designing a DOT-7A, Type A packaging, one should document that the packaging meets the above condition.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for discussions of friction or heat generation in the design documentation for the packaging. The information is likely to be found in documents such as engineering evaluations and test reports. If the load is not bound by the design load, documentation of the ability of the packaging-load combination to meet the requirement evaluation is required. Documentation of all evaluations is recommended.

(a)(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 or having its protective properties significantly weakened in the event of leakage.

When designing a DOT-7A, Type A packaging that meets the definition of a combination packaging, one should document that the inner packagings are packed, secured, and cushioned to prevent breakage, leakage, or movement under conditions normally incident to transportation. Also, the fact that leakage of the load from the inner packaging will not result in a dangerous reaction with the packaging or a weakening of the cushioning should be documented.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for discussions of cushioning and securing of inner packagings in the design documentation for the packaging. The information is likely to be found in documents such as engineering evaluations and test reports. If the planned packaging uses cushioning, the user should evaluate that the load will not result in the identified conditions if released from the inner packaging. If the planned load is not bound by the design load, documentation of the ability of the packaging-load combination to meet the requirements is required.

(a)(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.

When designing a DOT-7A, Type A packaging, one should document that the packagings are designed to meet the condition that the inner packagings not be damaged by the outer packaging. When a design requires the user to install a device that could result in the identified conditions, the notification should clearly direct how the device is to be installed, to avoid the condition.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of manufacturing processes in the design documentation for the packaging. Information documenting these requirements are met will likely be found in drawings, sketches, engineering evaluations, operating instructions, and DOT-mandated notifications. If the planned packaging uses devices that could result in the identified conditions, the user should ensure that the design evaluation has accounted for that possibility. If the load is not bound by the design load conditions, documentation that the planned load will not be damaged is required. Documentation of all evaluations is recommended.

(a)(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.

When designing a DOT-7A, Type A packaging, one should document that it is designed to meet the vibration conditions identified in 49 CFR 178.608. The

preferred method of documentation is a test and evaluation report. Additional vibration requirements are identified in 49 CFR 173.410(f). See Section 4.1.3.2.6, "Vibration test," for additional guidance.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of vibration in the design documentation for the packaging. Information on vibration is likely to be found in test reports and engineering evaluation documents. If the packaging design includes shielding, the user should check that the shield remains effective if subjected to the identified vibration conditions. When the planned load is not bound by the design load, an evaluation that the packaging-load combination will withstand vibration is required. Documentation of all evaluations is recommended.

(b) Non-bulk packaging filling limits.

(b)(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:

(b)(1)(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;

(b)(1)(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

(b)(1)(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.

These requirements are not applicable to a DOT-7A, Type A package. DOT-7A, Type A packagings do not incorporate packaging groups.

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

This requirement is not applicable to a DOT-7A, Type A package. The maximum gross weight is not required to be marked on a DOT-7A, Type A packaging by the manufacturer.

(b)(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:

(b)(3)(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.

(b)(3)(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.

(b)(3)(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 requirement is not applicable to a DOT-7A, Type A packaging.
Packing Groups are not applicable to radioactive material.

(b)(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 conforms to one of the following:

(b)(4)(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 (5 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;

(b)(4)(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

(b)(4)(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 requirement is not applicable to a DOT-7A, Type A packaging as
49 CFR 178.605 does not pertain to specification packagings.

(b)(5) No hazardous material may remain on the outside of a package after filling.

For DOT-7A, Type A packaging the requirements of 49 CFR 173.443 override this requirement. That section requires radioactive contamination on the surface of the package to be as low as reasonably achievable and establishes an upper limit for the contamination.

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

(c)(1)(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;

(c)(1)(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;

(c)(1)(iii) Corrosive materials (except ORM-D) in bottles are further packed in securely closed inner receptacles before packing in outer packagings; and

(c)(1)(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.

When designing a DOT-7A, Type A packaging that is also to contain a nonradioactive hazardous material, one should document that the above packaging requirements are met. It should be noted that the packaging requires dual markings: those required by the DOT-7A, Type A packaging specification and those required by the performance-oriented packaging requirements.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of other primary hazards in the design documentation for the packaging. Besides ensuring that the packaging requirements are met, the user should ensure that the quantity limits are also met. If the planned load is not bound by the design load, an evaluation of the ability of the planned packaging-load combination to meet the requirement must be documented. Documentation of all evaluations is recommended.

(c)(2) A packaging containing inner packagings of Division 6.2 materials may not contain other hazardous materials, except dry ice.

This requirement is not applicable to Type A quantity shipments of Class 7 (radioactive) material. The Class 7 (radioactive) hazard class is used when determining the packaging and shipping requirements.

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

When designing a DOT-7A, Type A packaging for liquids, one should document that any receptacles used to hold liquids will not be completely full at 55 °C (131 °F) or less.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of filling in the design documentation for the packaging. If the planned load is not bound by the design load, an evaluation that the planned packaging-load combination will meet the requirement must be documented. Documentation of all evaluations is recommended.

For additional information on filling requirements, see the discussion in Section 4.1.1.7, 49 CFR 173.412, "Additional design requirements for Type A packages."

4.1.1.3 49 CFR 173.24b, Additional general requirements for bulk packaging. Many requirements of this section are duplicated by the requirements in 49 CFR 173, Subpart I, or are not applicable to DOT-7A, Type A packaging. When a requirement is judged to be duplicated in 49 CFR 173, Subpart I, it is recommended that the judgment be documented and that the documentation showing that the requirement is met be identified. When a requirement is not applicable, it is recommended that evaluation that the material is not applicable be documented.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look at the design documentation for the packaging for evidence of compliance. The various types of documents likely to contain the needed information are identified in Section 4.1.1, "Regulatory Design Requirements."

(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--

(a)(1)(i) 46°C (115°F) for a noninsulated tank;

(a)(1)(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

(a)(1)(iii) 41°C (105°F) for an insulated tank.

(a)(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.

This requirement is only applicable to a DOT-7A, Type A packaging when it (1) also meets the definition of a cargo tank; portable tank; tank car (including dome capacity); or multi-unit tank car tank, or any compartment thereof, and (2) is used to haul the identified liquids. If a packaging is designed to meet these requirements, one should document clearly that the requirements are met by the packaging.

When selecting a packaging, the user should ensure the planned packaging-load combination meets the requirements. If the planned packaging-load combination is not bound by the design packaging-load combination, the user should document an evaluation of the planned packaging-load combination that shows the requirement is met.

(b) Equivalent steel. For the purposes of this section, the reference stainless steel is stainless 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:

$$e_1 = (12.74e_0)/(Rm_1\ A_1)^{1/3}$$

Formula for non-metric units:

$$e_1 = (144.2e_0)/(Rm_1\ A_1)^{1/3}$$

where:

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

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

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

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

This requirement is not applicable to DOT-7A, Type A packagings as no specific materials of construction are identified for DOT-7A, Type A packaging.

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

When designing a DOT-7A, Type A packaging that meets the definition of a bulk packaging, one should document the consideration of this requirement. When selecting a packaging for a load that can result in the identified conditions, the user must comply with the prohibition.

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

(d)(1) Is at a temperature outside of the packaging's design temperature range; or

(d)(2) Except as otherwise provided in this subchapter, exceeds the maximum weight of lading marked on the specification plate.

These requirements are applicable only to a DOT-7A Type A packaging that also meet the definition of a bulk packaging. The requirements are primarily intended to cover the use of specification packagings, such as cargo tanks. When designing or selecting a packaging, consideration of the restrictions should be given.

4.1.1.4 49 CFR 173.27, General requirements for transportation by aircraft. Many requirements of this section are duplicated by the requirements in 49 CFR 173, Subpart I, or are not applicable to a DOT-7A, Type A packaging. When a requirement is judged to be duplicated in 49 CFR 173, Subpart I, it is recommended that the judgment be documented and that the documentation showing that the requirement is met be identified. When a requirement is not applicable, it is recommended that evaluation that the material is not applicable be documented.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look at the design documentation for the packaging for evidence of compliance. The various types of documents likely to contain the needed information are identified in Section 4.1.1, “Regulatory Design Requirements.”

(a) The requirements of this section are in addition to the requirements in §173.24 and apply to packages offered or intended for transportation aboard aircraft. Notwithstanding any Packing Group III performance level specified in Column 5 of the §172.101 table, the required performance level for packages containing Class 4, 5, or 8 materials, when offered or intended for transportation aboard aircraft, is at the Packing Group II performance level, unless otherwise excepted from performance requirements in Subpart E of this part.

This requirement identifies that applicable parts of the regulations in the 49 CFR 173.27 apply to DOT-7A, Type A packagings intended for shipment by aircraft.

(b) Packages authorized on board aircraft. (1) When Column 9a of the §172.101 table indicates that a material is "Forbidden," that material may not be offered for transportation or transported aboard passenger-carrying aircraft.

(b)(2) When Column 9b of the §172.101 table indicates that a material is "Forbidden," that material may not be offered for transportation or transported aboard aircraft.

(b)(3) The maximum quantity of hazardous material in a package that may be offered for transportation or transported aboard a passenger-carrying aircraft or cargo aircraft may not exceed that quantity prescribed for the material in Column 9a or 9b, respectively, of the §172.101 table.

(b)(4) A package containing a hazardous material which is authorized aboard cargo aircraft but not aboard passenger aircraft must be labeled with the CARGO AIRCRAFT ONLY label required by §172.402(b) of this subchapter and may not be offered for transportation or transported aboard passenger-carrying aircraft.

These requirements must be met when making a shipment. The requirements do not impact packaging design or selection.

(c) Pressure requirements. (1) Packagings must be designed and constructed to prevent leakage that may be caused by changes in altitude and temperature during transportation aboard aircraft.

When designing a DOT-7A, Type A packaging for transportation by aircraft, one should document the consideration of these requirements.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of pressure requirements in the design documentation for the packaging. The information is likely to be found in test reports or engineering evaluations. If the planned packaging-load combination is not bound by the design packaging-load combination, an evaluation or test demonstrating that the planned packaging-load combination will not leak must be documented. Documentation of all evaluations is recommended.

(c)(2) Packagings for which retention of liquid is a basic function must be capable of withstanding without leakage the greater of--

(c)(2)(i) An internal pressure which produces a gauge pressure of not less than 75 kPa (11 psi) for liquids in Packing Group III of Class 3 or Division 6.1 or 95 kPa (14 psi) for other liquids; or

(c)(2)(ii) A pressure related to the vapor pressure of the liquid to be conveyed, determined by one of the following:

(c)(2)(ii)(A) The total gauge pressure measured in the receptacle [i.e., the vapor pressure of the material and the partial pressure of air or other inert gases, less 100 kPa (15 psi) at 55 °C (131 °F)], multiplied by a safety factor of 1.5; determined on the basis of a filling temperature of 15 °C (59 °F) and a degree of filling such that the receptacle is not completely liquid full at a temperature of 55 °C (131 °F) or less;

(c)(2)(ii)(B) 1.75 times the vapor pressure at 50 °C (122 °F) less 100 kPa (15 psi); or

(c)(2)(ii)(C) 1.5 times the vapor pressure at 55 °C (131 °F) less 100 kPa (15 psi).

When designing a DOT-7A, Type A packaging for liquids for transport by aircraft, one should document that the packaging will meet the identified requirement.

When selecting a packaging for liquids, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of pressure in the design documentation for the packaging. The information is likely to be found in design calculations, test reports, and engineering evaluations. The user should watch closely that the required pressure differential can be met. Most DOT-7A, Type A packagings are designed for a 75.0-kPa (11.2-psi) differential. If the planned load is not bound by the design load, an evaluation or test that shows the packaging-load combination will meet the pressure requirement must be documented. Documentation of all evaluations is recommended.

(c)(3) Notwithstanding the provisions of paragraph (c)(2) of this section--

(c)(3)(i) Hazardous materials may be contained in an inner packaging which does not itself meet the pressure requirement provided that the inner packaging is packed within a supplementary packaging which does meet the pressure requirement and other applicable packaging requirements of this subchapter.

(c)(3)(ii) Packagings which are subject to the hydrostatic pressure test and marking requirements of §178.605 and §178.503(a)(5), respectively, of this subchapter must have a marked test pressure of not less than 250 kPa (36 psi) for liquids in Packing Group I, 80 kPa (12 psi) for liquids in Packing Group III of Class 3 or Division 6.1, and 100 kPa (15 psi) for other liquids.

