Radioactive Material Shipping Packages

INTRODUCTION

This module provides information about identifying packaging used to transport radioactive material and how to recognize this material when responding to a transportation incident.

Four types of packages will be discussed; Excepted packaging, Industrial packaging, Type A packaging and Type B packaging. Consideration for the mode of transporting radioactive material will be discussed. You will learn the philosophy behind radioactive material packaging design as well as the safety features associated with the radioactive material package and the stringent package testing requirements.

PURPOSE

The purpose of this module is to provide you with a basic understanding of the types of packages used to transport radioactive material and the potential hazard posed by the material contained within these packages. This information will help increase your knowledge of appropriate responses to a radiological transportation incident.

MODULE OBJECTIVES

Upon completion of this module, you will be able to:

1. Identify typical packages used in the transport of radioactive material.
2. List examples of radioactive material that are shipped in various shipping packages.
3. Identify the risks associated with the various shipping packages.
4. Identify the testing methods for Type A and B Packages.
5. Identify some commonly transported sources of radioactive material.

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TRANSPORTING RADIOACTIVE MATERIAL

Radioactive material is a vital part of our modern society. They are used in our hospitals, factories, laboratories and homes. Life would be more difficult if we had to stop using radioactive material. Many of the benefits we get from radioactive material cannot be obtained by any other means.

Doctors use them to diagnose and treat many diseases. Smoke detectors use a small amount of radioactive material to provide early warning of fires in our homes. Products like plastic wrap, radial tires, and coffee filters are manufactured in factories that use radioactive material. There are many more uses of radioactive material in our modern society that provide enormous benefits.

Radioactive material is transported every day by highway, rail, air, and water. Radioactive material must be shipped from where it is produced to where it is used. The use of radioactive material sometimes produces radioactive waste that must then be shipped to a disposal site. Radioactive material is transported according to very strict federal regulations. The regulations are designed to protect the public and the environment from risks associated with radioactive material during normal and accident conditions. The DOE complies with all applicable regulations pertaining to the transport of radioactive material.

Radioactive material is generally shipped in its most stable form. Typically, that means they are shipped as solids. When radioactive liquids or gases are transported, federal regulations require additional precautions. Careful research and design goes into packaging radioactive material. Emergency planning, driver training, and strict government inspections are a part of a program that has never resulted in a radiologically related death or injury from a transportation incident.

Packaging and transportation of radioactive material requirements are defined in 10 CFR Part 71. *Packaging* means the assembly of components necessary to ensure compliance with the packaging requirements. *Package* means the packaging together with its radioactive contents as presented for transport. The various types of radioactive packaging will be discussed in the following pages.

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HAZARD EVALUATION

Federal regulations place strict administrative controls on the transport of radioactive material. The worldwide philosophy of radioactive material transport is that:

- Safety should be primarily focused on the package. Packaging is the first line of defense.
- Package integrity should be directly related to the degree of hazard of the material it contains

This two-part philosophy means that small quantities of radioactive material–quantities that would present little hazard if released–may be shipped in less secure packages than those that contain higher levels of radioactive material.

RADIOACTIVE MATERIAL PACKAGING

Radioactive material, like other commodities, is transported every day by highway, rail, air, and water. Radioactive material is packaged to ensure that radiation levels at the package surface do not exceed federal regulations. This ensures that shippers, the public, and the environment are not exposed to radiation levels that exceed recognized safe limits.

Different shipping packagings are required for various types, forms, quantities, and levels of radioactivity. We will discuss four packaging types:

- Excepted Packaging
- Industrial Packaging
- Type A Packaging
- Type B Packaging

There is another package type that is not authorized for domestic use but is referenced in the ERG. Type C Packages are authorized for international shipments of radioactive material by air. They are designed to withstand severe accident conditions associated with air transport. The Type C package performance requirements are significantly more stringent than those for Type B packages. Since they are not authorized for domestic use, it is unlikely that they would be encountered in the United States.

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Excepted Packaging is used to transport material with extremely low levels of radioactivity. Excepted packagings are authorized for limited quantities of radioactive material that would pose a very low hazard if released in an accident. Examples of material typically shipped in excepted packaging include consumer goods such as smoke detectors. Excepted packagings are excepted (excluded) from specific packaging, labeling, and shipping paper requirements; they are however, required to have the letters "UN" and the appropriate four-digit UN identification number marked on the outside of the package. Requirements for excepted packaging are addressed in 49 CFR 173.421.

