Transporting Radioactive Materials

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...answers to your questions

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MASTER

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Overview

Radioactive materials play an important role in our lives. They are used in the fields of medicine, industry, research, defense, and power production. To be used, most radioactive materials must first be transported—from their origin to processing and manufacturing facilities, to users, and, eventually, to storage and disposal sites.

Over 2 million packages of radioactive materials are shipped each year in the United States. These shipments are carried by trucks, trains, ships, and airplanes every day just like other commodities.

Compliance with Federal regulations ensures that radioactive materials are transported safely. Proper packaging is the key to safe shipment. Package designs for radioactive materials must protect the public and the environment even in case of an accident. As the level of radioactivity increases, packaging design requirements become more stringent.

Radioactive materials have been shipped in this country for more than 40 years. As with other commodities, vehicles carrying these materials have been involved in accidents. However, no deaths or serious injuries have resulted from exposure to the radioactive contents of these shipments.

People are concerned about how radioactive shipments might affect them and the environment. This booklet briefly answers some of the commonly asked questions about the transport of radioactive materials. More detailed information is available from the sources listed at the end of this booklet.

Radioactive materials are transported every day in support of many processes, such as medical diagnosis, research, and electricity production.

What is radiation?

Radiation is the energy released as unstable isotopes change to become more stable.

Most of the 92 naturally occurring elements on Earth are unstable and can change into other forms. Radiation begins in the center of the atoms of these elements, where energetic particles or waves of energy are released as the atoms decay to stable forms.

Alpha and beta particles and gamma rays are the three types of radiation present in nature and manmade sources.

Alpha particles

are the slowest of the three types of radiation. They can travel only a few inches in the air, losing their energy almost as soon as they collide with anything. They can easily be shielded by a sheet of paper or the outer layer of a person's skin.

Beta particles

are more energetic than alpha particles. They can travel in the air for a distance of a few feet. Beta particles can pass through a sheet of paper but may be stopped by a sheet of aluminum foil or glass.

Gamma rays

unlike alpha or beta particles, are waves of pure energy and are essentially x-rays. Gamma rays travel at the speed of light (186,000 miles per second). Gamma radiation can be very penetrating and requires concrete, lead, or steel to stop it.

A person's exposure to radiation is measured in millisievert (under international regulations) or in millirem. The average person receives 3.6 millisievert (360 millirem) per year from natural and manmade sources of radiation.

The Earth has been surrounded by radiation since its formation. This natural background radiation comes from many sources including soil, water, and the Sun.

Medical x-rays are examples of manmade sources of radiation.

Who sets the safety standards for exposure to radiation?

The International Atomic Energy Agency (IAEA) issues safety standards for radiation protection using recommendations provided by experts and independent reviews.

Recommendations for standards come from the International Commission on Radiation Protection (ICRP) and the U.S. National Council on Radiation Protection and Measurements (NCRPM). These organizations are composed of physicians, radiologists, and scientists specializing in the biological effects of radiation. Independent reviews are provided by the U.S. National Academy of Sciences and the United Nations Scientific Committee on the Effects of Atomic Radiation.

IAEA, an agency of the United Nations, issues and updates *Basic Standards for Radiation Protection* (Safety Series No. 9), which reflects the recommendations made by the ICRP, following review by IAEA member state-designated experts. In turn, IAEA also issues and updates the *Regulations for the Safe Transport of Radioactive Material* (Safety Series No. 6), which considers the requirements of Safety Series No. 9. Although written in regulatory language, IAEA's Safety Series No. 6 may only legally serve as recommendations. The U.S. Department of Transportation (DOT) and the U.S. Nuclear Regulatory Commission (NRC) have based the regulations that cover domestic U.S. shipments on relevant portions of IAEA Safety Series Nos. 6 and 9.

These standards are based on more than 50 years of research and experience with radioactivity. No other standards have been so extensively reviewed and agreed upon by international experts and organizations.

International shippers use the International Atomic Energy Agency regulations to safely transport radioactive materials.

What kinds of radioactive materials are transported?

Radioactive materials being shipped include uranium ores, nuclear fuel assemblies, spent fuel, radioisotopes, and radioactive waste.

Uranium ores

are shipped from mines and mills to purification processors and then to facilities that manufacture metal fuel assemblies and ceramic fuel pellets.

Nuclear fuel assemblies

are the fuel for commercial nuclear powerplants. Fuel assemblies are also produced for research reactors and national defense programs. Because uranium ores and unused fuel assemblies have not undergone fission in a reactor, they have very low levels of radiation in comparison to spent fuel assemblies.

Spent fuel

is used fuel that can no longer produce electricity effectively and must be replaced with fresh fuel. The spent fuel will eventually be shipped in heavy steel packagings for

permanent disposal in a geologic repository. Spent fuel is now being temporarily stored at powerplants. Some utilities with several powerplants have the option of transshipment, or transferring fuel assemblies from plants with less storage capacity to sites with greater space for spent fuel storage.