This subsection is not directly applicable to DOT-7A, Type A packaging. The first part clarifies that the packaging holding the load does not have to provide the pressure boundary. The second part is not applicable to DOT-7A, Type A packagings as they are not subject to sections 49 CFR 178.605 or 178.503(a)(5) of the regulations.

(d) Closures. Stoppers, corks or other such friction-type closures must be held securely, tightly and effectively in place by positive means. Each screw-type closure on any packaging must be secured to prevent closure from loosening due to vibration or substantial change in temperature.

When designing a DOT-7A, Type A packaging, one should document that the design meets the identified requirements.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of closures in the design documentation for the packaging. The information is likely to be found in drawings, sketches, specifications, and engineering evaluations. If the planned packaging-load combination is not bound by the design packaging-load combination, an evaluation or test that shows the closure meets the requirement must be documented. Documentation of all evaluations is recommended.

(e) Absorbent materials. Except as otherwise provided in this subchapter, liquids in Packing Group I or II of Class 3, 4, 5, 6, or 8, when in glass or earthenware inner packagings, must be packaged using material capable of absorbing and not likely to react dangerously with the liquid. Absorbent material is not required if the inner packagings are so protected that breakage of them and leakage of their contents from the outer packaging is not likely to occur under normal conditions of transportation and is not required for packagings containing liquids in Packing Group II for transport aboard cargo aircraft only. Where absorbent material is required and an outer packaging is not liquid-tight, a means of containing the liquid in the event of leakage must be used in the form of a leakproof liner, plastic bag or other equally efficient means of containment. Where absorbent material is required, the quantity and disposition of it in each outer packaging must be as follows:

(e)(1) For packagings containing liquids in Packing Group I offered for transportation or transported aboard passenger-carrying aircraft, each packaging must contain sufficient absorbent material to absorb the contents of all inner packagings containing such liquids;

(e)(2) For packagings containing liquids in Packing Group I offered for transportation or transported aboard cargo aircraft only and packagings containing liquids in Packing Group II offered for transportation or transported aboard passenger aircraft, each package must contain sufficient absorbent material to absorb the contents of any one of the inner packagings containing such liquids and, where they are of different sizes and quantities, sufficient absorbent material to absorb the contents of the inner packaging containing the greatest quantity of liquid.

These requirements are not applicable to packagings for Class 7 (radioactive) material.

(f) Combination packagings. Unless otherwise specified in this part, or in §171.11 of this subchapter, when combination packagings are offered for transportation aboard aircraft, inner packagings must conform to the quantity limitations set forth in Table 1 of this paragraph for transport aboard passenger-carrying aircraft and Table 2 of this paragraph for transport aboard cargo aircraft only, as follows:

Table 1. Maximum Net Capacity of Inner Packaging for Transportation on Passenger-carrying Aircraft.

Maximum net quantity per package from column 9a of the §172.101 table	Maximum authorized net capacity of each inner packaging	
	Glass, earthenware, or fiber inner packagings	Metal or plastic inner packagings
Liquids:		
Not greater than 0.5 L	0.5 L	0.5 L
Greater than 0.5 L, not greater than 1 L	0.5 L	1 L
Greater than 1 L, not greater than 5 L	1 L	5 L
Greater than 5 L, not greater than 60 L	2.5 L	10 L
Greater than 60 L, not greater than 220 L	5 L	25 L
Greater than 220 L	No limit	No limit
Solids:		
Not greater than 5 kg	0.5 kg	1 kg
Greater than 5 kg, not greater than 25 kg	1 kg	2.5 kg
Greater than 25 kg, not greater than 200 kg	5 kg	10 kg
Greater than 200 kg	No limit	No limit

Table 2. Maximum Net Capacity of Inner Packaging for Transportation on Cargo Aircraft.

Maximum net quantity per package from column 9b of the §172.101 table	Maximum authorized net capacity of each inner packaging	
	Glass, earthenware, or fiber inner packagings	Metal or plastic inner packagings
Liquids:		
Not greater than 2.5 L	1 L	1 L
Greater than 2.5 L, not greater than 30 L	2.5 L	2.5 L
Greater than 30 L, not greater than 60 L	5 L	10 L
Greater than 60 L, not greater than 220 L	5 L	25 L
Greater than 220 L	No limit	No limit
Solids:		
Not greater than 15 kg	1 kg	2.5 kg
Greater than 15 kg, not greater than 50 kg	2.5 kg	5 kg
Greater than 50 kg, not greater than 200 kg	5 kg	10 kg
Greater than 200 kg	No limit	No limit

These requirements are not applicable to packagings for Class 7 (radioactive) material.

(g) Cylinders. For any cylinder containing hazardous materials and incorporating valves, sufficient protection must be provided to prevent operation of, and damage to, the valves during transportation, by one of the following methods:

(g)(1) By equipping each cylinder with securely attached valve caps or protective head rings; or

(g)(2) By boxing or crating the cylinder.

When designing a DOT-7A, Type A packaging that is also a cylinder, one should document that the design meets the identified requirements.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of valve protection in the design documentation for the packaging. Information is likely to be found in drawings, sketches, specification, and engineering evaluations. If the planned packaging-load combination is not bound by the design packaging-load combination, an evaluation or test showing that any valves are protected must be documented. Documentation of all evaluations is recommended.

(h) Tank cars and cargo tanks. Any tank car or cargo tank containing a hazardous material may not be transported aboard aircraft.

These requirements are not applicable to packagings of Class 7 (radioactive) material unless the package also meets the definition of a tank car or cargo tank.

4.1.1.5 49 CFR 173.403, Definitions. The definitions provided in 49 CFR 173.403 are to be used with the regulatory requirements identified in 49 CFR 173, Subpart I. It is important to use the definitions from 49 CFR 173.403. The importance arises from some definitions found in 49 CFR 173.403 providing different meanings for the word than the definitions found in other parts of the DOT regulations. The following definitions, from 49 CFR 173.403, are judged to influence the design and selection of a DOT-7A, Type A packaging. Not every definition will apply to every packaging. Some definitions will not be applicable. A discussion is not provided for every definition. Some definitions are judged to be self explanatory.

The definitions provided in 49 CFR 173.403 are part of the DOT-7A, Type A packaging requirements. The definitions provide additional details that clarify and expand the packaging requirements identified elsewhere in 49 CFR 173, Subpart I. When developing documentation in the form of an engineering evaluation or comparative data showing that the construction methods, packaging design, and materials of construction comply with the requirements of Subpart I, the user should ensure that the applicable definitions are considered along with the requirements. The definitions are not included in the checklist presented in the appendix.

A_1 - means the maximum activity of special form Class 7 (radioactive) material permitted in a Type A package.

When designing a DOT-7A, Type A packaging for special form material, one should document that the design load is special form.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of special form in the design documentation for the packaging. The use of special form is likely to be identified in a design criterion, test report, engineering evaluation, or in a load characterization document. When a packaging requiring special form material is selected, the user should ensure that the special form documentation is available and that the A_1 limit is not exceeded.

A_2 - means the maximum activity of Class 7 (radioactive) material, other than special form, LSA (Low Specific Activity) or SCO (Surface Contaminated Object), permitted in a Type A package. These values are either listed in section 173.435 or derived in accordance with the procedure prescribed in section 173.433.

When designing a DOT-7A, Type A packaging for normal form material, one should document that the design load is normal form.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of normal form in the design documentation for the packaging. As a packaging that is not designed for special form is designed for normal form, there is a possibility that the subject will not be covered in packaging design documentation. When a packaging requiring normal form material is selected, the user should ensure that the A_2 limit is not exceeded.

Class 7 - (radioactive) material. See the definition of Radioactive material in this section.

Containment system - means the assembly of components of the packaging intended to retain the radioactive contents during transportation.

When designing a DOT-7A, Type A packaging, one should clearly identify the containment system in the design documentation. When selecting a packaging, the user should look carefully at the containment system. Failure to have all of the containment system components, or failure to assemble the packaging in accordance with the design, can result in loss of material.

Design - means the description of a special form Class 7 (radioactive) material, a package, packaging, or LSA-III, that enables those items to be fully identified. The description may include specifications, engineering drawings, reports showing compliance with regulatory requirements, and other relevant documentation.

When designing a DOT-7A, Type A packaging, one should prepare documentation that identifies the package and packaging in enough detail that it can be reproduced in all essential details. How the packaging design, materials, and methods of construction result in compliance with the regulatory requirements should be identified. It is recommended that each regulatory requirement that influences the design be identified and the feature that ensures regulatory compliance be carefully documented. The definition identifies the types of documents typically used to document regulatory compliance. This document recommends that to satisfy the documentation requirements of 49 CFR 173.415(a), some form of documentation be prepared that shows consideration for each of the design and testing requirements. It is recommended that the documentation identifies the requirements one at a time and follows each requirement with a statement that identifies how the requirement is met. The statement can contain references to supporting documentation of the types identified in the definition. When a requirement is not applicable, it is recommended that a statement to that effect be placed in the document.

Besides avoiding mistakes now, preparation of documentation in the suggested format can save time in the future. It is fairly certain that in the future the regulatory requirements will change and that packaging questions will arise. By having the applicable regulations identified, hours will not have to be spent looking for a copy of the old regulations to which the packaging was designed.

Exclusive use (also referred to in other regulations as "sole use" or "full load") - means sole use by a single consignor of a conveyance for which all initial, intermediate, and final loading and unloading are carried out in accordance with the direction of the consignor or consignee. The consignor and the carrier must ensure that any loading or unloading is performed by personnel having radiological training and resources appropriate for safe handling of the consignment. The consignor must issue specific instructions in writing, for maintenance of exclusive use shipment controls, and include them with the shipping paper information provided to the carrier by the consignor.

Usually this information will be used when preparing a shipment. The information can, however, influence a packaging design. By using the exclusive use shipping provision, packagings can be designed with higher surface radiation levels. This could be useful in instances where weight or size limitations exist at the handling facility. When selecting a packaging, the use of an exclusive use shipment may permit the use of an otherwise unacceptable packaging.

Fissile material - means plutonium-238, plutonium-239, plutonium-241, uranium-233, uranium-235, or any combination of these radionuclides. The definition does not apply to unirradiated natural uranium and depleted uranium, and natural uranium or depleted uranium that has been irradiated in a thermal reactor. Certain additional exceptions are provided in §173.453.

This document does not provide guidance for fissile packages. If the load contains fissile material document why a nonfissile Type A package is acceptable. See 10 CFR 71.53 for packaging exemptions.

Maximum normal operating pressure - means the maximum gauge pressure that would develop in a receptacle in a period of one year, in the absence of venting or cooling, under the heat conditions specified in 10 CFR 71.71(c)(1).

When designing a DOT-7A, Type A packaging, one should determine the maximum normal operating pressure and document the information. The load used in determining the pressure in the design documentation should be identified. When selecting a packaging, the user should determine the maximum normal operating pressure for the packaging-load combination selected.

Natural thorium - means thorium with the naturally occurring distribution of thorium isotopes (essentially 100 percent by weight of thorium-232).

Non-fixed radioactive contamination - means radioactive contamination that can be readily removed from a surface by wiping with an absorbent material. Non-fixed (removable) radioactive contamination is not significant if it does not exceed the limits specified in §173.443.

Normal form Class 7 (radioactive) material - means Class 7 (radioactive) material which has not been demonstrated to qualify as "special form Class 7 (radioactive) material."

Package - means, for Class 7 (radioactive) materials, the packaging together with its radioactive contents as presented for transport.

(2) "Type A package" - means a packaging that, together with its radioactive contents limited to A_1 or A_2 as appropriate, meets the requirements of sections 173.410 and 173.412 and is designed to retain the integrity of containment and shielding required by this part under normal conditions of transport as demonstrated by the tests set forth in section 173.465 or section 173.466, as appropriate. A Type A package does not require Competent Authority Approval.

(3) "Type B package" - means a Type B packaging that, together with its radioactive contents, is designed to retain the integrity of containment and shielding required by this part when subjected to the normal conditions of transport and hypothetical accident test conditions set forth in 10 CFR Part 71.

(3)(i) "Type B(U) package" means a Type B packaging that, together with its radioactive contents, for international shipments requires unilateral approval only of the package design and of any stowage provisions that may be necessary for heat dissipation.

(3)(ii) "Type B(M) package" means a Type B packaging, together with its radioactive contents, that for international shipments requires multilateral approval of the package

design, and may require approval of the conditions of shipment. Type B(M) packages are those Type B package designs which have a maximum normal operating pressure of more than 700 kilopascals per square centimeter (100 pounds per square inch) gauge or a relief device which would allow the release of Class 7 (radioactive) material to the environment under the hypothetical accident conditions specified in 10 CFR Part 71.