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Industrial Packaging is used in certain shipments of low activity material and contaminated objects, which are usually categorized as radioactive waste. Most low-level radioactive waste is shipped in these packages. Department of Transportation (DOT) regulations require that these packages allow no identifiable release of the material to the environment during normal transportation and handling. There are three categories of industrial packages: IP-1, IP-2, and IP-3. The category of package will be marked on the exterior of the package as shown below. Requirements for industrial packaging are addressed in 49 CFR 173.411.

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Type A Packaging is used to transport small quantities of radioactive material with higher concentrations of radioactivity than those shipped in industrial packagings. They are typically constructed of steel, wood, or fiberboard, and have an inner containment vessel made of glass, plastic, or metal surrounded with packing material made of polyethylene, rubber, or vermiculite. Examples of material typically shipped in Type A Packages include nuclear medicines (radiopharmaceuticals), radioactive waste, and radioactive sources used in industrial applications. Type A packaging and its radioactive contents must meet standard testing requirements designed to ensure that the package retains its containment integrity and shielding under normal transport conditions. Requirements for Type A packaging are addressed in 49 CFR 173.412.

Type A Packages must withstand moderate degrees of heat, cold, reduced air pressure, vibration, impact, water spray, drop, penetration, and stacking tests. Type A Packages are not, however, designed to withstand the forces of an accident. The consequences of a release of the material in one of these packages would not be significant since the quantity of material in this package is so limited. Type A packagings are only used to transport non life-endangering amounts of radioactive material.

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Type B Packaging is designed to transport material with the highest levels of radioactivity. As illustrated in the photos below, Type B packagings range from small hand-held radiography cameras to heavily shielded steel casks that weigh up to 260 tons. Examples of material transported in Type B packagings include spent nuclear fuel, high-level radioactive waste, and high concentrations of other radioactive material such as cesium and cobalt. These package designs must withstand all Type A tests, and a series of tests that simulate severe or "worst-case" accident conditions. Accident conditions are simulated by performance testing and engineering analysis. Life-endangering amounts of radioactive material are required to be transported in Type B Packages. Requirements for Type B packaging are addressed in 49 CFR 173.411. 49 CFR 173.413.

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To demonstrate that Type B Packages can withstand a severe accident, a tractor-trailer (below) carrying a Type B Package prototype was crashed into a massive concrete wall at 84 miles per hour. The package was slightly dented, but it did not release its simulated radioactive material.

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RISKS ASSOCIATED WITH SHIPPING PACKAGES

Unlike other hazard classes, radioactive material in transport has additional information about potential risk(s) to the responder. Some of this information can be obtained by first identifying the packaging type for the material being shipped. Excepted, Industrial, and Type A Packages contain non life-endangering amounts of radioactive material and present minimal risk if their contents are released in an accident. Type B Packages, however, may contain life-endangering amounts of radioactive material that could pose a significant risk if released during an accident.

The philosophy behind radioactive material transportation–where safety is primarily focused on packaging and package integrity being appropriate to the material hazard–dictates that Type B Packages be designed to withstand severe accident conditions. In DOE's and its predecessor's 50-year history of transporting radioactive material, there has never been a release from a Type B Package. In addition, there has never been an injury or death resulting from the release of radioactive material in a transportation incident.

RADIOACTIVE MATERIAL PACKAGE TESTING

Two federal agencies regulate the testing of radioactive material package designs for use in the United States: the U.S. Department of Transportation (DOT) and the U.S. Nuclear Regulatory Commission (NRC). DOT and NRC regulations are based on international regulations issued by the International Atomic Energy Agency (IAEA).

The DOT is responsible for specifying required test conditions for most packages. The NRC certifies that packages designed for material with higher levels of radioactivity (i.e., Type B Packages), such as spent fuel, meet NRC test requirements. Package designs are tested using computer simulation, scale model testing, and/or full-scale testing.

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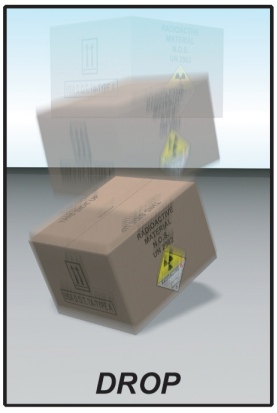
PACKAGE TESTING REQUIREMENTS

Type A Tests

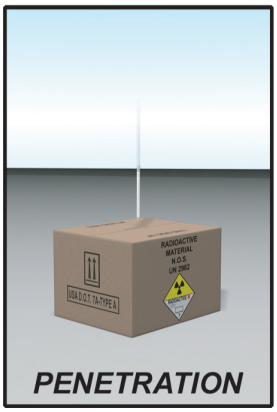
Type A Packages must be able to withstand a series of tests that simulate normal transport conditions. These tests include:

Water spray for 1 hour to simulate rainfall of 2 inches per hour.