Radioisotopes for research and defense

are produced at U.S. Government production reactors and transported to research laboratories across the country. Some facilities are designed to reprocess spent fuel for use in naval reactors, while others can produce material for nuclear weapons.

Radioisotopes for commercial applications

are produced at government reactors and private laboratories for a variety of commercial applications and transported to hospitals, research laboratories, and industrial plants.

Radioactive waste

results from the processes that use radioactive materials and must be transported to storage or disposal sites.

Radioactive waste also results when nuclear powerplants, Government production reactors, and other nuclear facilities are decommissioned. Decommissioning involves removing the spent fuel or other radioactive materials resulting from processes in the facility and disassembling all the internal structures that may have become contaminated during facility operation.

Packages of radioisotopes await shipment on the loading dock.

Why is it necessary to transport radioactive materials?

Radioactive materials are transported to medical, industrial, research, and manufacturing facilities; nuclear powerplants; and storage and disposal sites. They are used in a variety of applications, such as the diagnosis and treatment of disease, agricultural research, manufacture of commercial goods, industrial radiography, and electricity production.

SUMMARY OF RADIOACTIVE MATERIALS SHIPMENT DESTINATIONS (EXCLUDING WEAPONS AND WEAPONS COMPONENTS)

Source: *Transportation of Hazardous Materials*

Radioactive materials are produced at commercial and U.S. Department of Energy (DOE) laboratories and must be transported to the facilities that use them.

Radioactive materials are used to sterilize surgical gloves and instruments that might be damaged by conventional sterilization methods.

Medical facilities

require radioactive materials for many life-saving medical procedures. Today, about one-third of all patients admitted to U.S. hospitals are diagnosed or treated using radioisotopes.

Radioisotopes are used for developing new medicines, detecting broken bones, viewing internal organs, and treating some types of cancer. In addition to their importance in diagnosing and treating diseases, radioisotopes are used to sterilize surgical instruments and gloves that would be damaged by conventional sterilization techniques using high-temperature steam.

Industry, research, and manufacturing facilities

use radioactive materials for a variety of purposes, including leak detection in pipes and gas lines; laboratory experiments in physics, biology, and materials analysis; and consumer products such as smoke detectors and gas lanterns.

Agricultural research using radioactive materials has produced higher yielding food crops.

Nuclear powerplants

require uranium, a radioactive material occurring naturally in the earth, which is mined, processed, and manufactured for use as nuclear fuel. Nuclear powerplants currently provide approximately 20 percent of our Nation's electricity.

Storage and disposal sites

are end-cycle destinations for radioactive wastes. Disposal methods must protect against potential environmental contamination or inadvertent human intrusion while the radionuclides decay to safe levels.

What is radioactive waste?

Radioactive waste is the unusable byproduct from using, refining, and reprocessing radioactive materials, and from decommissioning equipment and facilities that use those materials. There are different types of waste.

High-level waste

results from chemically reprocessing the spent fuel originating from DOE nuclear reactors. Reprocessing recovers usable plutonium and uranium for use in defense programs. What remains after the plutonium and uranium are extracted is a residue consisting of fission products and small amounts of plutonium. High-level waste is shipped as a solid in heavily shielded packagings called casks.

Spent fuel

results from producing electricity at nuclear powerplants or from operating other reactors such as research reactors. After the usable fuel has been expended, highly radioactive fuel assemblies remain. The United States does not reprocess spent fuel from powerplants, but has reprocessed spent fuel from many types of reactors in the past. Spent fuel is shipped as a solid, and is packaged in casks for transport.

Transuranic waste

contains manmade elements heavier than uranium, thus the name trans (or beyond) uranic. Transuranic waste results from defense production activities and includes contaminated protective clothing, tools, glassware, and equipment. Although most transuranic waste is no more radioactive than low-level waste, it is radioactive for a longer period of time. Transuranic waste has been shipped in railcars. Future shipments of transuranic waste to the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico, will use a specially designed packaging, the TRUPACT-II, and will be shipped by truck.

Low-level waste

results from research, medical, and industrial processes that use radioactive materials. Commercial powerplant operations and defense-related activities, including weapons disassembly and cleanup of production sites, also produce some low-level waste. Low-level waste consists of contaminated rags, papers, filters, tools, equipment, and discarded protective clothing. Typically, low-level waste contains small amounts of radioactive material dispersed in large volumes of other material. It is far less hazardous than high-level waste. Low-level waste is usually packaged in sturdy wooden or steel crates and steel drums.

Uranium mill tailings

are radioactive rock and soil byproducts resulting from uranium mining and milling. Mill tailings contain small amounts of naturally occurring radium that decay and emit a radioactive gas, radon. When radon gas is released into the atmosphere, it disperses harmlessly, but radon gas might be harmful if a person breathes in high concentrations over a long period of time.