Packaging - means, for Class 7 (radioactive) materials, the assembly of components necessary to ensure compliance with the packaging requirements of this Subpart. It may consist of one or more receptacles, absorbent materials, spacing structures, thermal insulation, radiation shielding, service equipment for filling, emptying, venting and pressure relief, and devices for cooling or absorbing mechanical shocks. The conveyance, tie-down system, and auxiliary equipment may sometimes be designated as part of the packaging.

Radioactive material - means any material having a specific activity greater than 70 Bq per gram (0.002 microcurie per gram) (see definition of "specific activity").

Special form radioactive material - means radioactive material which satisfies the following conditions:

(1) It is either a single solid piece or is contained in a sealed capsule that can be opened only by destroying the capsule;

(2) The piece or capsule has at least one dimension not less than 5 millimeters (0.197 inch); and

(3) It satisfies the test requirements of §273.469. Special form encapsulations designed in accordance with the requirements of §173.398(g) in effect on June 30, 1983, and constructed prior to July 1, 1985 may continue to be used. Special form encapsulations either designed or constructed after June 30, 1985 must meet the requirements of this paragraph.

Specific activity of a radionuclide - means the activity of the radionuclide per unit mass of that nuclide. The specific activity of a material in which the radionuclide is essentially uniformly distributed is the activity per unit mass of the material.

Type A quantity - means a quantity of Class 7 (radioactive) material, the aggregate radioactivity which does not exceed A_1 for special form Class 7 (radioactive) material or A_2 for normal form Class 7 (radioactive) material, where A_1 and A_2 values are given in section 173.435 or are determined in accordance with section 173.433.

Type B quantity - means a quantity of material greater than a Type A quantity.

4.1.1.6 49 CFR 173.410, General design requirements. The requirements provided in 49 CFR 173.410 are general design requirements that apply to all packagings for Class 7 (radioactive) material. These requirements are part of the DOT-7A, Type A packaging requirements.

Documentation in the form of an engineering evaluation or comparative data showing that the construction methods, packaging design, and materials of construction comply with the following requirements are required by 49 CFR 173.415(a).

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.

When designing a DOT-7A, Type A packaging, one should document that the design can be easily handled and properly secured. When the packaging requires special handling or tie-down equipment, documentation of their need, use, and design is recommended. If the handling or tie-down components are required to pass the performance requirements, the documentation is required.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for discussions of handling and tie-downs in the design documentation for the packaging. Information on handling is likely to be found in design drawings, sketches, specifications, operating instructions, and engineering evaluations.

(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.

When designing a DOT-7A, Type A packaging, one should document that the design meets the lifting requirements identified above. When necessary, a safety factor for snatch lifts should be provided. The lifting attachments should be designed such that if they fail, the ability of the packaging to meet the performance requirements is not reduced to the point were testing would result in failure. When the packaging requires special lifting equipment, documentation of the need, design, and use is recommended. If the special lifting equipment is required to pass the performance requirements, the documentation for the equipment is required. The packaging should be reviewed for items or protrusions that could be used when lifting the package. For example, a vent plug or filter might be used to prevent movement of a choker. If there are parts that could be used for lifting, then how those parts meet the identified requirements should be documented.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of lifting in the design documentation for the packaging. Information is likely to be found in engineering evaluations and operating instructions. The user should verify that the planned load will not adversely impact lifting performance. If the load is not bound by the design load, the ability of the packaging-load combination to meet the requirement should be documented.

(c) The external surface, as far as practicable, will be free from protruding features and will be easily decontaminated.

When designing a DOT-7A, Type A packaging, a surface finish that can be decontaminated with a reasonable amount of effort should be used. For example, the outer surface can be washed or replaced. If the packaging is intended to be loaded where contamination is likely, a design that protects the outer surfaces of the packaging during loading should be considered. If the packaging requires protrusions, when practical, they should be designed with ease of cleaning in mind. It is recommended that a clear statement of consideration of the ease of decontamination be made in the design documentation for the packaging.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of decontamination in the design documentation for the packaging. It is quite likely that no direct evidence of consideration for the need to provide for ease of decontamination will be found. If direct evidence is not available, the user should look for indirect evidence in the design of the packaging. If available, information is likely to be found in engineering evaluations and operating instructions. The planned load for ease of removal from the packaging surface should be evaluated. While contamination from the design load may have been easy to remove, the planned load may be difficult.

(d) The outer layer of packaging will avoid, as far as practicable, pockets or crevices where water might collect.

When designing a DOT-7A, Type A packaging, one should avoid, when practical, designs that result in pockets or crevices where water can collect and later leak out. Freezing of water may damage the packaging. Also, water dripping from the package can cause individuals to believe that the packaging is leaking. This requirement should not influence the packaging selection process.

(e) Each feature that is added to the package will not reduce the safety of the package.

Any feature, such as a tarp or brace, added to the as-tested and/or evaluated package at transportation should be evaluated for its impact on safety. Documentation of the evaluation is recommended.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion about features added at shipment in the design documentation for the packaging. Information on this subject might be found in operating instructions. If a decision is made to add a feature to a packaging that was not previously used, the effect of adding the feature to the safety of the packaging should be evaluated. Any evaluations conducted should be documented.

(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 sections 173.24, 173.24a and 173.24b).

When designing a DOT-7A, Type A packaging, one should document that it is designed to meet the acceleration and vibration conditions associated with transportation. Showing that the package can meet the vibration requirements identified in 49 CFR 178.608 is an acceptable method for demonstrating compliance. The preferred method of documentation is a test and evaluation report. It should be noted that additional requirements are identified in 49 CFR 173.24a(a)(5). The documentation, besides covering the specific subjects identified, should cover the effects on shielding.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of vibration in the design documentation for the packaging. This type of information is likely to be found in a test report or an engineering evaluation. For a planned load that is not bound by the design load conditions, documentation of the ability of the packaging-load combination to withstand vibration and acceleration requirements is required.

(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.

When designing a DOT-7A, Type A packaging, document that the packaging will not suffer any significant chemical or galvanic reactions. This requirement is also identified in 49 CFR 173.24(e)(2). For Type A packages, the evaluation should include the effects that irradiation may have on the materials. The documentation should discuss reactions between materials of construction and between materials of construction and the load. A clear statement of the ability of the packaging to meet the requirements is recommended.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of physical and chemical compatibility in the design documentation for the packaging. Information on these subjects is likely to be found in design criterion and engineering evaluation documents. The ability of the packaging to handle the particular load must be evaluated. If the load is not bound by the design load, the user should document that the planned packaging-load combination meets the requirements. Documentation of all evaluations is recommended.

(h) All valves through which the package contents could escape will be protected against unauthorized operation;

When designing a DOT-7A, Type A packaging, one should document the features of the packaging that ensure all valves are protected from unauthorized operation.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for information about valves in the containment discussion of the design documentation for the packaging. The information is likely to be found in operating instructions, drawings, sketches, specifications, and engineering evaluation documents.

(i) For transport by air--

(i)(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;

(i)(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

(i)(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).

When designing a DOT-7A, Type A packaging, one should document that the design meets the additional design requirements for transport by aircraft identified above. The following should be noted.

1. The maximum surface temperature and conditions are identical to the requirements in 49 CFR 173.442.

2. The packaging performance over the identified temperature range is bound by the requirements in 49 CFR 173.412(c).

3. The pressure differential is more stringent than that identified in 49 CFR 173.412(f) if pressurization is not a factor.

One should ensure that the packaging is designed to withstand the maximum pressure differential that results from maximum normal operating pressure and the applicable reduced atmospheric pressure that can result from loss of cabin pressure during air transport. Documentation of compliance with the applicable parts of 49 CFR, Subpart I, can be used to demonstrate compliance with the temperature requirements.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for discussions about the features identified above in the design documentation for the packaging. Information is likely to be found in test reports and engineering evaluations. A thorough search should be made for the information documenting that the more stringent requirements are met. If the planned packaging-load combination is not bound by the design packaging-load combination, the user should document an evaluation showing that the planned packaging-load combination meets the identified requirements.

4.1.1.7 49 CFR 173.412, Additional design requirements for Type A packages. The requirements provided in 49 CFR 173.412 are additional design requirements that apply to DOT-7A, Type A packagings. These requirements are part of the DOT-7A, Type A packaging requirements. Documentation is in the form of an engineering evaluation or comparative data, showing that the construction methods, packaging design, and materials of construction comply with the following requirements is required by 49 CFR 173.415(a).

In addition to meeting the general design requirements prescribed in section 173.410, each Type A packaging must 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.

When designing a DOT-7A, Type A packaging, one should consider the need for installation of a tamper indication seal at the time of shipment. Normal handling should not result in impairment of the seal performance. The seal should not be easily defeated. Tape-type seals are acceptable. It should be noted that a packaging with a large bolted lid may require several seals to ensure the lid cannot be opened without breaking a seal.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion about seals in the design documentation for the packaging.

Information is likely to be found in operating instructions, drawings, sketches, and specifications. The document will most likely take the form of an engineering evaluation.

(b) The smallest external dimension of the package is not less than 10 centimeters (4 inches).

When designing a small DOT-7A, Type A packaging, one should document that the smallest dimension is 10 cm (4 in.) or greater.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a drawing, specification, or sketch that identifies dimensions in the design documentation for the packaging. Documentation of all evaluations is recommended.

(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.

When designing a DOT-7A, Type A packaging, one should document that the design meets the packaging transport and performance requirements over the identified temperature range. The following should be considered:

- The possibility of a physical change in state for the materials of construction and the load
- Materials with dissimilar coefficients of expansion
- Significant changes in the strength of materials of construction
- Materials that may suffer from brittle fracture over the identified temperature range.

Phase changes of payload materials over the temperature range should be evaluated for any adverse effects on the packaging performance. If the actual conditions are outside the identified range, it is important to remember that the design should meet the more stringent conditions.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of material properties in the design documentation for the packaging.

Information of this type is likely to be in an engineering evaluation or design criterion document. The following should also be done.

- Ensure the load was evaluated.
- Verify the load will not adversely influence performance.
- If the load is not bound by the design load, document an evaluation that the planned packaging-load combination meets the requirements.

It is important to remember that if the actual conditions are outside the identified range, the design should meet the more stringent conditions.

(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 section 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.

When designing a DOT-7A, Type A packaging, one should document that the design provides a secure closure that will not open because of transport conditions or pressure differentials. It is important to note that when a packaging that is a separate unit is used to provide a containment boundary, its closure must be positive and independent of other parts of the packaging. One should ensure that the packaging is designed to withstand the maximum pressure differential that results from maximum normal operating pressure coupled with the reduced atmospheric pressure requirement.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for discussions of containment and closures in the design documentation for the packaging. Information of this type is likely to be in an engineering evaluation or design document. The fact that the load will not adversely affect the packaging closure should be verified. Gas generation should be considered closely. If the load is not bound by the design load, the user should document an evaluation that the planned packaging-load combination will meet the requirement for the closure to remain closed.

(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.

When designing a DOT-7A, Type A packaging, one should document that the containment design considers the effects of radiolytic decomposition of the materials of construction and the effects of gas generation. It is important to note that the containment boundary and its closure must be designed to withstand the maximum pressure differentials that may occur during transport. One should ensure that the containment is designed to withstand the maximum pressure differential that results from maximum normal operating pressure coupled with the pressure outside the containment boundary.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for discussions of radiolytic decomposition and gas generation in the design documentation for the packaging. The information is likely to be found in an engineering evaluation document. The user should verify the load will not adversely impact the containment boundary. Because gas generation is load dependent, how much gas may be generated should be watched closely. If the load is not bound by the design load, the ability of the planned packaging-load combination to meet the identified requirements should be documented.

(f) The containment system will retain its radioactive contents under the reduction of ambient pressure to 25 kPa (3.6 pounds per square inch).

When designing a DOT-7A, Type A packaging, one should document that the containment design considers the effects of a reduced atmospheric pressure coupled with the effects of gas generation inside the containment boundary. The containment boundary and its closure must be designed to withstand the maximum pressure differentials that may occur during transport. One should ensure that the containment is designed to withstand the maximum pressure differential that results from maximum normal operating pressure coupled with the pressure outside the containment boundary. It should be noted that in 49 CFR 173.410(i)(3) a liquid packaging for transport by aircraft must be capable of withstanding a minimum pressure differential of 95 kPa inside to outside. Though not specifically required by this subsection, one should watch that reduced pressure will not result in a loss of shielding.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of pressure differentials in the design documentation for the packaging. This discussion is likely to be in a test report, engineering evaluation, or design criterion document. The user should verify the load will not adversely impact the containment boundary. A comparison should be made of the size of the particles used to challenge the containment boundary during performance testing to those of the planned load. If the particles in the planned load are smaller, the user should verify that containment will be maintained. Gas generation should be closely watched. If the load is not bound by the design load, the ability of the planned packaging-load combination to meet the identified requirement should be documented.