Free drop test onto a flat, hard surface. Drop distance varies based on weight of package (see below).

Stacking test of at least 5 times the weight of the package. This test is conducted for at least 24 hours.



Penetration test by dropping a 13-pound, 1.25-inch diameter bar vertically onto the package from a height of 3.3 feet (1 meter).

Package Mass	Free Drop Distance
< Mass 11,000 lbs.	4 feet
11,000 to 22,000 lbs.	3 feet
22,000 to 33,000 lbs.	2 feet
> 33,000 lbs.	1 foot

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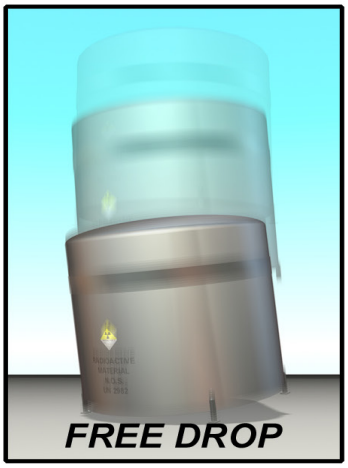
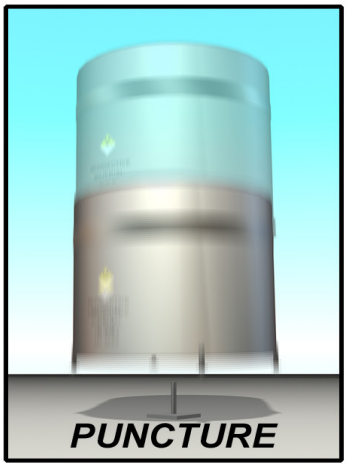
Type B Tests

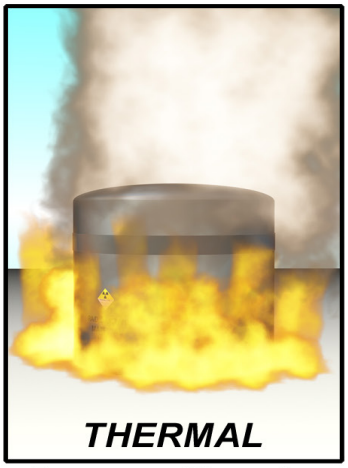
In addition to the requirements for Type A Packages, the Nuclear Regulatory Commission (NRC) requires that Type B Packages be able to withstand a series of tests that simulate severe accident conditions. These tests are conducted sequentially and include:



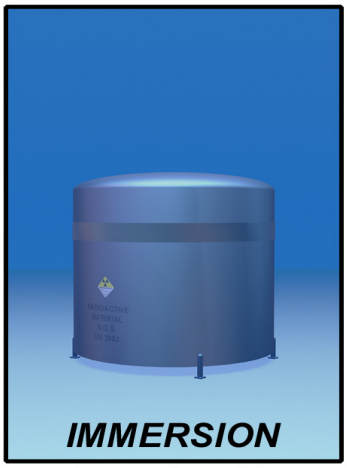
A 30-foot free drop onto a flat, essentially unyielding surface so that the package's weakest point is struck.



A 40-inch free drop onto a 6-inch diameter steel rod at least 8 inches long, striking the package at its most vulnerable spot.



Exposure of the entire package to 1475°F for 30 minutes.



Immersion of the package under 50 feet of water for at least 8 hours.

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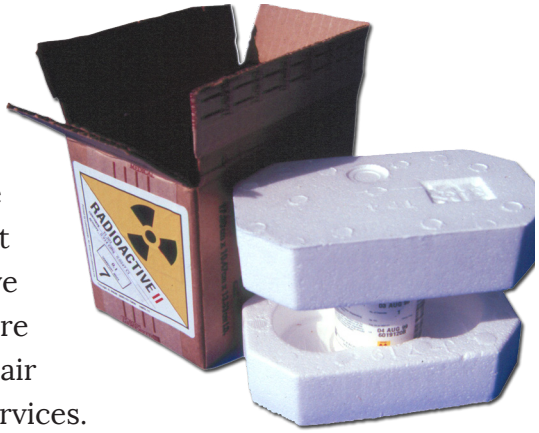
COMMON SOURCES OF RADIOACTIVE MATERIAL

Now that we've looked at the four types of shipping packages used to transport radioactive material, let's take a look at some commonly used and transported sources that you are likely to encounter as a first responder.

