INTRODUCTION
The federal government regulates radioactive material packaging, labeling, and transport. The labels used on packages of radioactive material can be used to help you obtain information about the activity and radiation level of the material within the package. Having knowledge of the radiation levels associated with packages of radioactive material can help you determine whether damage to a package has occurred.

This module provides information about radioactive material packaging and radiation levels associated with the radiation-warning labels used in radioactive material transport.

PURPOSE
The purpose of this module is to increase your understanding of the information contained on warning labels and the radiation levels associated with radioactive material packages. Being able to correctly read the warning labels can help you assess the radioactive material package integrity, which in turn will improve your ability to respond safely.

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

1. Identify radiation levels associated with the various radiation-warning labels.
2. Identify the importance of the transport index in determining package integrity.
3. Identify the maximum radiation levels expected on shipping packages and/or transport vehicles.
RADIATION LEVELS ASSOCIATED WITH RADIOACTIVE MATERIAL PACKAGES

The U.S. Government regulates domestic shipments of radioactive material. The U.S. Nuclear Regulatory Commission (NRC) and the U.S. Department of Transportation (DOT) share this responsibility. The areas regulated include the packaging, contents, radiation levels, and various transport requirements, including labeling and shipping papers.

Before transport, shippers of radioactive material are required to check the radiation levels of packages to ensure that all levels are within allowed limits. Radiation levels are checked on the packaging surface and at one meter (3.3 feet) from the package.

TRANSPORT INDEX (TI)

The transport index, often called the TI, is the dimensionless number\(^1\) placed on the label of a package to designate the degree of control to be exercised by the carrier during transportation. The TI is equal to the maximum radiation level in mrem/hour at one meter from an undamaged package. The TI can be an indicator for determining the external radiation hazard of an undamaged package and can be a starting point for determining whether or not damage has occurred.

\(^1\) Dimensionless number means that there are no units of measure (e.g., mrem) associated with the transport index.
For example, a package with a Radioactive Yellow-III label attached and a TI marked on the label of 2.5 should read between 50 to 200 mrem/hour on contact with the package and 2.5 mrem/hour at one meter from the package. A reading of 5 mrem/hour one meter from this type of package indicates potential damage.

**SHIPPING LABELS**

After checking radiation levels at a package’s surface and at one meter, shippers will attach a radiation-warning label to the package. Radiation-warning labels are attached to opposite sides of each package. Three different labels are applied based on contact and one meter radiation levels: Radioactive White-I, Radioactive Yellow-II, and Radioactive Yellow-III.

Radiation-warning labels will specify the contents and the activity of the material inside the package. In addition, Radioactive Yellow-II and Radioactive Yellow-III labels also specify the TI.
Radioactive White-I
The Radioactive White-I label is attached to packages with extremely low levels of external radiation. The maximum contact radiation level associated with this label is 0.5 mrem/hour.

Radioactive Yellow-II
The Radioactive Yellow-II label is attached to packages with external contact radiation levels ranging from greater than 0.5 mrem/hour to no more than 50 mrem/hour.

The Radioactive Yellow-II label also has a box for the transport index. The maximum allowable transport index for this label is 1.
Radioactive Yellow-III
The Radioactive Yellow-III label is attached to packages with external contact radiation levels ranging from greater than 50 mrem/hour to a maximum of 200 mrem/hour.

The maximum allowable transport index for this label is 10.

### Table: Radioactive Material Labels

<table>
<thead>
<tr>
<th>Category of Label</th>
<th>Maximum Contact Dose Rate</th>
<th>Maximum Dose Rate at 1 Meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>White-I</td>
<td>0.5 mrem/hr</td>
<td>N/A</td>
</tr>
<tr>
<td>Yellow-II</td>
<td>50 mrem/hr</td>
<td>1 mrem/hr</td>
</tr>
<tr>
<td>Yellow-III</td>
<td>200 mrem/hr</td>
<td>10 mrem/hr</td>
</tr>
</tbody>
</table>

The Radioactive Yellow-III label is attached to packages with external contact radiation levels ranging from greater than 50 mrem/hour to a maximum of 200 mrem/hour.
ASSESSING PACKAGE AND VEHICLE RADIATION LIMITS

Radiation Limits on Packages in Non-exclusive Use Shipments

When radioactive material is transported under normal conditions (non-exclusive use), each package must be designed and prepared for shipment so that the maximum radiation level does not exceed 200 mrem/hour at any point on the external surface of the package and the transport index does not exceed 10. When assessing a package’s integrity at an accident scene, you can use this information as a baseline for determining if damage has occurred to the package. For example, a dose rate reading of 250 mrem/hour on contact with the exterior of a package could indicate potential damage.

