DOE/NTP-005

U.S. Department of Energy

National Transportation Program

Radioactive Materials

Package Performance

DOE maintains a testing program for packaging designs and follows all Federal standards in the design and maintenance of radioactive materials packagings.

In the United States, safe transportation of radioactive materials is achieved by compliance with Federal regulations. Proper packaging is a key element of shipment safety.

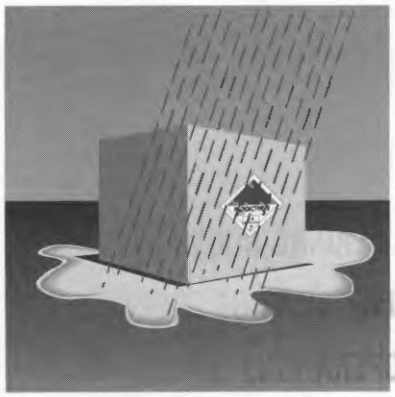
The U.S. Department of Energy (DOE) ships radioactive materials as part of many programs, including environmental cleanup, research and development, and National defense. To support its commitment to the safe transport of these materials, DOE maintains a testing program for new packaging designs and follows all Federal standards in the development of packagings. Two Federal agencies regulate the performance requirements for radioactive material packaging designs. The U.S. Department of Transportation (DOT) is responsible for specifying the general standards and requirements for all packaging designs. The U.S. Nuclear Regulatory Commission (NRC) certifies that packagings designed for materials with high levels of radioactivity, such as spent nuclear fuel, meet DOT requirements. DOT and NRC regulations are based on international safety standards set by the International Atomic Energy Agency.

Types of Packagings and Performance Requirements

Radioactive materials are packaged according to their form, quantity, and concentration. Four basic types of packaging are used: **Excepted, Industrial, Type A, and Type B**. Another packaging option, **Strong-Tight**, is still available for some domestic shipments.

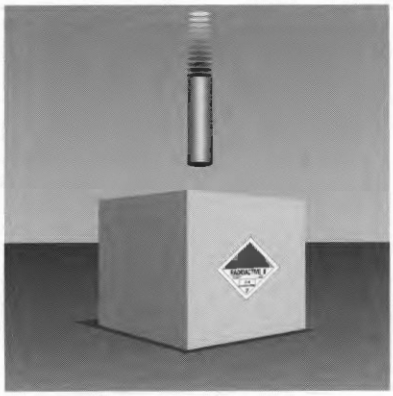
Excepted packagings are limited to materials with extremely low levels of radioactivity. Because of the very limited hazard posed by their contents, these packagings must meet design requirements that include ease of handling, materials allowed for construction of the packaging, and other safety-related features. This packaging type ranges from a product's fiberboard box to a sturdy wooden or steel crate. Typical shipments

Type A Tests:

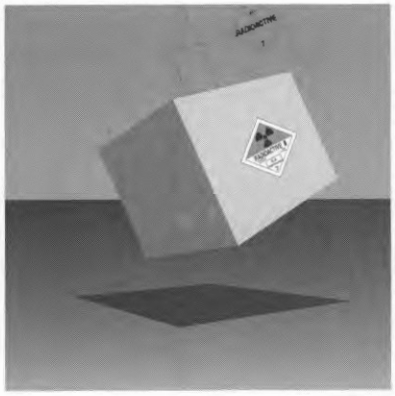


Water spray for 1 hour [to simulate rainfall of 2 inches per hour].

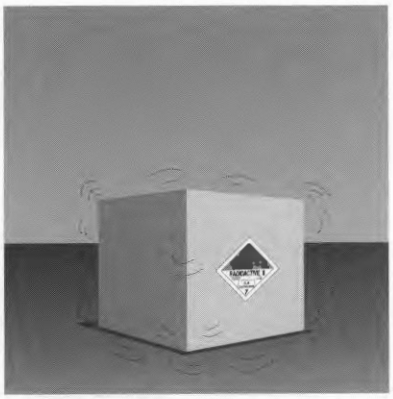
Compression of at least 5 times the weight of the package for at least 24 hours.



Penetration by dropping a 13.2-pound bar [1.25-inch diameter] vertically onto the package from a height of 40 inches.



Free-drop onto a flat, hard surface [4-foot drop if the package weighs 11,000 pounds or less].



Vibration for 1 hour on a platform vibrating so that the package will be raised high enough for a rigid material [0.063 inch thick] to be passed between the bottom of a package and the platform.

include limited quantities of materials, instruments, and articles such as smoke detectors.