(g) Each valve, other than a pressure relief device, is provided with an enclosure to retain any leakage.

When designing a DOT-7A, Type A packaging that has valves, one should document that the design provides leakage retaining enclosures. One should remember that the valve stem can leak, in addition to the closure.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of containment penetrations in the design documentation for the packaging. Information on this subject is likely to be found in documents such as drawings, sketches, specifications, engineering evaluations, operating instructions, and design criterion documents. Photos may also document that this requirement is met.

(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.

When designing a DOT-7A, Type A packaging, one should document that the design will not allow the packaging(s) that provide containment to escape from the shield. Loss of shielding that results in a significant increase in the packages external radiation field on the package is considered a packaging failure. Based on IAEA requirements, a 20% increase in radiation level on any outer surface of the package is judged significant (IAEA 1996).

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of shielding or mechanical strength in the design documentation for the packaging. This information is likely to be found in engineering evaluations and test reports.

(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.

When designing a DOT-7A, Type A packaging, one should consider designing the tie-downs so that they fail in a way that does not reduce the ability of the packaging to pass the performance requirements. If the tie-down attachments are part of the packaging, one should document that failure of the tie-down attachment will not result in packaging failure when the package is subjected to transport conditions or if subjected to the identified performance requirements.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a

discussion of how to tie down the package in the design documentation for the packaging. Information on tying down the package is likely to be found in an engineering evaluation document.

(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--

(j)(1) Loss or dispersal of the radioactive contents; and

(j)(2) A significant increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test.

When designing a DOT-7A, Type A packaging, one should document for each performance requirement and test that the design will not allow loss or dispersal of the radioactive contents or significant increases in radiation levels. The increase in radiation level is evaluated by looking at the level that exists for an undamaged package and comparing it with the radiation level from a damage package. One should consider the damage that results from application of both performance and test requirements. Based on IAEA requirements, a 20% increase in radiation on any outer surface of the package is judged significant (IAEA 1996).

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of performance requirements in the design documentation for the packaging. Information on the ability of the packaging to meet these requirements is likely to be found in test reports and engineering evaluations. As part of the packaging selection process, the user should consider how changing the load might affect the requirement to have no loss or dispersal of radioactive contents or a significant increase in radiation limits.

For example, many Type A packagings are based on drums or boxes loaded with waste materials that have the radioactive material uniformly distributed throughout the waste matrix. A packaging approval based on a load of this type will require additional testing or evaluations for a load concentrated into a small area even when the total radioactive material is less than or equal to that previously tested and/or evaluated. It should be noted that the damage to the package or shifting of the load results in different changes in the radiation levels for distributed sources verses point sources. Changes in density of the material can also result in performance differences. The density change may shift forces to a weaker feature of the package. Concentration of the material into a solid mass can also result in localization of forces that have not been evaluated. Containment boundaries should be looked at closely when particle sizes in the load become smaller. Just because a containment boundary retains sand does not ensure it will retain powder. The user should watch for loads that can expand and/or contract

such that they damage the package. Any evaluations of the planned packaging-load combinations that are not bound by the design load should be documented.

(k) Each packaging designed for liquids will--

(k)(1) Be designed to provide for ullage to accommodate variations in temperature of the contents, dynamic effects and filling dynamics;

(k)(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

(k)(3) Either--

(k)(3)(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

(k)(3)(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.

When designing a DOT-7A, Type A packaging, room must be allowed for expansion and contraction of the load. This basic requirement is also established in 49 CFR 173.24(h), 173.24a(d), and 173.24b(a). This subsection adds a requirement that the packaging must contain the load when subjected to the dynamics of transportation, performance requirements, and filling. The package must be designed to retain the liquids such that if subjected to the performance requirements identified in 49 CFR 173.466, there would be no loss of materials. The design documentation should identify how the above requirement is met.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for discussions of filling and ullage in the design documentation for the packaging. Information on the requirements is likely to be found in design evaluations and operating instructions. During the selection process, the ability of planned packaging-load combination to meet the identified conditions should be evaluated. If the load is not bound by the design packaging-load combination, the evaluation must be documented.

(l) Each package designed for gases, other than tritium not exceeding 40 TBq (1000Ci) or noble 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 section 173.466 or evaluated against these tests by any of the methods authorized by section 173.461(a).

When designing a DOT-7A, Type A packaging for a gas, other than tritium not exceeding 40 TBq (1000 Ci) or noble gases not exceeding the A_2 value, one should document that the packaging can pass the test identified in 49 CFR 173.466.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of testing in the design documentation for the packaging. Information is likely to be in an engineering evaluation or test report type document. During the packaging selection process, the ability of planned packaging-load combination to meet the identified conditions should be evaluated. If the planned load is not bound by the design load, the evaluation must be documented. If shipping other than tritium or a noble gas, the user should ensure the packaging was designed to meet the requirements of 49 CFR 173.466.

4.1.1.8 49 CFR Section 173.465 Type A packaging tests. The requirements provided in 49 CFR 173.465 are test conditions that a DOT-7A, Type A packaging must be able to withstand. Each DOT-7A, Type A packaging must, if subjected to these tests, be capable of meeting the conditions identified in 49 CFR 173.412(j). That is, when tested or evaluated using any of the methods authorized by section 173.461(a), the packaging will prevent--

(j)(1) Loss or dispersal of the radioactive contents; and

(j)(2) A significant increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test.

The test requirements are part of the DOT-7A, Type A packaging design requirements. Documentation in the form of complete documentation of tests and an engineering evaluation or comparative data showing that the construction methods, packaging design, and materials of construction comply with the following requirements are required by 49 CFR 173.415(a). All evaluations used in place of testing must be thorough and documented.

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

When designing a DOT-7A, Type A packaging, the conditions identified above must be considered. Documentation is required for the ability of the packaging to retain the material and not have a significant increase in radiation level if subjected to the identified conditions. The documentation should clearly identify the ability of the packaging to meet the requirements. Documentation can be in the form of test reports, comparisons to other approved packagings, evaluations, design calculations, and others. When conducting more than one test on a single packaging, the water spray conditions must be met and documented for all tests. When a single package is used for additional testing, the chance of

failure is increased. It should be kept in mind that the cost of evaluating a failure that results from additional testing to show that the packaging passes the requirements may actually cost more than the cost of an additional test unit.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of testing or compliance with performance requirements in the design documentation for the packaging. Information on the ability of the packaging to meet the water spray requirements is likely to be found in engineering evaluations and test reports. During the selection process, the packaging documentation should be evaluated with the planned load in mind. If the documentation for the design packaging-load combination does not bound the planned packaging-load combination, the results should be documented.

(b) Water spray test. 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 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 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.

When designing a DOT-7A, Type A packaging, one should remember the water spray condition. The package should suffer no loss of material or increase in radiation levels as a result of the water spray. One should remember that this is also a condition step. Materials that will withstand the test conditions after being soaked should be used for construction. When documenting that a DOT-7A, Type A packaging meets the water spray condition, the requirement should be discussed for each test. It is recommended that the ability of the packaging to withstand the water spray test be discussed along with the ability of the packaging to withstand the specified test conditions that follow.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of testing or water spray in the design documentation for the packaging. During the selection process, the packaging documentation should be evaluated with the planned load in mind. If the documentation does not bound the load, the planned packaging-load combination should be evaluated and the results documented.

(c) Free drop test. The specimen must drop onto the target so as to suffer maximum damage to the safety features being tested, and:

When designing a DOT-7A, Type A packaging, the water spray test should be kept in mind. The material selected should have a wet strength adequate to ensure passage of the required tests. When using a material that depends on a surface coating to prevent wetting of structural material, a method that ensures adequate coating should be provided. Experience with fiberboard packages has demonstrated problems with obtaining an even application of coatings. One should look at the packaging design and ask, "Where are the weak points of the package in respect to withstanding impact?"

One should note that to thoroughly test and/or evaluate the package, more than one impact point may require test and/or evaluation. While a corner impact on a rectangular parallelepiped is often the most likely failure point, it is not always the point to test. All features should be looked at. Penetration points and closures are often weak points in the containment system. Shielding, at times, is designed such that in some orientations it may move. Movement of the load within the containment and shield boundary can often result in failures. Load movement is often orientation sensitive. All features that cannot be easily determined as passing should be thoroughly evaluated.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, look for a discussion of drop testing or performance testing in the design documentation for the packaging. The information is likely to be found in a test report or engineering evaluation document. During the selection process evaluate the packaging documentation with the planned load in mind. Check to see if the planned load invalidates the orientation used for the drop test. If the design documentation does not bound the planned packaging-load combination, evaluate the ability of planned packaging-load combination to meet the drop test requirements and document the results.

(c)(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:

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

Packaging mass kilograms (pounds)	Free-drop distance meters (feet)
< mass 5,000 (11,000)	1.2 (4)
5,000 (11,000) mass to 10,000 (22,000)	0.9 (3)
10,000 (22,000) mass to 15,000 (33,000)	0.6 (2)
> 15,000 (33,000) mass	0.3 (1)

The drop height should be kept in mind when designing a DOT-7A, Type A packaging. The match between the packaging mass and the height of the drop should be documented. The drop height to target distance should be documented. Caution should be used when measuring the drop height of the packaging. A method that keeps the measurer out of harm's way is recommended; e.g., a length of sash chain of the correct length taped to the package. The chain can have a string attached for removing the chain before the drop without having to get close to the packaging. The orientation used for testing should usually result in an impact with the center of gravity over the impact point. However, another angle may need to be used to test the weakest point. If the packaging orientation results in a secondary impact, the secondary impact should be on the target. The angle used and why it was used should be documented.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of drop testing in the design documentation for the packaging. Information is likely to be in documents such as engineering evaluations and test reports. During the packaging selection process, the packaging documentation should be reviewed. The documentation for the description of the target should be looked at closely. Targets consisting of a concrete shop floor 15.2 cm (6 in.) thick, with a steel plate 2.54 cm (1 in.) thick by 1.2 m (4 ft) by 1.2 m (4 ft), placed loosely on the surface, have been used by some manufacturers as unyielding surfaces for a metal box 1.2 m (4 ft) x 1.2 m (4 ft) x 2.4 m (8 ft) weighing 4536 kg (10,000 lb). This type of target for this heavy of a package cannot be considered as an unyielding surface, nor will the secondary impact from the package be onto the target due to the dimensions of the package.

Also, the orientation used should be checked. In most cases, the impact should have the center of gravity over the impact point. However, it may be that to test the weakest point another angle needed to be used. The documentation should be evaluated with the planned load in mind. A load with a different density of material or a more solid form may not be bound by the material used for testing. For loads that are, or approximate, a point-source, the change in radiation levels from the undamaged to damaged packaging condition should be checked carefully. Small movements of the load or packaging surface can result in large changes in radiation levels. The user should be careful, as many packages are designed for a load with uniformly distributed radioactive material. If the planned load is not bound by the design load, documentation of the ability of the planned packaging-load combination to pass the drop test requirements is required.

(c)(2) For packages containing fissile material, the free drop test specified in paragraph (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.

As stated earlier, this document does not cover the design or use of fissile packagings. This requirement is applicable only to fissile packaging.

(c)(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).

When documenting a DOT-7A, Type A packaging with a gross mass of 50 kg (110 lb) or less, constructed with a rectangular-shaped outer packaging of fiberboard or wood, one should document clearly the ability of the packaging to pass the above requirement. One should remember that the package must be water sprayed before being drop tested. Movement of the internal packagings should be watched closely. Changes in surface dose rates should be checked.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of drop testing in the design documentation for the packaging. The information is likely to be in a test report or an engineering evaluation document. During the selection process, the packaging documentation should be evaluated with the planned load in mind. The user should check to see if the planned load results in a package that weighs less and therefore requires a drop test or evaluation. If the documentation does not bound the planned packaging-load combination, the packaging-load combination should be evaluated and the results documented.

(c)(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).