Low-level waste, which includes rags, papers, filters, and protective clothing, is packaged in a steel drum.

Spent fuel is transported in heavily shielded packagings.

Transuranic waste includes contaminated glassware, equipment, and protective clothing.

Where is radioactive waste transported?

Radioactive wastes are shipped to interim storage or permanent disposal sites. Each type of waste is sent to a disposal site that is appropriate for its characteristics.

High-level waste

resulting from defense programs is stored temporarily in underground tanks and vaults at government sites. This waste will be solidified in a glass form, packaged in stainless steel canisters, and placed in heavily shielded casks for transport to a permanent geologic repository, when one becomes available.

Spent fuel

resulting from commercial electricity production is currently stored in pools of water or in above-ground metal or concrete casks at nuclear powerplants. Like high-level waste, spent fuel will be shipped to a permanent geologic repository.

Transuranic waste

from defense production activities is stored at government sites throughout the country. Some of this waste will be shipped to WIPP.

The U.S. Department of Energy will use a special packaging, the TRUPACT-II, to ship transuranic waste to the Waste Isolation Pilot Plant.

WIPP, located in southeastern New Mexico, is a research and development facility designed to demonstrate the disposal of transuranic waste in deep, geologically stable, salt beds. If the test phase is successful, WIPP will become a permanent disposal facility for transuranic waste.

Low-level waste

that results from powerplants, hospitals, industrial processes, government research, and environmental cleanup is sent to disposal sites licensed by the NRC. Several commercial sites accept waste from commercial producers

of low-level waste, and some states have formed regional compacts to dispose of low-level waste when these facilities close. Sites have been established throughout the DOE complex for disposal of DOE low-level waste.

Uranium mill tailings

are transported to several disposal facilities specifically designed to accept mill tailings. When the disposal site reaches capacity, it is sealed to prevent dispersion of radon gas.

Low-level waste is transported to disposal sites licensed by the U.S. Nuclear Regulatory Commission.

How are radioactive materials transported?

Radioactive materials are transported by airplane, truck, rail, or ship. Both government and commercial vehicles are used. Because of careful packaging, radioactive materials are transported in general commerce along with other commodities.

The selection of a specific mode of transport depends on many factors, including size and weight of the packages, radioisotope characteristics and composition, the distance to be shipped, and the availability of transport facilities.

Radiopharmaceuticals are frequently short-lived, and the packages are small and weigh very little. They must be delivered quickly to hospitals and medical laboratories, so air shipment is generally the best method. Spent fuel from nuclear powerplants is shipped in large, heavily shielded packagings, which are more easily moved by trucks, rail cars, or ships.

Because of strict regulations on what radioactive materials can be shipped by air, and since water transport is slow and geographically limited, trucks and trains are used for most large and heavy radioactive material shipments in the United States.

Radiopharmaceuticals are short-lived, and are generally transported by airplane.

Large shipments from other countries are transported by ship.

Trucks are used to transport a variety of radioactive materials, including fission products used to manufacture nuclear fuel.

Large volumes of material, such as uranium hexafluoride, are often transported by rail.

How many radioactive materials shipments are made each year?

About 2 million radioactive materials shipments are made each year.

The use of radioactive materials is so common in the United States that these materials are transported throughout the Nation every day. The number of radioactive materials shipments is small compared with the 100 million shipments of other hazardous material being shipped yearly. Of the 2 million radioactive shipments made annually, most involve small quantities of low-level materials. DOE shipments account for only 0.561 percent of all radioactive materials shipments in the United States.

TOTAL ANNUAL HAZARDOUS AND RADIOACTIVE SHIPMENTS IN THE UNITED STATES AND BY THE U.S. DEPARTMENT OF ENERGY

Source: Shipment Mobility Accountability Collection
Summary Report: Fiscal Year 1992
The Transportation of Nuclear Materials

NUMBER OF DOE SHIPMENTS BY MODE OF TRANSPORTATION FOR FISCAL YEAR 1992

Sources: Shipment Mobility Accountability Collection
Summary Report: Fiscal Year 1992

Who regulates the transport of radioactive materials?

DOT, NRC and the Interstate Commerce Commission all have regulatory responsibilities to ensure safe radioactive materials transport. The regulations of these agencies are based on recommendations made by the IAEA.

Other agencies regulating handling and transport include the U.S. Postal Service, the U.S. Coast Guard, the Occupational Safety and Health Administration, and the Environmental Protection Agency (EPA).

Although DOE is a shipper, not a regulator, of radioactive materials, it administers its shipments according to a series of

DOE Orders and other internal guidance. DOE uses Federally approved packaging, and it meets DOT's regulations for packaging and shipping. DOE follows all NRC standards in developing its own packaging.

The U.S. Department of Transportation (DOT) has primary responsibility for regulating the safe transport of radioactive materials. Detailed information on DOT requirements is found in the Code of Federal Regulations, Title 49.

