

UNIT ELEVEN

RADIOACTIVE MATERIALS TRANSPORTATION

Transportation accidents involving radioactive materials are rare. Of the 500 billion total domestic shipments annually, only 3 million contain radioactive materials. However, when accidents do occur, local emergency responders are almost always the first to arrive on the scene. When a radiological response team is called upon, its first responsibility is to assess the scene and determine how to control emergency conditions. In order to do so, radiological responders must be able to recognize and interpret the package types, labels, and placards required by the most recent (September, 1995) Department of Transportation regulations for radioactive materials transport.

This topic is covered to some extent in all of the FEMA radiological series courses. In this course the unit is intended as a review for those participants who have already mastered the competencies involved and a critical learning objective for those who have not.

Your initial assessment of a transportation accident involving radioactive material reveals that the carrier is not placarded, but some of the packages that have been thrown from the vehicle have yellow radioactive labels and others have white labels. In addition, one of the packages is completely torn apart, and the inner container is broken, revealing small metal capsules.

How do you interpret this situation based only upon the information provided? (Use another sheet if needed)

GATE FRAME QUESTION



ANSWER

Your answer should include the adjacent information.

Because the carrier is not placarded, there should not be any Radioactive Yellow III packages or radioactive LSA material in the shipment. Therefore, the yellow radioactive labels should be Radioactive Yellow II. This means that if the package is intact and the contents have not shifted, the exposure rate on the surface of the container exceeds 0.005 mSv/hr (0.5 mrem/hr), but is less than 0.5 mSv/hr (50 mrem/hr) and does not exceed 0.01 mSv/hr (1 mrem/hr) 1 meter away. The white radioactive labels mean that the intact packages have exposure rates under 0.005 mSv/hr (0.5 mrem/hr) on any outer surface of the container and do not present a great exposure risk.

Cardboard packages are either Excepted packages or Type A packages. In either case, the type of packaging indicates small amounts of radioactive material.

The spilled capsules are considered to be in “special form.” Special form is either an indispersable solid of radioactive material or a sealed capsule containing radioactive material. This means that the material has a very high degree of physical integrity so that if the material were released from the package in an accident, while there might be a radiation hazard, it is highly unlikely to be a contamination hazard.

If your answer included all or most of the above points, you should be ready for the Summary Questions at the end of this unit. Turn to page 11-23.

If your answer did not include these points, it would be advisable for you to complete the instruction for this unit. Turn to page 11-3.



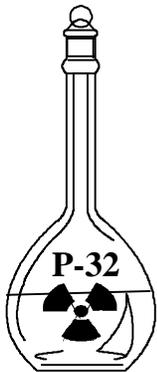
FORMS OF RADIOACTIVE MATERIAL

For packaging purposes, DOT regulations provide for two forms of radioactive materials, “special form” and “normal form.”



A radioactive material that is shipped as a single solid piece or encapsulated in a very strong metal capsule is in *special form*. A small cylinder containing radioactive cobalt metal for use in industrial radiography is an example of a special form material.

A radioactive material that is shipped as a solid, liquid, or gas is considered to be *normal form*. Radioactive materials shipped in normal form can present a contamination hazard as well as exposure hazard if the package were to fail. Most radioactive material is shipped in normal form.



Radiological response team members can determine what form a radioactive material is in by looking at the shipping papers or the package markings. If a radioactive material is in special form, the words “special form” will be part of the proper shipping name. If those words do not appear in the proper shipping name, the material is in normal form.

If the material is in special form, there should be little or no risk of contamination, even if the capsule is released from its package, but the exposure hazard could be quite high. If the material is in normal form, the packaging requirements will be more stringent; if it is released from the packaging, there may be a contamination hazard and potential external radiation hazard.

The question on the next page will help you assess your understanding of these concepts.



QUESTION

Circle the correct answer.

If you were to see the words “special form” on a smashed package of radioactive material, you would conclude that

- a. there is some likelihood of high radiation exposure but little chance of radioactive contamination.
- b. there is little likelihood of high exposure rates but some likelihood of a contamination hazard.

Turn the page to check your answer.



ANSWERS

- a. That's correct. You understand that the term "special form" means the material is a single solid piece or encapsulated, reducing the probability of contamination.

Proceed to page 11-7.

- b. No, that is not correct. Single solid pieces or encapsulated materials have a reduced chance of allowing the radioactive material to be released to the environment.

Move on to the next section.