When documenting a DOT-7A, Type A packaging with a gross mass of 100 kg (220 lb) or less, constructed with a cylindrical shaped outer packaging of fiberboard, one should document clearly the ability of the packaging to pass the above requirement. When documenting a DOT-7A, Type A packaging that weighs 100 kg (220 lb) or less, and the outer packaging is constructed of fiberboard, the ability of the packaging to pass the above requirement should be clearly documented. One should remember that the package must be water sprayed before being drop tested. Movement of the internal packagings should be watched closely. Changes in surface dose rates should be checked.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of drop testing in the design documentation for the packaging. The information is likely be in a test report or an engineering evaluation document. During the selection process, the packaging documentation should be evaluated with the particular load in mind. The user should check to see if the planned load results in a lighter package that requires a drop test. If the documentation does

not bound the planned packaging-load combination, the planned packaging-load combination should be evaluated and the results documented.

(c)(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.

The drop target should be kept in mind when designing a DOT-7A, Type A packaging. When conducting testing, one should make sure the target is both large enough in physical dimensions and mass. It is recommended that the target have a length and width that are larger than the length and width of the test unit by enough to ensure any secondary impact is on the target. When possible, a target should be used that provides a mass ten times the mass of the packaging being tested. Sometimes a smaller mass may be acceptable. If the smaller mass target is used, then why it is acceptable should be documented. The more unyielding the package the more massive and unyielding the target should be.

The target should be unyielding to the packaging being tested. While a concrete floor 15.2 cm (6-in.) thick may be unyielding to a lightweight fiberboard, wood, or plastic package, it is not likely to be unyielding to a heavy metal package. When a plate of metal or another material is used to protect the surface of the test pad, the plate should be firmly attached to the pad and have even contact. If the plate does not contact the pad evenly, the plate can bend and act as a spring. If the plate is not firmly attached, it can move. Both spring action and movement result in less damage to the packaging. It is highly recommended that the target be clearly documented as unyielding to the packaging being tested. It is recommended that in the test documentation that the drop target be described in enough detail to show the physical dimensions are large enough for the packaging being tested. Also, it should be documented that the mass and rigidity of the target are such that the target is unyielding for the packaging being tested.

If a pure evaluation is conducted, the target conditions used for the evaluation should be identified. The secondary impact in the evaluation should be included. The condition after testing should be described in enough detail to permit dose calculations for the damaged condition. Damage to the internal packaging and shifting of the load should be considered.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of drop testing and/or a description of the target in the design documentation for the packaging. The information is likely to be in a document such as a drawing, sketch, specification, test report, or an engineering evaluation. The documentation for the description of the target should be looked at closely. Targets consisting of a concrete shop floor 15.2 cm (6 in.) thick with a steel plate 2.54 cm (1 in.) thick by 1.2 m (4 ft) by 1.2 m (4 ft), placed loosely on the surface, have been used by some manufacturers as unyielding surfaces for a metal box 1.2

m (4 ft) by 1.2 m (4 ft) by 2.4 m (8 ft) weighing 4536 kg (10,000 lb). During the selection process, the packaging documentation should be evaluated with the planned load in mind. An increase in the weight of the packaging-load combination that invalidates the testing should be watched for. If the documentation for the design packaging-load does not bound the planned packaging-load combination, the planned packaging-load combination should be tested and/or evaluated and the results documented.

(d) Stacking test. (1) The specimen must be subjected for a period of at least 24 hours to a compressive load equivalent to the greater of the following:

(d)(1)(i) Five times the mass of the actual package; or

(d)(1)(ii) The equivalent of 13 kilopascals (1.9 pounds per square inch) multiplied by the vertically projected area of the package.

(d)(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.

When documenting that a DOT-7A, Type A packaging meets the stacking requirement, one should clearly state how the compression load was determined. It is recommended that the determination clearly demonstrates that the compression load chosen is the greater of the two identified weights. How the water spray requirement was met should be identified. Also, how the package was loaded should be identified. It should be noted that the packaging is to be in the position it would normally rest. It should be noted that the above requirements make no provisions for skipping the stacking test. The ability of shapes such as horizontal cylinders and spheres should be able to withstand the identified forces even though they are unlikely to be stacked. The documentation should discuss and describe any damage to the packaging, such as crushing or bending. A clear statement that the package passes the requirements should be made.

If a pure evaluation is conducted, the stacking conditions used for the evaluation should be identified. If the evaluation indicates any damage, such as bending or crushing, the condition of the package should be described. The after-test condition should be described in enough detail to permit dose calculations for the damaged condition.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of compression or stack testing in the design documentation for the packaging. The information is likely to be in a test report or an engineering evaluation document. During the selection process, the packaging documentation should be evaluated with the planned packaging-load combination in mind. If the documentation does not bound the planned packaging-load combination, the

ability of the planned packaging-load combination should be tested and/or evaluated to pass the stacking test and the results documented.

(e) Penetration test. For the penetration test, the specimen must be placed on a rigid, flat, horizontal surface that will not move significantly while the test is being performed.

(e)(1) A bar of 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
(e)(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.

The penetration requirement should be kept in mind when designing a DOT-7A, Type A packaging. The penetration bar drop should not result in a loss of material from the package or a significant increase in radiation levels. The water spray requirement should be considered. When testing packagings that will tear, the motion of the penetration bar should be unrestricted at impact. That is, if a guide tube is used for the penetration bar, the bar should be clear of the guide at impact and free to rotate about the point of impact. If the bar penetrates the containment, one should very carefully assess that no loss of material occurs. For example, a single drop test may make a hole small enough that the load cannot escape. Another drop test may result in a larger hole due to tearing. It is recommended that the bar should not penetrate the containment boundary. It should be noted that a single drop may not be enough. Several drops may be required to ensure failure will not occur. The design load should be examined, and areas or features likely to fail should be identified. One should identify that packagings are placed on a horizontal surface that will not move. This is particularly important with lightweight packagings. It should be documented that the bar meets the size, shape, and weight requirements. Also, the height of the drop and impact point(s) should be documented. One should watch not only for loss of material but also for changes in radiation levels.

If a pure evaluation is conducted, the penetration test conditions used for the evaluation should be identified. If the evaluation indicates any damage, such as bending or puncture, the condition of the package should be described. The after-test condition should be described in enough detail to permit dose calculations for the damaged condition.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of penetration testing in the design documentation for the packaging. The information is likely to be in a test report or an engineering evaluation document. During the selection process, the packaging documentation should be evaluated with the planned load in mind. The user should watch for packagings

where the containment was breached. If the documentation does not bound the planned packaging-load combination, the ability of the planned packaging-load combination to pass the penetration test should be tested and/or evaluated and the results documented.

4.1.2 Additional Regulatory Design Requirements

The following regulatory requirements are not identified in 49 CFR 178.350 as design requirements. These requirements are identified within the requirements as applying to DOT-7A, Type A packaging designs for liquids and for gases. Because they are design requirements, the documentation identified in 49 CFR 173.415(a) is required. The following subsection of this document contains the requirements from 49 CFR 173.466.

4.1.2.1 49 CFR 173.466, Additional tests for Type A packagings designed for liquids and gases.

(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:

When designing a DOT-7A, Type A packaging for either liquid or gas loads, the additional requirements identified in this regulatory requirement must be followed and the ability of the packaging to meet the performance requirements documented.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of performance testing in the design documentation for the packaging. The information is likely to be in a test report or an engineering evaluation document. During the selection process, the packaging documentation should be evaluated with the planned load in mind. If the planned load is not bound by the design load, the evaluation should be documented, showing that the packaging passes the requirements when loaded as planned.

(a)(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).

When designing a DOT-7A, Type A packaging for liquids or gas, the water spray test should be kept in mind along with the other guidance given previously for the 1.2-m (4-ft) drop. As the energy associated with the 9-m (30-ft) drop is much greater, one should look closely for crushing or movement of the load that results in changes in radiation levels. It is recommended that energy absorbers used inside the packaging rebound to near their initial position.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of drop testing in the design documentation for the packaging. The information is likely to be in a test report or an engineering evaluation document. During the selection process, the packaging documentation should be evaluated with the planned load in mind. If the documentation does not bound the planned load, the ability of planned packaging-load combination to pass the free drop test should be tested and/or evaluated and the results documented.

(a)(2) Penetration test. The specimen must be subjected to the test specified in §173.465(e) except that the height of the drop must be 1.7 meters (5.5 feet).

When designing a DOT-7A, Type A packaging for liquids or gas, the water spray test should be kept in mind along with the other guidance given previously for the 1-m (3.3-ft) penetration test. As the energy associated with the 1.7-m (5.5-ft) foot drop is greater, more penetration and possible tearing should be considered.

When selecting a packaging, if documentation formatted similarly to that recommended in this document is not available, the user should look for a discussion of penetration or performance testing in the design documentation for the packaging. The information is likely to be in a test report or an engineering evaluation document. During the selection process, the packaging documentation should be evaluated with the planned load in mind. If the documentation does not bound the planned load, the ability of the planned packaging-load combination to pass the penetration test should be tested and/or evaluated and the results documented.

4.1.3 Testing and Evaluation

The previous design requirements identify the tests that the packaging must be able to survive without suffering loss of material or increases in radiation levels at the surface of the package. The tests are identified previously as they establish design conditions. The following subsections discuss activities and documentation associated with the tests and/or evaluations themselves.

4.1.3.1 Pretest Inspection. The regulations in 49 CFR 173.462, “Preparation of specimens for testing,” identify some pretest conditions that are to be met. These conditions should be considered even when using an alternate method of demonstrating the packaging is capable of passing the tests. It is recommended that the following requirements be documented. Although records of these activities are not specifically required, demonstrating compliance without them might be difficult.

(a) Each specimen (i.e., sample, prototype or scale model) must be examined before testing to identify and record faults or damage, including:

(a)(1) Divergence from the specifications or drawings;

(a)(2) Defects in construction;

(a)(3) Corrosion or other deterioration; and

(a)(4) Distortion of features.

When the packaging is examined before testing, it should match the design drawings supplied with the packaging. When examining the specimens, it is recommended that critical dimensions be checked and compliance documented. For example, the thickness of the material used for construction and the fit of closures should be documented. Joints, seams, and closures should be examined closely for defects. Variation from the design that affects the ability of the package to pass performance requirements should be looked for. Corrosion or other forms of deterioration that effect performance should be looked for. Any required dunnage should be checked. One should check that the features of the packaging are not distorted to the point they could affect test results. The closure instructions should be used. One should check that the notification (see discussions in Sections 1.5.2, 4.1.4, and 5.1 of this document) provides the information necessary to ensure the packaging meets the regulatory requirements when followed. The closure instructions should be checked to ensure the package will be loaded and closed into the same configuration each time it is used.

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

It is recommended that corrections or allowances for variations in design be documented. One should ensure that any allowances for variations from design are technically correct. One should ensure the package tested or evaluated is the packaging to be shipped. It is recommended that all methods of evaluation be clearly identified and, unless very common, that an explanation and reference be provided.

(c) The containment system of the packaging must be clearly specified.

If the design does not clearly identify the containment system, it must be identified. It should be noted that the containment system is not always clear. For example, with some lightweight loadings, a drum may pass the requirements with the drum body, lid, gasket, and locking ring. Other loadings may require the addition of a sealant on the gasket at the gasket-body interface to pass. Perhaps another loading will use a sealed plastic liner inside the drum. Failure to clearly

define the containment system could result in the use of the wrong configuration and perhaps a package failure.

(d) The external features of the specimen must be clearly identified so that reference may be made to any part of it.

The features of the specimen must be clearly identified. The design documents may or may not be clear. If the package is very symmetrical and has few features that can be used for reference, it may be advisable to apply some markings to the package that do not affect the performance of the packaging. The markings can then be used when describing and assessing damage to the packaging.

4.1.3.2 Testing. The test requirements are identified previously. Testing requires documentation. This subsection provides recommendations on testing and test documentation. The documentation required is identified in 49 CFR 173.415(a). The identified tests are water spray, drop, stacking, and penetration. If the packaging is for a liquid or gas load, additional drop and penetration tests are required. There are two packaging design features for which testing is recommended. The first is the ability of the packaging to withstand the pressure differential identified for the conditions under which the packaging-load combination is to be used. Documentation that the package can withstand the differential pressure is required. Differential pressure testing, while not required, is often easier to conduct than to evaluate. The second feature is the ability of the packaging to withstand vibration and acceleration. While the regulations do not require a packaging to be vibration tested, the packaging is required to be able to pass the test, and a test protocol is presented. When testing is conducted, following the protocol is recommended.

4.1.3.2.1 Differential Pressure. There are many ways to conduct this test. With some packaging designs, it may be enough to test just the containment boundary. When only the containment boundary is tested, the evaluation of the test results should consider the other packaging components. It is possible that the change in pressure may result in damage to another packaging component that results in a significant increase in radiation level. It should be noted that pressure tests result in the potential for physical damage to packaging, equipment, and personnel. Whatever method is used should ensure that the potential hazards are identified and precautions are taken.