Consumer products such as smoke detectors are an example of a commonly transported consumer product. The amount of radioactivity in the household smoke detector falls below regulatory limits and therefore these materials will not be marked or labeled as "radioactive material" during transport. Because the level of radioactivity falls below regulatory limits, consumer products such as smoke detectors are typically transported in excepted packages.

Radiopharmaceuticals are radioactive drugs that are used for medical diagnoses and in radiation therapy. Radiopharmaceuticals are the most commonly transported radioactive material in the U.S. Most radiopharmaceuticals have very short half-lives and are typically transported by air and express delivery services. These materials can be in liquid, gas, powdered, or solid form. Radiopharmaceuticals are commonly transported in Type A Packages.



Industrial sources are specially designed and sealed sources of radiation used in construction and other industrial applications to check welds and metal for flaws, to check concrete and asphalt, and to test the density of soil. Soil density gauges are one example of a commonly transported industrial source. They usually

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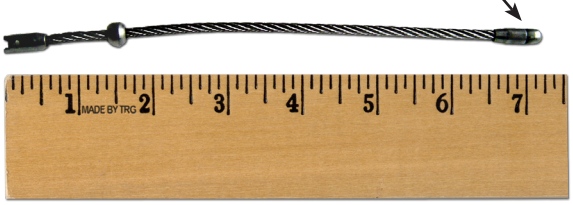
contain a cesium-137 and/or americium-241:beryllium source. These types of gauges do not typically contain life-endangering amounts of radioactive material and are usually transported in Type A Packages. Radiography sources, on the other hand, often contain a very high level source (commonly iridium-192 or cobalt-60) that could pose a high exposure risk if the source were outside of its packaging. When these high activity radiography sources are transported, they are shipped in Type B Packages.

Pictured below from top to bottom are: a soil density gauge sitting outside of its shipping/carrying case; a hand-held radiography camera and an example of a radiography source (commonly referred to as a "pigtail"). When not in use, the pigtail is secured inside the radiography camera.

Soil Density Gauge

Radiography Camera

Radiation Source



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Nuclear fuels may be either new fuel being transported to a nuclear power station or spent (used) fuel being transported for reprocessing, storage, or disposal. There is a big difference in activity levels between new fuel and spent fuel. New fuel in not very radioactive and would likely be transported in an excepted package. Spent nuclear fuel on the other hand, is highly radioactive. This is because of the high activity fission products that remain after the uranium atoms in the fuel are fissioned (split). Both new and spent fuel material are solid in form. Because of its high activity, spent nuclear fuel is transported in specially designed Type B Packages called shipping casks. Pictured below is a spent fuel shipping cask being surveyed by radiological control personnel.

Radioactive waste comes from nuclear power generating facilities, nuclear processing plants, research institutions, medical facilities, or other locations. Radioactive waste is commonly transported by highway and rail. Pictured on the following page are 55-gallon drums of radioactive waste (typically containing items such as contaminated protective clothing, rags, etc.) and a railcar loaded with contaminated soil from cleanup operations at a DOE facility. Radioactive waste may be transported in any one of the four types of shipping packages covered in this module, depending on the activity level of the waste being transported.

Radioactive Material Shipping Packages

Radioactive material is one of the most highly regulated hazardous material transported. The U.S. Department of Transportation regulates domestic shipments of radioactive material. Both the U.S. Nuclear Regulatory Commission and the U.S. Environmental Protection Agency have a role in assisting with development of the hazardous material shipping regulations. The philosophy for managing the transport of radioactive material is highly proactive. Radioactive material has been moved across this country for more than 70 years and, to date, there has never been a death or injury resulting from exposure to this material during transport.

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Check Your Understanding

1. This type of packaging, along with its radioactive contents, must meet standard testing requirements designed to ensure that the package retains its containment integrity and shielding under normal transport conditions.
   a. Type A packaging
   b. Type B packaging
   c. Industrial packaging
   d. Excepted packaging

2. _____ __ packaging must be able to withstand a series of tests that simulate severe or "worst case" accident conditions.

3. Radiopharmaceuticals are typically shipped in _____ __ packagings and spent nuclear fuel is typically shipped in _____ __ packagings.

4. Which of the following statements best applies to the risks associated with material shipped in Type A Packages?
   a. Type A Packages are used to transport very high levels of radioactive material
   b. Type A Packages are used to transport exempt quantities of radioactive material
   c. Type A Packages are built to withstand the most severe accident conditions
   d. Type A Packages contain non life-endangering amounts of radioactive material

5. One commonly transported source of radioactive material is (pick one):
   a. Radio waves
   b. Visible light
   c. Radiopharmaceuticals
   d. Microwaves

ANSWERS

1. a
2. Type B
3. Type A
   Type B
4. d
5. c