INTRODUCTION
This module provides information about identifying packagings 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.
TRANSPORTING RADIOACTIVE MATERIAL

Radioactive materials are 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 materials 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 materials are 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 materials. 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.
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
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.
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.
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.
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 125 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 and 10 CFR 71.
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.
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 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.
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**: Water spray for 1 hour to simulate rainfall of 2 inches per hour.
- **DROP**: Free drop test onto a flat, hard surface.
- **STACKING**: Stacking test of at least 5 times the weight of the package. This test is conducted for at least 24 hours.
- **PENETRATION**: Penetration test by dropping a 13-pound, 1.25-inch diameter bar vertically onto the package from a height of 3.3 feet.
PACKAGE TESTING REQUIREMENTS
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:

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

- **PUNCTURE**
  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.

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

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