If the package is small enough, it can be placed into a vacuum chamber. To establish the correct pressure differential, it may be necessary to pressurize the package before testing. This method most closely duplicates the design condition. Packagings can also have pressure applied inside the package. Pressurization with gas or liquid can be used. If the load is a gas, that is the preferred media. The gas used for testing should have characteristics that match the intended load or result in a conservative test. If the package is for liquids or solids, water often makes a good test load and medium for pressurization. If air or other gas is used to pressurize the container, one should consider placing some solid material in the package to reduce the volume in which energy will be stored. If the liquid to be shipped in the package has a viscosity or surface tension that is less than water, either a different test liquid should be found or the results

should be evaluated to match the load. It should be noted that not all packages will require testing. For example, a package for special form material may only require a cursory review to show it can meet the design conditions. The pass/fail criterion for loss of containment is qualitative. Using the physical senses, there should be no sign of material being lost or changes to the packaging that could result in increased radiation levels outside the packaging.

Documentation should be prepared that identifies the package being tested, the test setup, the internal and external pressures, medium used to pressurize the package, medium used to simulate the load, duration of test, and observed conditions during and after testing. The results should be evaluated and a pass/fail statement made. When selecting a packaging, the planned packaging-load combination should be evaluated. If the planned packaging-load combination is not bound by the design packaging-load combination, the testing and/or evaluation that shows the packaging is acceptable should be documented.

4.1.3.2.2 Water Spray. The water spray is both a test and a packaging conditioning step. It is required to be conducted before each of the other tests as a conditioning step. If analysis is used rather than an actual water spray, one should be sure to discuss both the test and the condition aspects of the requirement. The completion of this requirement prior to the other tests should always be documented, even if it is conducted by comparison or evaluation.

As a test, the water spray should not result in material moving from inside the package to the outside. For example, in-leakage of water that moves past the load might dissolve some of the load and carry it out of the packaging. The water should also not result in damage to the package that would result in increased radiation dose rates outside the package.

As a conditioning process, the intent is that any weakening of the package due to exposure to water will be identified and taken into account. The water spray may be applied to one side of the packaging at a time or to all sides at once. A different wait time is identified for each condition. The water spray pattern should result in a fairly even distribution of water over the surface. If multiple spray nozzles are used, the areas receiving the least spray should receive the spray at the minimum rate. The intent is for the water to soak into the package and for the outer surface not to become significantly dry.

Document the setup used to water spray the packagings; the rate of water application; the application pattern; the sequence of the water application (i.e., all sides at once or in sequence); how loss of material or radiation level changes were determined; and the time between the end of water spray and the start of next test. The results should be evaluated and a pass/fail statement made. When selecting a packaging, the planned packaging-load combination should be evaluated. If the planned use is not bound by the design packaging-load combination, the testing and/or evaluation that shows the packaging is acceptable should be documented.

4.1.3.2.3 Free-Drop Test. Before starting the test, it should be verified that the impact area meets the requirements identified for the target and that the water spray conditioning step has occurred. The packaging should be prepared as it is prepared for shipment. One should ensure that any telltale material placed in the package to help in determining loss of material will remain in a physical form that will challenge the containment boundary. Materials, such as a

mixture of flour and fluorescein, have been observed to clump when placed in a packaging with damp soil. A load should be used that is as much like the intended use as possible. How pass/fail will be determined should be identified. The packaging should be rigged for dropping. The method of release should disturb the start of the free drop as little as possible. The impact on the target should be as close to center as possible while keeping the secondary impact on the target. After the drop, the package and drop area should be examined for signs of loss of material. When fluorescein is used as a telltale, the application of a fine water mist to the damaged areas of the packaging is a good method for enhancing observation of a leak. An ultraviolet light may also be used. The damage should be quantified to the extent possible. If material escapes from a packaging during testing, the test pad should be cleaned thoroughly before the next test is conducted.

Documentation should be prepared that identifies the package being tested; the required calibrated equipment (and the date of calibrations); the physical characteristic of the load; weight (gross, net, and tare); and any telltale material used. Documentation should identify the pass/fail criteria used, free drop height, the relationship between the package gross weight and free-drop height, and the drop orientation.

One should describe the impact and slap-down during the free-drop test, any material that escaped from the package, and any damage to the package. The damage to the package should be quantified. After verifying no loss of material, the packaging should be opened and examined for any damage to the interior packaging. Any damage to interior packagings should be described, and the damage should be quantified to the best extent possible. For packages that use internal packagings, it should be determined how much the interior damage allows the load to move toward the exterior surface of the package. Any shielding should be checked for damage, such as cracks, dents, movements, or any other changes that would result in increases in dose rates outside the package. If the interior packaging that holds the load fails, one should evaluate the possibility of the material moving to a position that results in an increase in a radiation dose outside the package. One should document 0.3-m (1-ft) free drops onto corners when required. All of the collected data should be evaluated, and whether the package has passed or failed should be determined. The results of the evaluation should be identified. Any changes that the user should be aware of when selecting the package for use should be noted.

4.1.3.2.4 Stacking Test. Before starting the test, the water spray conditioning step should be verified as completed. One should document the time between water spray and the start of the stacking test, that the packaging is setting in the normal resting orientation, the weight placed on the packaging, that the weight meets the requirements, any deviation of the package from the as-shipped condition, how the weight is positioned, the time the stacking test was started, the time the stacking test was stopped, the condition of the packaging at the end of the test, any loss of material, and any change in the packaging. All of the collected data should be evaluated, and whether the package has passed or failed should be determined. The results of the evaluation should be identified. Any changes that the user should be aware of when selecting the package for use should be noted.

4.1.3.2.5 Penetration Test. Before starting the test, the water spray conditioning step should be verified as completed. One should document the time between water spray and start of

the penetration test, any deviation of the package from the as shipped condition, the surface on which the packaging rests for the test, how the package is positioned, the distance between the bottom of the penetration bar and the impact point (for liquid and gas packagings document both test heights), any equipment used to guide the penetration bar, the condition of the penetration bar after the test, and the condition of the packaging at the end of test. All of the collected data should be evaluated, and whether the package has passed or failed should be determined. The results of the evaluation should be determined. Any changes that the user should be aware of when selecting the package for use should be noted.

4.1.3.2.6 Vibration Test. The ability to withstand vibration is a design requirement. Documentation of the ability of the packaging to withstand vibration is required. It is recommended that the ability to meet this requirement be demonstrated by application of the vibration test identified in 49 CFR 178.608, "Vibration Standard." The requirement in this standard to use three random samples may be modified to permit the testing of only one sample, prototype, or scale model. This modification is in keeping with the DOT-7A, Type A packaging test requirements identified in 49 CFR 173.465. The DOT-7A, Type a testing requirements do not identify the number of packagings to be subjected to each test. In addition, the requirements allow the use of a new package for each test, and permit the use of a single packaging for all tests.

The packagings used for the vibration test should be prepared as for shipment. When testing cannot be conducted, the ability of the packaging to meet the vibration requirements can be evaluated. The evaluation should look at material fatigue, the ability of the closure to remain tightly closed, and the retention of shielding capabilities. It should be noted that the protocol presented in the regulations is written for nonradioactive hazards. Because the protocol is written for nonradioactive hazards, there is no mention of the need to check for changes in radiation levels. When evaluating shielding, the effects of vibration on the internal packaging and load should be considered. With point sources small movements can result in large changes in the radiation levels outside the package.

4.1.3.3 Post-test Inspection. The post-test inspections should document any changes in the packaging and the load. If there is damage in the closure area, the damage should be documented and an evaluation conducted. One should identify whether the packaging passed or failed the containment requirements. If the evaluation shows the closure is close to failure, it should be noted as near failure, and why it is acceptable should be explained. Compressions and dents that result should be quantified to the best extent possible. When visual examination of shielding is not adequate to identify failure, pretest and post-test measurements should be conducted using suitable radiation sources and detectors. If radiation used for testing is not the same as the load, the results should be evaluated using the appropriate correction factors. The movement of the load within the shielding and any movement of the shield within the outer packaging should be quantified. The packaging should be evaluated for changes in surface radiation levels due to movement of the package surface or load. One should ensure the type of load and the positioning within the package is documented for the post-testing condition. Any changes that the user should be aware of when selecting the package for use should be noted.

4.1.3.4 Evaluations. The evaluations of the ability of the packaging to meet design and test requirements should be documented. One should remember to evaluate the test results and determine if the packagings passed or failed. It is highly recommended that documentation in the form of a simple pass or fail statement not be used. A statement that says, "The package passed the 1.2-m (4-ft) drop test," is of little use to someone wanting to evaluate the use of the packaging for a different load.

When evaluating a test, the damage that occurs to the packaging should be documented both quantitatively and qualitatively. The documentation of damage to the packaging should be in enough detail to permit an understanding of the pass-fail judgment. That includes the judgment that the radiation levels on the surface of the package are not significant. The evaluation should identify the pass/fail criteria and the method of data collection (if more than a simple observation). For evaluation methods that use more than simple techniques, the sources of the techniques should be referenced or their acceptability documented. When scale models are used, one should document why the model used is acceptable. References for scaling methods employed should be provided. When a pure evaluation is used, the documentation should describe the damage to the packaging. Any computer codes used in the evaluation processes should be identified. If applicable, benchmarks for computer codes should be identified. For computer codes that are not accepted for general use, their acceptability should be documented. When demonstrating compliance through the use of comparisons to a previous package, one should clearly identify both packages, the test or design requirement, and the features being compared.

When selecting a packaging for use with a different load, the user should review the evaluations very carefully. Omissions and errors in the documentation should be watched for, as well as changes in requirements because of the change in the load. Small changes can have a large impact on the packaging performance. Also, one must not assume that evaluations are correct. Even for packagings purchased commercially, problems have been observed with packaging documentation. Problems have been seen with documentation for tests, comparison, and evaluations. For some packaging-load combinations, the secondary impact may be more severe than the initial impact. Evaluations have been observed where the secondary impact was ignored altogether. In one case where the secondary impact was ignored, the energy in the secondary impact was greater than the energy of the primary impact. When a comparison is used to evaluate a packaging, one should look closely at the evaluation for acceptability and accuracy. Comparisons where the dimensions or mass of the load are increased should be suspect as there is little information to support such evaluations. Also, one should watch for changes in more than one dimension; if used, one should look for documentation of the acceptability of the methodology.

4.1.4 Notification

In 49 CFR 178.2(c) the responsibility is placed on the manufacturer to supply a written notification to the person to whom a packaging is transferred. In 49 CFR 178.2(e) the manufacturer is defined 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."

These two definitions are identified here because for many DOT-7A, Type A packagings the shipping organization is also the manufacturer. A common package where this occurs is the 208-L (55-gal) drum used to ship radioactively contaminated waste. The following example is used to identify potential problems.

In this example, a decision is made to prepare a waste package using a drum. A drum meeting the description in the Type A packaging documentation is obtained from a manufacturer. For a drum to meet the DOT-7A, Type A packaging description, it must be essentially identical to the tested packaging. This requires that the drum be built using the same materials, methods of construction, and design. The drum then arrives along with a notification that identifies how the drum is used as a UN performance package. The drum carries none of the markings required by the DOT-7A, Type A packaging requirements. At this point, one should either go back and buy a packaging certified and marked by the manufacturer or become the packaging manufacturer.

Continuing with the unmarked drum requires identifying for the user the steps required to bring the drum into compliance with the DOT-7A, Type A packaging specification and how to properly load and close the package. In short, preparing a notification is necessary. The drum manufacturer's notification, as written, may not be used. It does not apply to the drum being used as a DOT-7A, Type A packaging. The new notification prepared must be clear enough to ensure the DOT-7A, Type A packaging is prepared and closed as it was for testing. As a manufacturer, one must ensure the packaging is marked in accordance with the marking requirements identified in 49 CFR 178.3. Also, one must remember to follow the record-keeping requirements and be ready to permit the DOT to conduct facility inspections.

When buying a package, one should watch how the order is written. If the manufacturer is instructed to mark the drum "USA DOT 7A Type A," the responsibility of the manufacturer remains with the purchaser. The definition of manufacturer should be read closely. One should write an order to buy a DOT-7A, Type A packaging that is also a drum from the manufacturer. When a marked package is obtained, the instructions in the manufacturer's notification should be followed. It should be noted that the drum and notification may not supply all of the information needed from the manufacturer to use the drum as DOT-7A, Type A packaging. If the notification is the only information received, the package should not be shipped. The shipment cannot be made even if the package meets all of the specification's requirements. The reason not to ship the package is that the shipper must have in his possession the documentation identified in 49 CFR 173.415(a) at the time of shipment. The documentation must also be retained for one year after completion of the shipment.