U.S. Department of Transportation

has the primary responsibility for the safe transport of radioactive materials in the United States. DOT regulations set the standards for packaging and transporting materials and the general labeling, documenting, loading and unloading, and handling requirements. The regulations also specify that drivers receive training to ensure they are qualified to transport radioactive shipments safely.

Nuclear Regulatory Commission

regulates the packaging and transport operations of its licensees, including commercial shippers of radioactive materials. It sets design and performance standards for materials with higher levels of radioactivity. NRC certifies cask designs.

Interstate Commerce Commission

is responsible for the economic aspects of shipping radioactive materials, such as regulating carrier rates and for issuing operating authority.

Who is responsible for preparing and transporting radioactive materials?

In general, the shippers and carriers are responsible for ensuring a shipment of radioactive materials is properly prepared and transported according to applicable regulations.

The shipper, who prepares the materials for transport at the facility where they are produced, classifies and packages the materials, marks and labels the packages, and prepares the shipping papers before turning radioactive materials over to a carrier for shipment. The shipper must sign the shipping papers, certifying that all information is correct.

The carrier who transports the materials is responsible for examining the shipper's certification papers, checking packages for proper labeling and marking, placarding the vehicle, stowing and securing the packages, complying with driver training and routing requirements, and following vehicle safety requirements. If an accident occurs, the carrier must report the incident to DOT or another agency, as applicable.

A shipper fills out paperwork on a radioactive shipment. This paperwork offers detailed information on the materials and will accompany the shipment during transport.

How are radioactive materials packaged for shipment?

Radioactive materials are specially packaged in accordance with DOT and NRC regulations. The form, quantity, and concentration of the radioactive materials determine the type of packaging used.

Type A packages are used to transport small quantities of radiopharmaceuticals used for medical procedures.

The package is then marked and labeled to provide information about its contents.

Three basic types of packaging are used: industrial packages (formerly called strong, tight packages); Type A; and Type B.

Industrial packages are used to transport materials with extremely low levels of radioactivity. Examples are uranium or thorium ores and concentrates and consumer goods such as smoke detectors. Industrial packages range from a product's cardboard box to a sturdy wooden or steel crate.

Type A packages are used to transport small quantities of radioactive materials with higher concentrations of radioactivity than those shipped in industrial packages. Typically, Type A packages have an

Materials with higher levels of radioactivity are transported in Type B packages.

inner containment vessel made of glass, plastic, or metal and packing material made of polyethylene, rubber, or vermiculite. Examples of materials transported in Type A packages include radiopharmaceuticals and low-level waste.

Type B packages are used to transport materials with the highest levels of radioactivity. Type B packages range from small steel drums to heavily shielded steel casks that can weigh up to 125 tons. Examples of materials transported in Type B packages include spent fuel, high-level radioactive waste, and high concentrations of some radioisotopes, such as cesium and tritium.

All radioactive materials must be packaged to ensure that the radiation level at the package surface does not exceed DOT regulations. This ensures that package handlers, transporters, and the public do not receive dose rates in excess of recognized safe limits.

After radioactive materials are put in the proper packaging, they are sealed, surveyed with special instruments to ensure radiation is within regulatory limits, and checked for external contamination.

Industrial packages are used to transport materials that present low hazards because of their low concentration of radioactive material. Examples are consumer goods, such as smoke detectors.

How are packages tested?

Type A and B packages must be capable of withstanding a series of transport conditions simulated either by performance testing and/or engineering analyses. The conditions become more rigorous as the radiation level of the intended contents increases.

Most industrial packages undergo testing and are constructed to meet certain performance standards. DOT also requires that the packages allow no identifiable release of the material to the environment during normal transportation and handling.

Type A packages, used to transport materials with relatively low levels of radioactivity, are designed to protect and retain their contents under normal transport conditions and must maintain sufficient shielding to limit radiation exposure to handling personnel.

Type B packages, used to transport materials with the highest levels of radioactivity, are designed to protect and retain their contents in both normal and severe accident conditions. Type B package designs are certified by the NRC before use. Every 5 years, the package design is reviewed by the NRC to determine if its certificate will be renewed. DOE is able to certify some of its own packages.

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

A package design is subjected to stringent tests and other analyses before being put into service. DOT regulations specify test measurements in metric units.

Type A Tests

Water spray for 1 hour [to simulate rainfall of 5 centimeters (2 inches) per hour].

Free-fall drop test onto a flat, hard surface [a 1.2-meter (4-foot) drop if the package weighs 4,989.5-kilograms (11,000 pounds) or less].

Compression test of at least 5 times the weight of the package.

Penetration test by dropping a 6-kilogram (13-pound) bar [3.2-centimeter (1.25-inch) diameter] vertically onto the package from a height of 1 meter (3.3 feet).

Type B Tests

A 9-meter (30-foot) drop onto a flat, unyielding surface so that the package's weakest point is struck.