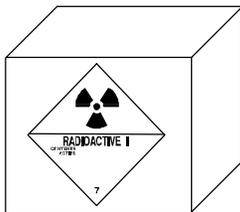


PACKAGING TYPES FOR RADIOACTIVE MATERIALS

Packaging for radioactive materials falls into four broad categories:

- Excepted packages
- Type A packages
- Type B packages
- Industrial packages

Excepted packages provide radioactive materials the least amount of protection in transit. However, when shipping radioactive materials, this category of packages can only be used when shipping a limited quantity of the material. The relative concentration of radioactive material would be low (typically, there is a small amount of radioactive material mixed with large amounts of non-radioactive material.) Excepted packages are not required to meet specific testing requirements. The only requirement is that they be capable of holding their contents during normal non-accident conditions of transportation. Examples of materials shipped in excepted packages include manufactured items such as watch dials, smoke detectors, and medical test kits.



Type A packages or Type B packages must be used if a shipment of radioactive materials involves more than a limited quantity. A *Type A package* (typically a one-cubic foot cardboard box with interlocking cardboard spacers inside) is generally stronger than an excepted package, but not as strong as a Type B package. Type A packages must pass a series of tests before the design is approved for use. These tests simulate conditions that the packages might be exposed to in normal transportation circumstances or minor mishaps including water spray, free-fall, compression, and penetration. An example of a material shipped in Type A packages is radiopharmaceuticals for medical use.





Type B packages carry the maximum allowable amounts of radioactivity. They must meet the same criteria as Type A packages and pass additional tests designed to simulate accident conditions including water immersion, free drop, fire and puncture tests. Type B packages have never released their contents during transportation accidents. Examples of materials shipped in Type B packages are spent fuel and large cobalt-60 sources.

Industrial packages are used to ship low specific activity (LSA) material or surface contaminated objects (SCO). There are three subcategories of industrial packages, IP-1 IP-2 and IP-3. IP-1 must meet general design criteria for shipment of radioactive materials. IP-2 must also meet free drop and stacking tests. IP-3 must meet all type A tests except for liquid absorbents and gaseous requirements.

Industrial packages are used for such materials as ores, natural or depleted uranium, mill tailings or contaminated debris.

Answer the following question.

QUESTION

Circle the correct answer.

Laboratory chemicals containing “tracer” radionuclides for research have very small amounts of radioactive materials. These laboratory chemicals are likely to be shipped in

- a. Type B packages.
- b. Type A packages.

Turn the page to check your answer.



ANSWERS

- a. No, Type B packaging is designed for shipping large amounts of radioactive materials.

Try another one.

- b. Right! Type A packaging is used when the exposure and contamination hazards are minimal.

Continue on to the next section.

QUESTION

Circle the correct answer.

Radiography devices or cameras are used for checking welds at construction sites and other industrial locations. They typically weigh about 50 lbs. and may be transported inside the radiographer's truck in a convenience overpack box. The device or packaging (its overpack) may have either Yellow II or III labels. The device typically contains 3.7 TBq (100Ci) Ir -192. These packages are classified as

- a. Type A.
b. Type B.

Turn the page to check your answer.



ANSWERS

- a. No, Type A containers are designed for small amounts of radioactive material and only need to be sturdy enough to withstand normal shipping conditions.

Please reread pages 11-6 and 11-7 before moving on to the next section.

- b. Correct. Type B containers are substantially stronger and sturdier than the typical cardboard Type A package.

Go ahead with the next section.



LABELS ON RADIOACTIVE MATERIALS PACKAGES

Besides the outward physical appearance of the package itself, the packaging label can be used in hazard assessment of the radiological hazard. The label for a specific container depends on the exposure rates measured outside that package. The purpose of labeling is to inform anyone near or in contact with the package of the external radiation hazard and, in some cases, its contents. In addition to the relative exposure rate limits, these three labels identify the contents of the package and the contained activity in becquerels. Activity may also be listed in curies following becquerels.

Remember that the external exposure rate from any package overpack determines the label used, while the specific contents and quantity determine the package type.

The *Radioactive White I* label is placed on packages of radioactive materials that have exposure rates under 0.005 mSv/hr (0.5 mrem/hr) on any outer surface of the container. Because this is considered a very low hazard, there are no regulations specifying the number of Radioactive White I packages on a conveyance or vehicle.





A *Radioactive Yellow II* label is applied to a package if the exposure rate on the surface of the container exceeds 0.005 mSv/hr (0.5 mrem/hr), but is less than 0.5 mSv/hr (50 mrem/hr) and does not exceed 0.01 mSv/hr (1 mrem/hr) one meter away.



Containers labeled *Radioactive Yellow III* containers may have exposure rates up to 2mSv/hr (200 mrem/hr) on contact and 0.1mSv/hr (10 mrem/hr) at one meter.