One must remember, if supplying a DOT specification packaging to someone else for use, to supply the required notification and documentation also. When a notification is prepared, it must identify all packaging requirements not met at the time of transfer and the type and

dimensions of any closures, including gaskets, needed to satisfy performance test requirements. The following quotes the requirements found in 49 CFR 178.2(c).

> **(c) Notification. Except as specifically provided in §§178.337-18 and 178.345-10 of this part, the manufacturer or other person certifying compliance with the requirements of this part, and each subsequent distributor of that packaging shall--**
>
> **(c)(1) Notify in writing each person to whom that packaging is transferred--**
>
> **(c)(1)(i) Of all requirements in this part not met at the time of transfer, and**
>
> **(c)(1)(ii) Of the type and dimensions of any closures, including gaskets, needed to satisfy performance test requirements.**
>
> **(c)(2) Retain copies of each written notification for at least one year from date of issuance; and**
>
> **(c)(3) Make copies of all written notifications available for inspection by a representative of the Department.**

Section 6.0 of the appendix provides space for documenting that the notification requirement was met and where the documentation is located.

4.1.5 Marking

This section discusses packaging marking requirements. The package marking requirements that apply at the time of shipment are not covered. In 49 CFR 178 requirements for the marking of Type A packagings are covered in two sections, 49 CFR 178.3, “Marking of packagings,” and 178.350, “Specification 7A; general packaging, Type A.” The markings are normally placed on the packaging by the organization performing the duties of the packaging manufacturer. The organization using the packaging is responsible at the time of shipment to ensure that all package requirements are met. This includes ensuring that the packaging is properly marked.

The packaging should be checked to verify it is marked “USA DOT 7A Type A” and “Radioactive Material” as required in 178.350(b). The name and address, or registered symbol, of the manufacturer should also be marked on the packaging as required in 178.3. Also, the correct size and placement of the markings should also be verified.

The author has observed packagings received from manufacturers with errors in all of the requirements. The most common errors observed result in the failure to correctly identify the manufacturer. These errors include failure to supply an address and the use of a symbol that has not been registered. Improper size or wording of the markings are the next most common type of error.

Section 7.0 of the appendix provides space for documenting that the marking requirement was met and where the documentation is located.

4.2 IDENTIFICATION OF SPLIT IN RESPONSIBILITIES FOR MEETING PACKAGING REQUIREMENTS

Section 1.5 identifies the responsibilities of the shipper and the manufacturer. In that section two items are pointed out. One, the responsibilities for ensuring a package meets all regulatory requirements at the time of shipment are placed on the shipper. Two, the packaging supplier must notify the packaging user of all packaging requirements not met when the packaging is provided. In the regulations the DOT-7A, Type A packaging definition is not clearly identified. The manner of presentation used in the regulations can easily lead to a manufacturer missing packaging requirements. This can lead to notifications that contain errors. Shippers should not assume that because the packaging is marked "USA DOT 7A Type A" and “Radioactive Material,” that all applicable packaging requirements are met for their load. In this section, an attempt is made to identify the complex relationship between the packaging manufacturer and the shipper. Potential problems that can result from the relationship are pointed out, and some avoidance techniques are suggested.

4.2.1 Manufacturer

In 49 CFR 178, the DOT assigns most of the responsibility for packaging integrity to the packaging manufacturer and some to the person using the package. Understanding this division of responsibility between manufacturer and shipper is essential when supplying a Type A packaging for use. If the responsibilities are not clearly understood, the shipper might be led to believe some responsibilities are met when they are not met. In 49 CFR 178.2, the responsibility is placed on the manufacturer to supply a written notification to the person to whom a packaging is transferred. This notification must identify all packaging requirements not met at the time of transfer and the type and dimensions of any closures, including gaskets, needed to satisfy performance test requirements.

For DOT-7A, Type A packagings, the identification of packaging requirements and the division of the responsibilities for ensuring compliance is unclear. In 49 CFR 173.415, 49 CFR 178.350 is identified as the source of the design and construction requirements for DOT-7A, Type A packages. That reference leads back to 49 CFR 173, Subpart I, for all but a few marking requirements. The terms "manufacturer" or "manufacturing" do not appear in 49 CFR 173, Subpart I. The requirements in 49 CFR 173, Subpart I, are all placed on the shipper. Not all requirements that influence packaging design are identified as design requirements. For example, acceptable thermal and radiation levels are identified as influencing the packaging design, but are not identified as design requirements. This has resulted in some packaging manufacturers missing and misinterpreting requirements. It is very important that the organization or individual supplying the packaging clearly identifies the requirements addressed and any actions required to bring the packaging into regulatory compliance. An organization manufacturing a DOT-7A, Type A packaging needs to follow the packaging requirements

identified in 49 CFR 173, Subpart I, keeping in mind that they are taking on responsibilities identified for the shipper. When supplying that packaging to another organization, it is required that any requirement not met be identified. With the large amount of variability built into the packaging requirements, that is not a trivial task. The shipper needs the manufacturer to clearly define what requirements were considered, to identify how they were met, and to identify which requirements remain to be completed. It is recommended that the manufacturer prepare documentation that identifies all of the DOT-7A, Type A packaging requirements and specifies which were judged as not applicable, which were met, and how they were met. A format similar to that used in DOE (1996 and 1998) is recommended. A manufacturer should provide clear identification of the design load. Knowledge of that load facilitates user assessment of regulatory compliance and the acceptability of the packaging for a planned load. Manufacturers of Specification 7A, general packaging, Type A, should use great care when designing and selling a packaging to this specification.

4.2.2 Shipper

When preparing a Type A shipment, the shipper must determine that the packaging is an authorized packaging per the applicable requirements identified in 49 CFR 173. The shipper must also ensure that the package has been manufactured, assembled, and marked in accordance with the applicable requirements identified within 49 CFR 173, 178, or 179. This document was prepared to assist the shipper in ensuring compliance with the requirements associated with a DOT-7A, Type A packaging.

The packaging manufacturer or subsequent distributor of a DOT specification or UN standard packaging is subject to the requirements of 49 CFR 178 and must perform all functions necessary to bring that package into compliance as identified by 49 CFR 178.2. Also, requirements identified within 49 CFR 173.415 specifically require documentation of compliance for a DOT-7A, Type A packaging: "Each offeror of a Specification 7A package must maintain on file for at least one year after the latest shipment, and shall provide to DOT on request, complete documentation of tests and an engineering evaluation or comparative data showing that the construction methods, packaging design, and materials of construction comply with that specification." Prior to the first use of a DOT-7A, Type A packaging-load combination, it is recommended that the documentation required to be in the shipper's possession at the time of shipment be reviewed against the identified standards. Reviewing the documentation can avoid problems that might otherwise result from a misunderstanding of what requirements remain to be completed before shipment.

It should be noted that the radioactive material in the design load for a DOT-7A, Type A packaging is often vaguely identified by the manufacturer. For example, in the document, DOE (1996 and 1998), the radioactive material is not identified for the design load for most metal drum and box-based packagings. The test load is identified in most cases as sand with some metal parts, such as lead bricks or steel ingots, to add weight. It is up to the shipper to compare the physical characteristics of the planned load with the test load and to show compatibility. It is also necessary to show that the radioactive material placed into the package is acceptable. This means being able to show the radiation levels do not significantly change if the package is

damaged similarly to the way it was during testing or by changes in environmental conditions. It should be noted that point sources inside a metal drum or box have a high probability of failure. This is due to the rapid increase in dose rate with decreasing distance to the source. When making an evaluation of radiation levels, both internal shifting of the load and inward movement of the surface of the packaging should be considered.

While 49 CFR 173.415 identifies 49 CFR 178.350 as the source of the design and construction requirements for Specification 7A packages, that section references back to 49 CFR 173, Subpart I, for all but a few marking requirements. The terms "manufacturer" or "manufacturing" do not appear in 49 CFR 173, Subpart I. The requirements in 49 CFR 173, Subpart I, are all placed on the shipper. Also, requirements such as acceptable thermal and radiation levels that influence the packaging designs are not identified as design requirements. This has resulted in packaging problems. Cases of packaging manufacturers missing and misinterpreting requirements have been observed. The shipper must carefully check that all requirements applicable to the planned DOT-7A, Type A packaging-load combination have been addressed and are met.

First, before buying a DOT-7A, Type A packaging, the load must be properly classified.

Next, a copy of the supporting documentation should be obtained from the manufacturer. The documentation should be reviewed against the packaging requirements for the planned load. When reviewing documentation, completeness and validity should be checked. The packaging may not be designed to handle the load or transportation mode being considered. Compatibility of the load with the materials of construction should be checked. If a gasket material is changed to obtain compatibility with the load, the fact that the change results in a package meeting all packaging requirements should be documented. That means stepping through every requirement that the performance of the part can affect. While adding additional packaging not used in the original design is acceptable, the effect of the additional material to the package must be evaluated. Documentation of the evaluation is recommended.

4.3 VERIFICATION METHODOLOGY

Many organizations use quality assurance audits to check on the ability of a system of controls to produce quality products. Often these audits look only at the system controls and not at implementation of the base requirements. The assumption is that if an effective system is in place, the requirements will be correctly implemented. For DOT-7A, Type A packaging manufacturers, this assumption is likely to be wrong. Persistent problems with DOT-7A, Type A packagings from manufacturers with acceptable quality assurance programs have been observed. For example, in one sample of five manufacturers with acceptable quality systems, during a compliance review four were observed to have regulatory compliance problems. Problems have been observed in both old and new companies. The problems stem from manufacturers being unaware of the requirements or failing to keep up with changing requirements. As a result, the following subsections recommend verifying that the regulatory requirements are properly implemented, and that the quality system ensures the production of packagings essentially identical to those tested.

4.3.1 Desktop Review

A desktop review is one technique for evaluating the operation of a system of controls. For a desktop review to be useful, the system must produce a documentation trail. The methodology for a desktop review is to obtain the documentation for the system to be reviewed and the standards the system is to meet. The documentation is then reviewed against the standards. Deficiencies in the documentation are identified, and an effort is made to find the missing documentation. When all documentation available has been reviewed, a report identifying where the system is successful and where deficiencies exist is prepared.

For DOT-7A, Type A packaging, this technique can be used to evaluate the packaging documentation for the design, manufacture, test, and evaluation. For DOT-7A, Type A packagings, each of these packaging activities are required to produce documentation. The key steps involved in using the technique are as follows.

1. Identify what packaging activity is to be evaluated.
2. Identify the applicable standards for the activity.
3. Obtain the documentation for the packaging activity.
4. Review the packaging documentation against the packaging standards.
5. Identify any deficiencies in the documentation.
6. Search for missing documentation.
7. Prepare a report that documents the result of the review.

If missing documentation has been identified, corrective action should be taken and the process repeated until all the required documentation is available.

The advantages of the desktop review are relatively low cost and they require little time to perform. A disadvantage is that the desktop review looks only at the quality of the paper trail, not the quality of the workmanship or product.

The first time a DOT-7A, Type A packaging is procured, it is recommended that a thorough desktop review of the packaging documentation be conducted. All of the main topics should be confirmed to be covered. The current packaging standards are shown in the appendix. However, caution should be used as the packaging may be designed to an older standard. Two of the difficulties pointed out for packagings received from commercial sources were identified using this technique. During the desktop review, the basics of physics and good engineering practices should be kept in mind. In one evaluation during the documentation review, it was noticed that a box measuring 61 cm (2 ft) by 61 cm (2 ft) by 9.1 m (30 ft) was evaluated for a 61-cm (2-ft) corner drop. No discussion was provided in the evaluation of what happened to the packaging when the end of the packaging that was 9.1 m (30 ft) above the test surface rotated about the point of impact and slammed onto the test surface. In another evaluation it was noticed the units of measure were inconsistent in the calculations used to evaluate the drop test. A dimensional analysis of the evaluation identified that an error had been made.