Industrial packagings (IP) are used to transport materials that, because of their low concentration of radioactive materials, present a limited hazard to the public and the environment. Examples include contaminated equipment, radioactive waste solidified in such materials as concrete or glass, and liquids. This packaging type is grouped into three categories based on packaging strength:

- **IP-1** packagings must meet the same general design requirements of an excepted packaging.
- **IP-2** packagings must pass Type A packaging design free-drop and stacking (compression) tests.
- **IP-3** packagings must pass IP-2 tests and the water spray and penetration tests required for Type A packagings used to ship solid contents.

Strong-Tight packagings are still used in the United States for shipment of certain materials with low levels of radioactivity, such as natural uranium and rubble from the decommissioning of nuclear reactors. They are not required to meet all of the general design requirements for radioactive materials packagings and, so, are only authorized for domestic shipments in vehicles hired exclusively for those shipments. This is allowed because of the low hazard and historical safety record for the transport of such materials.

Type A packagings are used to transport radioactive materials with higher concentrations or amounts of radioactivity than excepted or industrial packagings. Designed to protect and retain their contents under normal transport conditions, Type A packagings must maintain sufficient shielding to limit radiation exposure to handling personnel.

Examples of materials shipped in Type A packagings include radiopharmaceuticals and low-level radioactive wastes. (Low-level radioactive waste is unwanted radioactive material created in the process of handling and use of radioactive substances. It usuallly contains small amounts of short-lived radioactive material dispersed in large quantities of material and poses little transportation risk.) Typically, Type A packagings consist of an inner containment vessel made of glass, plastic, or metal surrounded by packaging material made of polyethylene, rubber, or an absorbent in a fiberboard, wood, or metal outer container. They must be able to withstand heavy rain, free-drops, stacking, vibration, and penetration by a dropped weight.

Type B packagings are used to transport materials with high radioactivity levels including spent nuclear fuel; high-level radioactive waste; and high concentrations of cesium-137, cobalt sources, and other such radioisotopes. Because of the high level of radioactivity, Type B packagings are designed to retain their contents under both normal transport and severe accident conditions. These packagings range in size from small drums (55 gallon) to heavily shielded steel casks that can weigh more than 98 tons.

Type B designs are certified by the NRC before use and are recertified every 5 years. DOE is allowed to certify some of its own packagings that have been shown to meet DOT and NRC standards.

Type B packaging designs must undergo analyses and/or tests to determine their ability to retain their contents and maintain sufficient shielding in a severe accident. In addition to Type A packaging requirements, Type B designs must meet sequential test conditions including free drop, crush (in some cases), puncture, heat, and a 3-foot water immersion test (for fissile materials). A separate, undamaged container may be used for the 50-foot water immersion test required for all Type B packaging designs.

These tests can be done by computer analyses. It is important to understand that Type B performance requirements are not meant to duplicate real transportation accidents, but to produce package damage that is equivalent to, or worse than, what may occur in severe transportation accidents.

Packaging Certification Methods

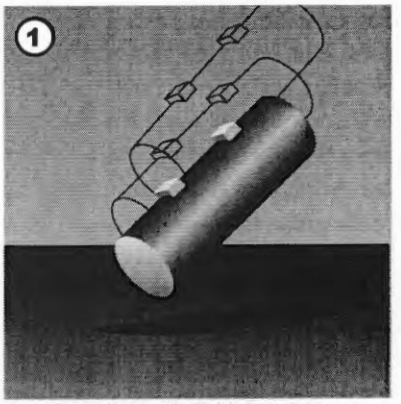
The ability of a packaging to withstand test conditions may be demonstrated by comparing designs to similar packagings, engineering analyses (using computer-simulated tests), or by scale-model or full-scale testing. In most cases, a combination of methods is used. DOT and NRC require complete documentation that each packaging design can meet the test conditions before it is used for actual transport. In addition, quality assurance documentation must be completed for each packaging built according to an approved packaging design.

Computer-Simulated Tests

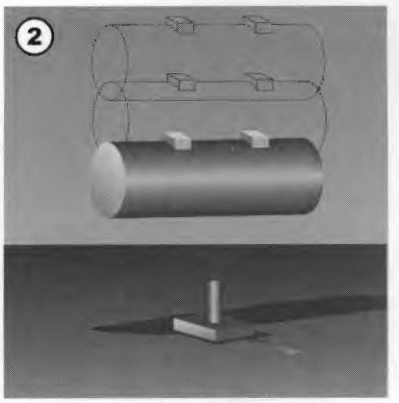
Computer software can be used to simulate package response to normal transport and accident conditions. These simulations also provide data that can help predict how well the package will withstand specific conditions.

Computer simulations offer valuable information when used in conjunction with other tests, because the computer prediction can be directly compared to other physical test results. This information provides an accurate picture of package performance under accident conditions. When based on actual tests, computer analyses can often satisfy design verification requirements.