A 1-meter (40-inch) free drop onto a 15-centimeter (6-inch) diameter steel rod at least 20 centimeters (8 inches) long, striking the package at its most vulnerable spot.

Exposure of the entire package to 800°C (1475°F) for 30 minutes.

Immersion of the package under 15 meters (50 feet) of water. For fissile materials, packages are also immersed under 0.9 meters (3 feet) of water for at least 8 hours.

Unyielding surfaces are used during package drop tests. In actual accidents, the point of impact, such as bridge supports, will be yielding and absorb some of the impact damage. Using an unyielding target during tests ensures the package will sustain far more damage than it would in an actual accident.

Are package test conditions realistic?

Full-scale tests, analytical reviews, and experience with actual transportation accidents confirm that tests for radioactive material packages are realistic.

Full-scale demonstrations were conducted in the United States in the 1970s to confirm that a Type B package built to Federal standards could protect and retain its contents in the most severe accidents. Similar tests have been conducted in the United Kingdom, Germany, and Japan. In each of these tests, the cask prototype was deformed as predicted by analysis, but no simulated radioactive material was released. These tests verified computer-model projections.

Real-life accidents involving radioactive material shipments have occurred. To date, none has resulted in serious injuries or fatalities due to the radioactive cargo. In fact, data from actual accidents as well as analytical projections show that accidents produce impact and fire conditions far less severe than the Type B hypothetical accident conditions of the regulations.

Full-scale tests included crashing tractor-trailers carrying cask prototypes into concrete walls at 98.19 and 135.24 kilometers (61 and 84 miles) per hour. At 98.19 kilometers per hour (61mph) there was no effect on the cask. At 135.24 kilometers per hour (84 mph), the cask was slightly dented, but it did not release its simulated radioactive material.

How are packages and vehicles carrying radioactive materials identified?

Radioactive material shipments are identified by distinctive markings and labels on packages. Certain types of radioactive shipments are identified by a placard on each side of the vehicle.

Markings on the package list the proper shipping name, the identification number, and the shipper's name and address.

Labels applied to the package identify the kind of material, the level of radioactivity of the package contents, and the transport index (on Yellow II and III labels). Labels are placed on opposite sides of a package.

The transport index is a number indicating the maximum radiation level being emitted from a package measured at 1 meter from the package surface. The transport index also limits the number of packages of radioactive materials that may be carried together, thus eliminating the possibility of an uncontrolled chain reaction.

Some vehicles carrying radioactive materials must have a placard on the front, rear, and both sides. (Where vehicle placards are impractical—for example, on aircraft and watercraft—they are not required to be displayed.) Highway Route Controlled

Quantity (HRCQ) shipments must display a white square behind each placard. HRCQ shipments contain materials with higher levels of radioactivity, such as spent fuel.

More detailed information about shipment contents is provided on shipping papers carried in the cab of the vehicle. They provide more details about the material's characteristics than the label, including a signed certification showing the material is properly classified, described, packaged, marked, and labeled, and in proper condition for transport. The shipping papers also contain emergency information, such as contacts and telephone numbers, in case an accident happens during the shipment.

Packages of radioactive materials are labeled with a Radioactive I, II, or III label depending on the activity level of the material.

Radioactive materials shipments are identified by diamond-shaped placards located on all four sides of the vehicle.

How are routes for radioactive materials shipments chosen?

Routes for vehicles carrying certain radioactive materials are chosen according to DOT regulations to minimize radiological risk.

Federal regulations require that certain radioactive materials shipments travel on designated routes.

DOT regulations require carriers of HRCQ shipments of radioactive materials to evaluate factors such as:

- accident rate,
- transit time,
- population density,
- activities,
- time of day, and
- day of week.

HRCQ shipments are composed of materials with high levels of radioactivity, such as spent fuel. These shipments are made along specific routes called preferred routes. A preferred route consists of interstate highways and bypass routes around cities, where possible, or an alternative route selected by a State or Tribal routing authority. If the routing authority selects an alternative route, it must use a routing analysis that minimizes overall risk,

and alternative route selections must be preceded by consultations with affected State and local authorities before such designations can go into effect. Drivers must enter or exit a preferred route at the closest point to the pick-up or delivery location of their HRCQ cargo. Regulations allow drivers to deviate slightly from the shortest distance pickup and delivery routes only to increase shipment safety.

Rail shipment routes are determined by the shipper and the railroad companies that operate between the origin and destination. Shippers and railroad companies determine rail routes based on safety, best available trackage, schedule efficiency, and cost effectiveness.

Are State and Tribal authorities notified of radioactive materials shipments?

On all shipments of high level radioactive waste and spent fuel, State authorities are notified in writing in advance of transporting through that State. This written notice includes the planned schedule(s), route, shipment description, and carrier name and address.