4.3.2 Manufacturing Facility Visit and Review

Another review technique for evaluating the operation of a system is an onsite review. This review technique does not require the system to produce a documentation trail. The methodology for an onsite review is to obtain the standards that the system is to meet. The standards are reviewed, and a checklist of key items is identified. The manufacturer is contacted, and arrangements are made for a visit to the site to review the packaging activities being conducted. The manufacturer is told the purpose of the review and what is being looked for. The manufacturer is asked to supply documentation for the key items, if available. The information supplied is reviewed before the onsite visit is conducted. When documentation shows that a requirement is being met, the time spent on that area can be reduced during the site visit. Compliance with the requirements should be verified during the visit. Also, during the visit those items not previously evaluated are reviewed for compliance. The results of the visit should be identified to the manufacturer before leaving the facility. Any problems observed should be documented and discussed with the manufacturer. After the visit a report is prepared. The report identifies where the system is successful and where deficiencies exist.

For a DOT-7A, Type A packaging, this technique can be used to evaluate the packaging documentation for the design, manufacture, test, and evaluation. Because each of these packaging activities is required to produce packaging documentation, the review should be simplified. The key steps involved in using the technique are as follows.

1. Identify what packaging activity is to be evaluated.

2. Identify the applicable standards for the activity.

3. Contact the manufacturer of the activity and arrange for onsite review and copies of available documentation.

4. Review the packaging documentation against the packaging standards and identify any deficiencies in the documentation.

5. Conduct onsite review of packaging activities and search for missing documentation.

6. Reveal initial results of the review to the activity manufacturer.

7. Prepare a report that documents the result of the review.

For DOT-7A, Type A packaging activities, the standards identify documentation requirements for all packaging activities. The identification and documentation of those standards are the main topic of this document. One should ensure that the minimum requirements are met.

When reviewing design activities, the following steps should be taken.

1. Look for implementation of design requirements.

2. Check that the current regulatory design requirements are being followed.

3. Verify that the design documentation is in enough detail to ensure that each packaging built to the design will essentially be identical in all details important to safety.

The review of the manufacturing activities should ensure that the packaging built is essentially identical in all details important to safety each time. The DOT-7A, Type A packaging testing and evaluation are normally conducted only once for a packaging design. The following steps should be taken.

1. Review testing documentation, procedures, and equipment for compliance with the standards.

2. Verify that testing can be tied to a particular design.

3. Check that design tested is the design being provided.

4. Verify that tests are conducted using equipment that meets the regulatory requirements.

5. Look closely at test pads. The test pads should be large enough and unyielding for the packaging being tested.

6. Look for how the ability of the packaging to meet the reduced pressure requirement is verified.

7. Verify that the correct pressure differential is designed for and used when testing or evaluating.

8. Check that the manufacturer has prepared a notification as required by 49 CFR 178.2(c) and that the notification is supplied to the next organization in the chain of those taking custody of the packaging.

When conducting an onsite packaging review, checking the secondary packaging requirements is recommended. One should look for documentation for training of design, manufacture, and test personnel. In 49 CFR 173.700, specific training requirements are identified for personnel involved in activities that can directly affect the safety of a shipment. During compliance reviews, packaging manufacturers who had not conducted the required DOT training were observed. Some manufacturers were unaware of the training requirements. When

training is missing, very close attention should be paid to the implementation of packaging requirements. It is hard for personnel to implement unknown requirements that result from poor training.

If a symbol is used on the packaging in place of the manufacturer's name and address, the symbol should be verified as properly registered. DOT-7A, Type A packagings with unregistered symbols and no name and address have been observed.

The advantage of the onsite review is that it looks at both the quality of the paper trail and the quality of the workmanship or product. Disadvantages are high cost, travel, and a relatively large amount of required time.

4.3.3 Obtaining Review Materials

Obtaining review materials is a key step in both desktop and manufacturing facility reviews. Usually, obtaining the materials requires dealing with another organization. Often, that organization will be a separate company; therefore, it is important to clearly identify what is being requested and what use will be made of the information. Because there is no specific format for the required DOT-7A, Type A packaging documentation, clearly identifying what is wanted is not always easy. Documenting the information needed is highly recommended, even for simple phone requests.

The starting point in requesting information should be understanding what is needed. The following steps should be taken.

1. Identify what documentation is required for the packaging.

2. Prepare a request for the information needed to permit use of the packaging with the planned load.

3. Identify these needs to the packaging manufacturer and request that they supply them.

4. When requesting information on a non-catalog item, be prepared to pay for the requested information. Remember, preparation of the requested information costs the manufacturer both time and money.

The documentation received from manufacturers can vary widely. Sometimes the only documentation supplied is a sketch and a very brief test report that states the package passed the test requirements. If documentation of this type is received, additional information should be requested or a different packaging should be chosen.

For an example of the documentation needed for a DOT-7A, Type A packaging, the document DOE (1996 and 1998) should be reviewed. In DOE (1996 and 1998), a sketch and brief description are presented for each packaging. The information is useful for making an

initial decision of packaging usefulness. The information references the applicable appendices for a package. In the appendices, the regulatory requirements in effect when the packaging was designed and tested are identified. Identified in the appendices along with the requirements are the abilities of the packaging to meet the requirements or the need for users of the packaging to develop additional information; e.g., developing the documentation that shows the planned load is compatible with the packaging. The collection of the initial description and the backup data in the appendices represents an example of the minimum information required to document the design, testing, and/or evaluation of a package. It should be noted that, as pointed out in DOE (1996 and 1998), the user needs to generate the additional documentation to complete the documentation requirements identified in 49 CFR 173.415(a).

Contact by phone is quick and convenient although, in most cases, documenting the request for information in writing is recommended. When timeliness is required, a telefax or E-mail message works well. Overall, the use of written messages results in a clearer communication of what is needed and results in fewer misunderstandings. If a follow-up written message is not used, the individual taking the request should be asked to repeat it. This technique will reduce misunderstandings.

When an initial phone or personal contact is not used, one should ensure that the written request makes it clear why the information is requested. If available, a phone number or E-mail address should be provided where the person filling the request can make contact to obtain additional information or clarification. This can help to speed responses over the use of mail alone.

4.3.3.1 Request Design Documentation. When requesting design documentation, make it clear that only enough detail to verify the packaging design, not build the packaging is needed. Request the design documentation necessary to show the packaging meets applicable regulatory requirements. Design documents can be drawings, sketches, specifications, engineering calculations, engineering evaluations, reasoned evaluations, photos, videos, notifications, and any other information that shows the packaging meets the regulatory requirements. While the documentation can be in any form or combination of forms, to be of value, the documentation must be in some way tied to the packaging design.

4.3.3.2 Request Manufacturing Documentation. When requesting manufacturing documentation, it should be made clear that only enough detail is needed to verify the packaging, not build the packaging. Only the manufacturing documentation necessary to show the packaging matches the design and meets applicable regulatory requirements should be requested. Documentation can be training records, procedures, testing results, inspections, job controls, material controls, quality assurance records, and any other type of information that documents the manufacture of the packaging results in a packaging essentially identical to the tested packaging. While the documentation can be in any form or combination of forms, to be of value the documentation must be in some way tied to the design and testing and/or evaluation of the packaging.

4.3.3.3 Request Testing and/or Evaluation Documentation. When requesting testing and/or evaluation documentation, it should be made clear that only enough detail is needed to verify the

packaging meets the applicable performance requirements. The test and evaluation documentation that shows the packaging meets applicable regulatory requirements should be requested. Documentation can be procedures, testing results, test reports, inspections, job controls, material controls, quality assurance records, reasoned evaluations, drawings, sketches, specifications, photos, videos, and any other type of information that documents the test and/or evaluations. The document must show that the packaging meets all of the applicable packaging requirements. The documentation should also show the test procedures and equipment used to conduct the tests meet the regulatory requirements. The equipment for which information should be requested is shown in Section 4.3.4. Enough information is needed to show that the equipment meets the regulatory requirements for the packaging being tested. For example, the water spray apparatus can apply the minimum rate over the largest size package to be tested. While the documentation can be in any form or combination of forms, to be of value the documentation must be in some way tied to the design, manufacturing methods, and testing and/or evaluation of the packaging.

If straight evaluations are used in place of testing and evaluation, the evaluation methodology should be reviewed for thoroughness. The evaluations should be checked for validity. If the evaluation is not a commonly used standard method and documentation for the validity of a method is not presented or referenced, documentation should be requested. Water spray evaluations should cover loss of material, changes in dose rates associated with the package, and effects on materials of construction. Drop test evaluations should consider effects of water spray and primary and secondary impacts on the ability of the packaging to withstand the test without loss of contents or increase in radiation level. The ability of the evaluation method to demonstrate the impact of the packaging onto an unyielding target should be documented. The features of the packaging evaluated should be identified along with why they were selected. If features are not evaluated that appear to have the potential for failure, the reason for not evaluating them should be documented. The ability of the closures to retain material should be identified. The ability of the damaged packaging to meet shielding requirements should be discussed. Evaluation of the penetration test should identify the selected impact points and the reasoning for their selection. The evaluation should identify the calculated damage. Pass/fail criteria, along with a statement of the ability of the packaging, should be documented. The evaluation of the stacking test should identify pass/fail criteria. For all evaluations, the methodology used and why it is acceptable should be identified.

4.3.4 What To Verify During Review Process

What to verify during a review is dependent of the purpose of the review. The review should focus on showing compliance with requirements. In general, the reviewer should look for an understanding by the manufacturer of the need for ensuring containment, shielding, and differential pressure requirements are met. If the reviewer is not thoroughly familiar with the requirements associated with a DOT-7A, Type A packaging, the assistance of someone who understands the requirements should be obtained. Either the reviewer or the assistant should prepare a checklist for use during the review process. The use of a checklist focuses the review on the items judged important and provides guidance for the unfamiliar reviewer.

When verifying the design process, the following items should be considered:

- Identification of the design load
- Identification of transportation mode(s)
- Selection of the applicable packaging requirements
- Proper application of the packaging requirements
- Selection of the materials of construction
- Selection of the methods of construction
- Documentation of the design
    - Drawings and sketches
    - Specification
    - Design calculations
    - Engineering evaluations
    - Loading and closure instructions.

When verifying the manufacturing process, the following items should be considered:

- Method of design implementation
- Process controls
- Material controls
- Job controls
- Work flow
- Inspections
- Tests.

When verifying the testing process, the following items should be considered:

- Test equipment
    - Water spray apparatus/setup
    - Penetration bar
    - Penetration bar guides
    - Measuring equipment
    - Compression setup
    - Pressure test equipment
    - Drop test pad
    - Release mechanism
    - Weighing equipment
    - Weights

- Vibration table
- Test loads

- Equipment calibrations
- Test procedures
- Test documentation
- Test evaluations
- Test reports.

General Items

When verifying the manufacturing processes, the following should be considered:

- Preparing a notification
- Distributing a notification
- Providing DOT-required training
- Maintaining awareness of changing regulatory requirements.

5.0 VERIFYING THAT THE PACKAGING IS PROPERLY LOADED

This section provides guidance on how to verify that a Type A packaging is properly loaded. The guidance includes ensuring the packaging notification prepared by the manufacturer is followed.

5.1 VERIFYING NOTIFICATION IMPLEMENTATION

Each manufacturer is to provide for a DOT-7A, Type A packaging notification that identifies the requirements that are not met at the time the packaging is transferred to the next owner. The notification is to include information on the packaging closure. The notification is intended to provide the organization that uses the packaging with the information needed to complete the packaging for shipment in such a manner that it meets all of the design and performance requirements.

Verifying the implementation of the packaging notification can be accomplished through the use of a desktop or onsite review. The first step is determining if a notification is applicable. Packagings manufactured before October 1994 did not require a notification to be prepared. After that date newly manufactured packagings should have notifications prepared. If a notification is not available for a packaging manufactured after October 1994, the manufacturer should be contacted and a copy requested. Based on a series of five reviews of DOT-7A, Type A packaging manufacturers conducted in 1996, notifications may not be available when requested. Four of the manufacturers reviewed were unaware of the requirement to provide a notification. If a desktop review is conducted, a copy of the notification to use as the standard and copies of any procedures written to cover use of the packaging should be obtained. The procedures should be reviewed to ensure they correctly and fully implement any uncompleted packaging requirements and result in proper closure of the package. If the notification is implemented through use of the notification document, one should try to talk to the operating personnel. When talking to the personnel conducting the work, one should verify they understand what is to be completed and how to load and close the package. If an onsite review is conducted, if possible, the same steps as outlined for the desktop review should be conducted. In addition, if possible, one should arrange to witness the completion of a packaging. To verify use of the notification when procedures are not used, one should look for the shipper to have a copy of the notification. One should talk to the personnel that completed the packaging and verify that the notification is followed.

6.0 REFERENCES

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49 CFR 173, "Shippers--General Requirements for Shipments and Packagings," *Code of Federal Regulations*, as amended.

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