Labeling is not required for LSA materials when shipped domestically, and the only required marking is “Radioactive LSA” when shipped exclusive use with placards on the vehicle.

The exact reading at the time of shipping for a specific package can be found from the transport index (TI), which is included only on Yellow II and Yellow III labels. Except in the case of fissile materials, the transport index equals 100 times the highest exposure rate in mSv/hr one meter from the package surface. The transport index is used to limit the total amount of exposure from radioactive materials shipped on one vehicle. The total of all the transport indices on one carrier is not to exceed 50. In other words, if you assembled all the packages containing radioactive material on one shipment and stood 1 meter from them, you would be exposed to no more than 0.5 mSv/hr (50 mrem/hr). For RAM which have “fissile” as part of the shipping name, the TI may not represent the maximum radiation level at 1 meter from the package. In some case the TI may be related to the characteristics of the fissile material. The TI, based on criticality properties, maybe assigned by the shipper so that the maximum of 50 TI per vehicle will be safe for fissile shipments.



Test your knowledge of labeling by answering the following question.

QUESTION

Circle the correct answer.

If you find a Radioactive White I labeled package on the ground, and you measure more than 0.035 mSv/hr (3.5 mrem/hr) on the surface of the box, what would you deduce?

- a. The contents have shifted to one side or the package was breached and the outside of the package is contaminated.
- b. The reading is appropriate at the surface of a package labeled Radioactive White I.

Turn the page to check your answer.



ANSWERS

- a. Yes, these are two feasible possibilities.

Move on to the next section.

- b. No, surface readings on Radioactive White I packages cannot exceed 0.005 mSv/hr (0.5 mrem/hr) therefore, a 0.035mSv/hr (3.5 mrem/hr)reading is not within normal limits.

Try another problem.

QUESTION

Circle the correct answer.

If the transport index on a Yellow II package is 1 and you get a reading of 0.65 mSv/hr (65 mrem/hr) on the surface of the package, is the package breached?

- a. yes, possibly
- b. not necessarily.

Turn the page to check your answer.



ANSWERS

- a. Correct. You understand that the transport index is the highest exposure rate *one meter* from the package and a higher reading at the surface would be normal. However, Yellow II has a maximum reading of 0.5 mSv/hr (50 mrem/hr) at the surface. Since the surface reading is now 0.65 mSv/hr (65 mrem/hr) either the contents have shifted or are leaking and the package may be contaminated.

Proceed to the next section.

- b. No. It is true that the reading at 1 meter from the package should not exceed 0.01mSv/hr but for yellow II the maximum surface reading is 0.5 mSv/hr. A reading of 65 mrem/hr would indicate a shift in contents or possible a break and leakage.

Reread this section before moving ahead to the next section.

Proceed to the next page.



PLACARDING



The most outward indication of radioactive materials on a truck, freight container, or rail car is a “radioactive” warning placard on all sides. Placards serve as a warning that there may be a need for radiological safety measures in the event of an accident. Vehicles must be placarded if they carry one or more packages with the Radioactive Yellow III label or LSA material (nonradioactive items that may be contaminated in some way).

*It is not unusual to detect radiation when monitoring the outside of a vehicle carrying radioactive material. However, certain limits are set to prevent serious exposure to persons outside the vehicle. The exact external exposure rate limits depend on whether the vehicle is carrying only radioactive materials, termed *exclusive use*, or contains radioactive as well as nonradioactive materials, termed *non-exclusive use*.*

- For a *non-exclusive use* vehicle, the exposure rate limit any package surface is 2 mSv/hr (200 mrem/hr). Individual packages cannot exceed .1mSv/hr (10mR/hr) at 1 meter. At one meter from the actual vehicle, the exposure rate must not exceed .1Sv/hr (10mR/hr).
- For *exclusive use* vehicles the limits are somewhat different. On contact with the outside vehicle surface, the limit is the same (2 mSv/hr or 200 mrem/hr), but 0.1 mSv/hr is allowed as far as 2 meters away. Individual packages may not exceed 10mSv (1000 rem/hr).
- Exposure rates in the driving cab must not exceed 0.02 mSv/hr (2 mrem/hr) with some exceptions for private carriers with radiation protection programs that provide drivers with training and dosimetry.

Answer the question on the next page.



QUESTION

Circle the correct answer.

A tractor trailer involved in a collision has a radioactive placard on the side, but that is all you know about the truck's contents. Your survey meter is reading 10 mSv/hr (1000 mrem/hr) at the surface of a package spilled from the overturned vehicle. You inform the incident commander that

- a. this reading is within normal limits according to DOT regulations.
- b. you do not have enough information to know if this is a normal reading.

Turn the page to check your answer.