In addition to written notification, DOE uses a satellite tracking system, known as TRANSCOM, to monitor selected shipments of radioactive materials, such as shipments of transuranic waste to WIPP. States and Tribal governments along the shipping routes can become authorized to access the system 24 hours a day to observe movement of DOE shipments through their jurisdictions. This system enables them to see where a shipment is at any time, which facilitates a quick response by emergency response teams in the event of an accident.

Trained personnel can pinpoint vehicles' locations and communicate with vehicle drivers.

TRANSCOM combines navigation, satellite communications, and computer networking to continuously monitor the location and status of high-level radioactive waste and spent fuel.

What responsibilities do State, Tribal, and local governments have in radioactive materials transport?

State, Tribal, and local governments are responsible for the safety of their residents and other persons within their jurisdictions. Their activities include establishing legislative designating alternate routes, emergency response, vehicle inspection, enforcement of traffic laws, and highway construction and maintenance.

State, Tribal, and local governments may pass legislation specifying requirements for transporters of radioactive materials within their jurisdictions. These laws may stand if they are consistent with Federal laws, and if they do not impede commerce or business. Examples of State, Tribal, and local requirements include carrier permits and fees and restriction on hours of travel. State, Tribal, and local governments also provide input to proposed Federal regulations and participate in planning activities affecting them.

State and Tribal governments also may designate alternate routes using DOT guidelines.

In cases where State and Tribal government policies conflict, they may enter into transportation agreements. These agreements address a variety of transportation issues, such

as road construction and maintenance. Tribal adoption of State statutes, and formal State requirements to involve Tribes in emergency response training.

State, Tribal, and local emergency response personnel are the first on scene responders to transportation accidents involving radioactive materials. To ensure their responders are prepared to deal with an accident effectively, State, Tribal, and local governments develop

emergency response plans that outline specific procedures, designate special response teams, and offer special training in material identification, regulations, response procedures, and personal protection.

In addition, State, Tribal, and local enforcement personnel are responsible for conducting vehicle inspections both in terminals and along roadsides.

A State police officer checks the radiation levels of a spent fuel shipment entering his jurisdiction.

Who responds to an accident involving a shipment of radioactive materials?

As with any traffic accident, the local, tribal, and State police, fire departments, and State emergency response teams must be notified in transportation accidents involving radioactive materials. These responders may request support from Federal agencies if needed.

Photo: Rex Perry, The Tennessean

First responders perform life-saving duties, extinguish fires, prevent dispersion of any released material, clear unauthorized people from the immediate area, and control traffic.

Local responders usually contact State public health agencies. These agencies have trained personnel to conduct radiological tests at the site to determine if any radioactive material releases have occurred.

Most local and State governments have emergency plans and training programs to prepare first responders for transportation accidents involving radioactive materials.

DOE's Radiological Assistance Program also offers first responders assistance ranging from

telephone advice to onsite radiological monitoring. DOE maintains Regional Coordinating Offices (RCOs) in eight regions across the country. These RCOs receive calls for assistance 24 hours a day, and they are prepared to send trained personnel and equipment to the accident site. DOE offers emergency response training courses designed to teach first responders to identify radioactive materials, know the hazards involved, perform the correct response procedures, and take personal protection measures due to the radioactive cargo.

Assistance and emergency response training are also provided by the Federal Emergency Management Agency, DOE, NRC, and EPA. Assistance is also offered by the chemical

industry through the Chemical Transportation Emergency Center (CHEMTEC). The National Response Center works closely with CHEMTEC on emergency calls and activates National Response Teams, if necessary.

Electric utilities operating nuclear power plants have voluntary assistance agreements with other utilities so that a utility near the scene of a transportation accident would respond on behalf of the utility shipping the material.

The carrier hauling the cargo works with contractors with special expertise and appropriate governmental agencies to address all issues related to accident cleanup. Cleanup duties include arranging for repackaging the cargo, as necessary, and disposing of contaminated materials.

The U.S. Department of Energy receives calls for radiological assistance through its eight Regional Coordinating Offices located across the country.

How is liability coverage provided for transportation accidents?

Depending on the mode of transport, carriers of radioactive materials may have provided insurance, be insured, or have a combination of the two types of coverage.

The required amount of coverage for carriers of radioactive materials varies according to the mode of transport (road, rail, waterway, or air) and the type and quantity of material being shipped. For example, motor carriers of HRCQ of radioactive materials are required to have \$5 million liability coverage. If the damages from an accident exceed the amount of carrier coverage, umbrella coverage is provided by the Price Anderson Act. The Act also covers damages created as a result of terrorism, sabotage, and other illegal acts occurring during transport. In addition, 1988 amendments clarified that public liability is also covered for costs of precautionary evacuation initiated by State, Tribal, or local officials. Funding for this coverage comes from a combination of private insurance and government indemnity.

The maximum financial protection available is currently about \$7.4 billion per accident. If the damages from an accident exceed the maximum limits of protection, Congress may review the accident and take necessary action to provide full and prompt compensation to the public for all public liability claims.