Sequence for Physical Testing of Type B Packaging Designs*
(as listed in 10 CFR 71.73)

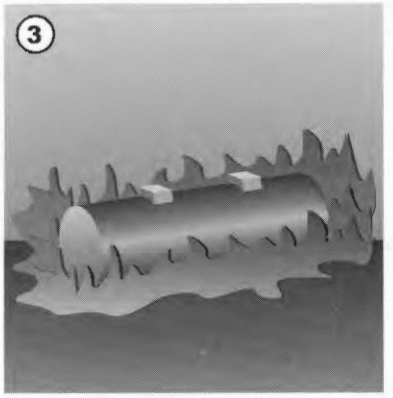


Free Drop (Impact): A 30-foot drop onto a flat, unyielding** surface so that the package's weakest point is struck.

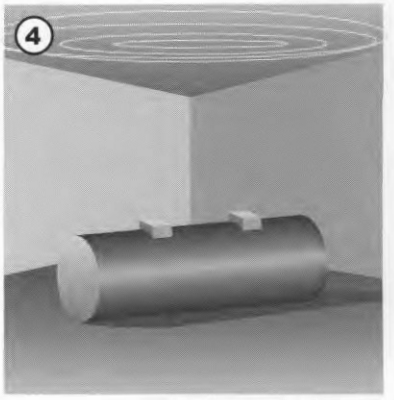


Puncture: A 40-inch free drop onto a 6-inch diameter steel rod at least 8 inches long, striking the package at its most vulnerable spot.

Crush: For some low-density, light-weight packages, a drop of a 1,100-pound mass from 30 feet onto the package resting on an unyielding target is required.



Heat: Exposure of the entire package to 1,475°F for 30 minutes.



Immersion (fissile materials): Package immersed under 3 feet of water in a position where maximum leakage is expected.

Immersion (all packages): A separate, undamaged package is submerged under 50 feet of water.

* Documentation is required that each design can meet the test conditions. Individual packagings are not tested before each use.
** Using an unyielding surface ensures that any impact will be absorbed by the package rather than the surface.

Full-scale demonstrations have been conducted to verify that computer codes and scale-model testing accurately predict damage to Type B packages.

This scale model of a spent fuel cask is ready for the puncture test. Instruments attached to its left side will collect performance data.

Scale-Model Tests

For some packaging designs, an accurate prediction of damage expected in a severe accident can be determined by testing a scale- or reduced-size model of the package. Scale-model testing is frequently used to confirm predictions generated in computer-simulated tests.

Scale-model tests are more cost effective than full-size tests because models are less expensive to build and the testing takes less time. However, scale model testing cannot be used to determine thermal performance, and some important features may be too small to accurately model.

Full-Scale Tests

As with scale-model tests, full-scale tests can be used to verify the accuracy of computer predictions and improve simulation techniques. However, in the case of large, complex packages, construction of a full-size model is very expensive and consumes a significant amount of time, compared to generating similar information by testing a scale model or by computer analyses. Therefore, full-scale testing is used judiciously and often used only to test specific packaging features (e.g., the closure) which are not easily modeled on a computer or reproduced to scale.

All drop tests use an unyielding surface (normally steel or armor plate backed up by massive amounts of reinforced concrete) upon which the test model is dropped. The intent is to simulate the most severe accident conditions and to have all the impact energy absorbed by the package. The unyielding impact pad ensures that a package will sustain far more damage than it would if it were involved in an actual accident. In actual accidents, the impact surface, such as steel beams or concrete abutments, as well as the transport vehicle, can yield and absorb significant amounts of the impact energy.

The open pool fire test is aimed at assuring packages will be leak tight following accidents that involve fire. A package that has already been through drop and puncture tests is engulfed in 1,475°F flames for 30 minutes. After the package cools, it is checked to assure there has been no release of contents.

Summary

Package performance requirements analysis promotes compliance with international and U.S. standards for the protection of the public, workers, and the environment.

Additional information on DOE's National Transportation Program may be obtained from:

National Transportation Program	DOE Center for Environmental Management Information	Transportation Resource Exchange Center
U.S. Department of Energy	P.O. Box 23769	ATR Institute
Albuquerque Operations Office	Washington, DC 20026-3769	University of New Mexico
P.O. Box 5400, MS SC-5		1001 University Blvd., SE
Albuquerque, NM 87185-5400		Albuquerque, NM 87106-4342
Phone: 505-845-6134	1-800-7EM-DATA	Phone: 1-877-287-TREX (8739)
Fax: 505-845-5508	1-800-736-3282	Fax: 505-246-6001
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