Additionally, you should not expect to see radiation dose rates on the surface of the vehicle transporting the material that are greater than the limits allowed for the packages inside the vehicle. An exception might occur if several packages with dose rates close to 200 mrem/hour were located near the exterior surface of a vehicle; in such a case, you may see a dose rate reading on the exterior of the vehicle somewhat above 200 mrem/hour.
Radiation Limits for Exclusive Use Vehicles
Packages that exceed the radiation levels previously mentioned must be transported by exclusive use. Packages in exclusive use vehicles may have radiation levels up to 1,000 mrem/hour on their exterior surface provided that:

a) the shipment is made in a Closed Transport Vehicle;
b) the package is secured within the vehicle so that its position remains fixed during transportation, and
c) there are no loading or unloading operations between the beginning and end of the transportation.

No point on the outer surfaces, or outer plane, of the vehicle may exceed 200 mrem/hour. Radiation levels at 2 meters from the vehicle cannot exceed 10 mrem/hour. Drivers of exclusive shipments are required to have specific written instructions for the shipment. These instructions must be included with the shipping papers.

Note: To determine if a shipment is being transported under the exclusive use provisions, you can look at the shipping papers, ask the driver, and/or contact the shipper.

2 “Exclusive use” means a single shipper transports the material and all initial, intermediate, and final loading and unloading are carried out in accordance with the direction of the shipper or receiver.

3 Closed Transport Vehicle means a transport vehicle or conveyance equipped with a securely attached exterior enclosure that, during normal transportation, restricts the access of unauthorized persons to the cargo space.
Checking Packages for External Contamination

If a package appears to be breached or you suspect it may be breached, you can check for the presence of removable contamination by taking a smear of the package. Removable contamination is defined as the radioactive material that can be transferred from a surface by rubbing with moderate pressure. The smear (or wipe/swipe test) is the universal method of assessing removable contamination. A small cloth, filter paper, or fiberglass disk is used to “wipe” an area or object suspected of being contaminated. A smear should cover a minimum surface area of 100 cm² (approximately equal to a square measuring 4” by 4”). Smears should be dry and taken using moderate pressure. Protective clothing should always be worn when taking smear samples to minimize the chance of personnel contamination.

Individual smear samples should be kept separate to avoid cross contamination. Smear packets (similar to the one pictured at right) make this easy and are available from a variety of vendors. If pieces of cloth or paper towel are used, they can be kept separate by using plastic storage bags. Data should be maintained indicating the date and location of each smear sample.
Smears can be counted (surveyed) in the field using a contamination survey meter. The smear(s) should be counted in a low background area by properly trained personnel. Count the smears by holding the probe approximately ½” from the surface of the smear. Pause for 5-10 seconds over the area to provide adequate time for instrument response. Become familiar with your jurisdiction’s or state’s guidelines for when an object is considered contaminated. For example, some jurisdictions use twice background or 100 CPM above background as a positive indication of contamination. Field counting techniques, like those described here, can be used to check for removable contamination, but may not be appropriate for releasing material as “clean.” Release surveys should be conducted under the direction of the state or local Radiation Authority.
1. An undamaged package with a Radioactive White-I label can have a maximum radiation level of _____ mrem/hour at the surface of the package.
   a) 50 mrem/hour
   b) 200 mrem/hour
   c) 0.5 mrem/hour
   d) 20 mrem/hour

2. How does the shipper obtain the transport index for a package?
   a) By taking the maximum radiation level (measured in mrem/hour) at one meter from the undamaged package.
   b) By taking the maximum weight of the package divided by the radiological dose rate.
   c) By taking the contact dose rate on the package’s inner container.
   d) By taking the square root of the total number of packages allowed on the shipment.

3. The Radioactive ______ label is attached to packages with external radiation levels ranging from greater than 50 mrem/hour to a maximum of 200 mrem/hour.

4. The maximum radiation level on packages in non-exclusive use vehicles is _____ mrem/hour.

5. The maximum contact radiation level allowed on packages transported inside exclusive use closed transport vehicles is _____ mrem/hour.

**Answers**

1. c
2. a
3. Yellow-III
4. 200
5. 1,000