In the event of a transportation accident involving radioactive materials, financial protection is available through the carrier and the U.S. Government.

Could someone sabotage radioactive materials shipments?

Safeguards, such as special security measures, vehicles, sophisticated communications with command centers, and packages requiring special facilities to open them make sabotage of high-level radioactive materials unlikely.

The weight of the steel casks used to transport high-level radioactive materials would discourage most would-be hijackers from attempting to remove the cask from the vehicle. These casks can weigh up to 125 tons. Typically, these materials are encased in metal shielding and two layers of steel.

In addition, high-level radioactive materials are transported under strict controls. State, Tribal, and local governments are notified of shipments in advance. Under certain conditions, escorts either follow or ride in the truck cab or in a railcar. Other safety

measures include devices that can shut down or immobilize the vehicle in case of a hijack attempt. DOE has the equipment to monitor its high-level radioactive waste and spent fuel shipments and maintain two-way communication with the drivers.

In general, the higher the potential consequences from a shipment of radioactive materials being stolen or sabotaged, the more stringent are the safeguards in place to ensure it will be protected.

Personnel barriers are used to deter unauthorized access to casks carrying high-level radioactive materials.

How much radiation do people living along transport routes receive?

People living close to a transport route (less than 100 feet away) of a vehicle containing the highest level or greatest quantity of radioactive materials (spent fuel or high level waste) would receive 0.000005 millisievert (0.0005 millirem) per routine shipment. In comparison, people spending a day at the beach would receive around 0.0028 millisievert (0.28 millirem) of radiation.

Because no harmful effects to humans have ever been documented at 100 millisievert or below, most scientists believe that the low exposures that people receive in everyday life pose very little risk of producing harmful effects.

According to NCRPM, the average person receives around 3.6 millisievert (360 millirem) annually from natural and manmade sources of radiation. People living in houses where 100 spent fuel shipments pass by every year would only receive an additional 0.0005 millisievert (0.05 millirem) per year—about half the radiation they receive annually from watching television.

Recognized radiation experts study biological effects and make recommendations to EPA on radiation protection standards. These scientists have data showing that high exposures to radiation [over 1,000 millisievert (100,000 millirem)] received over a short period of time can cause radiation sickness or even death. However, scientists disagree about the risk of low exposures to radiation [100 millisievert (10,000 millirem) or below].

AVERAGE ANNUAL RADIATION EXPOSURES FOR A PERSON LIVING IN THE UNITED STATES (IN MILLISIEVERT)

Source: BEIR-V, *Health Effects of Exposure to Low Levels of Ionizing Radiation*

How many radioactive materials transportation accidents have occurred and what were the consequences?

Between 1971 and 1991, 329 transportation accidents involved radioactive materials, according to a DOE database that tracks accident information. The database defines a transportation accident as "a transport event ranging from a minor accident to a major collision that involves the vehicle transporting the radioactive material."

Like other kinds of shipments, radioactive materials in transit have been involved in accidents. In most cases, there was no release of any radioactive material into the environment. When releases have occurred, the material has been cleaned up with no identifiable harm to people or to the environment. No one has ever been killed or seriously injured in an accident involving radioactive materials because of the nature of the cargo.

Between 1971 and 1991 in the United States, 53^{*} accidents involving Type B packages have occurred. In one case, a Type B package failed to contain its contents. In the accident, a radiography camera, used to inspect welds on pipes, fell off a truck and opened to expose a radioactive capsule. The capsule caused no harm to the public or damage to the environment. Seven spent fuel shipments have been involved in accidents. One spent

This truck tipped over as it merged onto the interstate. The 49,000-pound package, carrying low-level waste, fell off the truck but did not open.

fuel accident resulted in damage to the cask. In the accident, the truck turned over and the package absorbed most of the impact with the ground. Although the truck was severely damaged, the package sustained minor damage. No radioactive materials were released, and the package was loaded on another truck and taken to its destination.

Within the same time frame, 219^{*} accidents involving industrial packages and Type A

packages occurred. These types of packaging are designed and tested for normal transport conditions. There were 62^{*} additional accidents where the package category was unknown. Only a few of these accidents resulted in a small release of radioactivity. In each case, the material was cleaned up, and there was no harm to the public or damage to the environment.

* Totals do not equal because of accidents occurred involving 2nd package types.

Where can I find additional information about transporting radioactive materials?