ANSWERS

- a. This might be an appropriate response if you knew the vehicle was exclusive use. If it were non-exclusive use the reading is higher than would be expected according to DOT regulations.

Try the next question

- b. That's right. You need to know something about the contents of the shipment to provide meaningful advice about the radiation hazard.

Move on to page 11-19.

QUESTION

Circle the correct answer.

The contents of a derailed freight train car have spilled onto the embankment. You see a radioactive placard on the outside of the car but nothing except barrels or drums with spilled contents inside the car. The incident commander asks you about the risk. You state:

- a. there must be a Radioactive Yellow III labeled package buried somewhere in the rubble or thrown clear of the area.
- b. the barrels may be radioactive LSA, but you can't see the markings.

Turn the page to check your answer.



ANSWERS

- a. Incorrect. While a carrier hauling Radioactive Yellow III containers is required to be placarded, radioactive LSA also requires a placard on the carrier.

Review page 11-15.

- b. Correct. Shipments of radioactive LSA require placarding but not labeling except for the words “Radioactive LSA.”

Move to the next section.



SHIPPING PAPERS

In some cases, the shipping vehicle may be badly damaged in the accident. The radioactive placards on the vehicle may not be visible due to the damage, but you still need some indication of the possible hazard. One other clue could be the *shipping papers*. As with the shipment of any other hazardous material through public areas, vehicles transporting radioactive materials must carry papers that properly identify the materials and specify associated quantities and hazards.

The shipping papers, also called *bills of lading*, *air bills*, and *cargo manifests*, contain the following useful information for hazard assessment:

- Proper shipping name;
- Proper hazard classification of the material;
- Four-digit hazardous materials identification number;
- Total quantity by weight, volume, or where appropriate, simply radioactivity;
- Name of radionuclides as listed in DOT regulations;
- Description of chemical form (if not special form);
- Activity in becquerels, terabecquerels, or SI units followed by customary units (curies, etc.);
- Type of labels applied to each package; and
- Transport index assigned to each package bearing Radioactive Yellow II or III labels.



The shipping papers should be located in the cab of a truck, the cockpit of an airplane, the bridge of a ship, or the engine of a train. Unless adverse conditions prohibit, the emergency responder should obtain these papers before



calling for assistance since the information about the hazard can be found there.

Answer the next question to check your understanding of these concepts.

QUESTION

Circle the correct answer.

An emergency responder refers to shipping papers to determine

- a. the level of radiation coming from the carrier.
- b. the amount of radioactivity on the carrier.

Turn the page to check your answer.



ANSWERS

- a. No, the actual radiation levels can only be determined using a radiation detection instrument.

Try another problem.

- b. That's right. Shipping papers include the activity of the material in becquerels or terabecquerels.

Turn to page 11-24.

QUESTION

Circle the correct answer.

You respond to an accident scene in which steel cylinders bearing yellow radioactive labels have been thrown near and far from a tractor trailer. It is not known whether any of the cylinders have been damaged. One of the cylinders is lying directly next to the cab of the overturned vehicle. The driver walked away from the accident and informs you that the shipping papers are in his lockbox under the seat. Your next move is to

- a. obtain from the driver as much information about the load as possible.
- b. find a way into the cab and locate the shipping papers.

Turn the page to check your answer.



ANSWERS

- a. That is the better choice. Steel cylinders are Type B containers, indicating a potentially high exposure rate if one of the containers were breached.

Proceed to page 11-24.

- b. Because of the possibility that the cylinder near the cab may be damaged and causing a radiation hazard, it would be more sensible to attempt to gain necessary information from other sources first.

Reread this section before proceeding to the Summary Questions.



SUMMARY QUESTIONS

QUESTION

Circle the correct answer.

1. Upon arriving at the scene of a cargo plane crash you note that two of the damaged cardboard boxes contain white radiation labels but they are illegible. From this initial assessment, you know that
 - a. the radiation hazard from those packages is likely to be substantial.
 - b. the radiation hazard from the packages is likely to be relatively low level.

Turn the page to check your answer.



ANSWERS

- a. Incorrect. Radioactive White I labels are used when the radiation hazard is small.

Go back and review the unit.

- b. Correct.

Move on to the next Summary Question.

QUESTION

Circle the correct answer.

2. A radioactive placard on a carrier means that
- a. the vehicle contains high-level radioactive material called radioactive LSA.
 - b. the vehicle carries radioactive LSA or the shipment includes at least one package labeled Radioactive Yellow III.

Turn the page to check your answer.



ANSWERS

a. Incorrect.

Go back to page 11-16 and review.

b. Correct.

Proceed to Unit Twelve.