U.S. DEPARTMENT OF ENERGY

For general information, contact:

Office of Scientific and Technical
Information

U.S. Department of Energy
P.O. Box 62

Oak Ridge, TN 37831
(615) 576-1222

For more information on DOE's shipping
program, contact:

Transportation and Technology
Information Center
Trevion II

U.S. Department of Energy, EM-56.1
Washington, DC 20585
(301) 903-7286

U.S. Department of Energy
Office of Public Affairs
WIPP Project Office
P.O. Box 3090
Carlsbad, NM 88221
(505) 885-7337

Transportation Technology Center
Sandia National Laboratories
Dept. 6320
Albuquerque, NM 87185
(505) 844-2416

For information on DOE's transportation
program for spent fuel and high-level
radioactive waste to a geologic repository or
an interim storage facility, contact:

OC RWM Information Center
P.O. Box 44375
Washington, DC 20026
(1-800-225-NWPA or 202-488-5513 in
Washington, DC)

OTHER GOVERNMENT AGENCIES AND FACILITIES

U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4600

U.S. Environmental Protection Agency
Office of Radiation Programs
401 M Street SW
Washington, DC 20460
(202) 260-9600

U.S. Nuclear Regulatory Commission
Office of Nuclear Materials Safety and
Safeguards
Washington, DC 20555
(301) 504-3432

U.S. Department of Transportation
Research and Special Program
Administration
Office of Hazardous Materials Standards
400 Seventh Street, SW
Washington, DC 20590
(202) 366-4488

Federal Emergency Management Agency
500 C Street, SW
Washington, DC 20472
(202) 646-2500

NONGOVERNMENT

American Nuclear Society
555 North Kensington Avenue
La Grange Park, IL 60525
(708) 352-6611

American Trucking Associations
2200 Mill Road
Alexandria, VA 22314-4677
(703) 838-1700

Association of American Railroads
50 F Street NW
Washington, DC 20001
(202) 639-2100

International Atomic Energy Agency
UNIPUB
4611 F Assembly Drive
Lanham, MD 20706
(301) 459-2255

U.S. Council for Energy Awareness
1776 F Street NW, Suite 400
Washington, DC 20006-3708
(202) 293-0770

Glossary

Accident

An unexpected event that may result in injury to persons and damage to vehicles or packages.

Alpha Particles

The slowest of the three types of radiation. These particles are easily stopped by paper.

Beta Particles

Medium-energy radiation that travels faster than alpha particles. These particles are stopped by aluminum foil or glass.

Cask

Heavy, multilayered, steel containers used to ship radioactive materials with higher levels of radioactivity. A cask is an example of Type B packaging.

Fuel Assembly

A bundle of rods containing ceramic pellets of uranium dioxide used to produce electricity in a nuclear powerplant.

Gamma Rays

The most penetrating type of radiation. These are waves of pure energy that travel at the speed of light. Concrete, lead, or steel are required to stop gamma rays.

High-level Waste

The waste materials that remain after spent fuel is reprocessed. High-level waste is a residue consisting of fission products and small amounts of plutonium.

Isotope

Atoms of the same element that have the same number of protons, but a different number of neutrons. A single element may have many isotopes, for example, uranium-235 and uranium-239.

Low-level Waste

Waste materials with low levels of radioactivity dispersed in large volumes of other material, usually rags, papers, filters, equipment, or protective clothing.

Millirem

A unit measuring radiation's effect on the human body.

Millisievert

A metric unit measuring radiation's effect on the human body equal to one-thousandth of a sievert.

Radioactive Contamination

The occurrence of radioactive material being deposited on skin, clothing, or any location where it is not desired.

Radiation

The energy released as unstable isotopes change to become more stable.

Radioactive Waste

The unusable byproduct from using, refining, and reprocessing radioactive material.

Radioactivity

The property of an unstable isotope which decays by releasing energetic particles or waves of energy.

Shielding

Materials, such as concrete, water, and lead, that are placed around radioactive materials to protect people and the environment from radiation.

Spent Fuel

Nuclear fuel that has been removed from the reactor at a nuclear powerplant after being used to produce electricity. Spent fuel is highly radioactive.

Industrial Package

Containers used to transport materials with the lowest levels of radioactivity, such as smoke detectors.

Transport Index

A number indicating the maximum radiation level being emitted from a package at 1 meter. This number helps a shipper to calculate the number of packages that can be shipped together.

Transuranic Waste

Waste contaminated with radioactive elements heavier than uranium, thus the name trans (or beyond) uranic.

Type A Packaging

Packaging used to transport small quantities of radioactive materials, such as radio-pharmaceuticals.

Type B Packaging

Packaging used to transport materials with the highest levels of radioactivity, such as spent fuel and high-level waste.

Uranium Tailings

Radioactive rock and soil byproducts resulting from uranium mining and milling.

Acronyms

CHEMTREC

Chemical Transportation Emergency
Center

DOE

U.S. Department of Energy

DOT

U.S. Department of Transportation

EPA

Environmental Protection Agency

HRCQ

Highway Route Controlled Quantities

IAEA

International Atomic Energy Agency

ICRP

International Commission on Radiation
Protection

NCRPM

U.S. National Council on Radiation
Protection and Measurements

NRC

U.S. Nuclear Regulatory Commission

RCO

Regional Coordinating Office

WIPP

Waste Isolation Pilot Plant

DATE

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