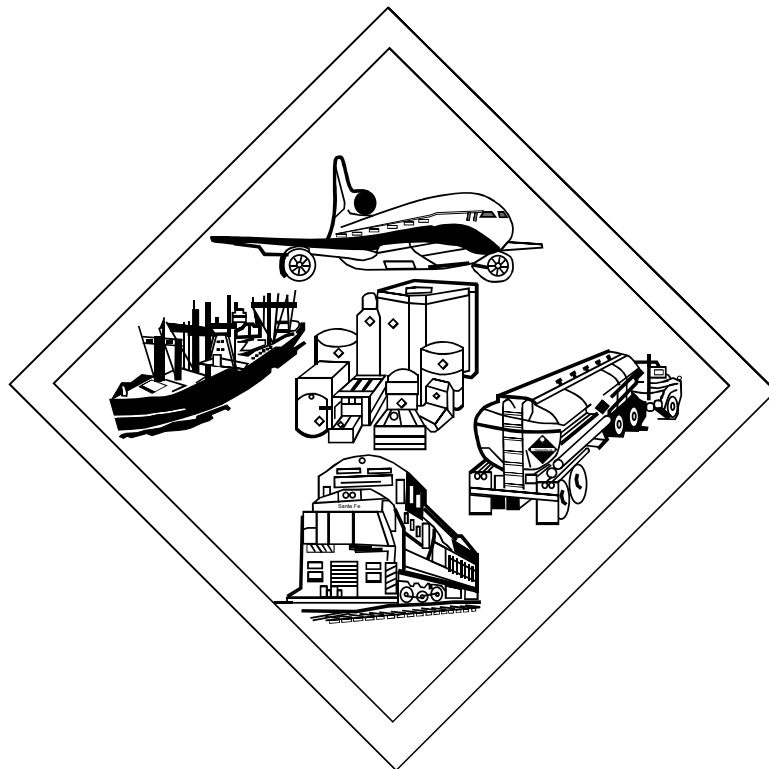


Transportation of Radioactive Material



The issues associated with the transportation of radioactive material are very complex due in part to the regulatory requirements of both the NRC and the Department of Transportation (DOT). As a result, this will be a very brief overview of the relevant issues.

UN Classification

Class 1	Explosives
Class 2	Gases
Class 3	Flammable Liquids
Class 4	Flammable Solids
Class 5	Oxidizers and Organic Peroxides
Class 6	Poisonous and Etiological Materials
<i>Class 7</i>	<i>Radioactive Materials</i>
Class 8	Corrosives
Class 9	Miscellaneous Hazardous Materials

All hazardous materials which could potentially be transported are assigned to one of the nine United Nations Classes. In general, the hazardous materials listed pose an immediate threat to health and safety. However, for radioactive material, the threat is potentially the non-immediate risk of cancer, although in large enough quantities, radiation can pose an immediate threat.

Groups Promulgating Rules Governing Transport of Radioactive Materials

Department of Transportation
Nuclear Regulatory Commission
Department of Energy
Postal Services
State Agencies

Regulations to control the transport of radioactive materials were initiated about 1935 by the Postal Service. Over the years, the Interstate Commerce Commission (ICC) became involved. Currently, there are at least five groups which promulgate rules governing the transport of radioactive material. These are the DOT, NRC, Postal Service, DOE, and the States.

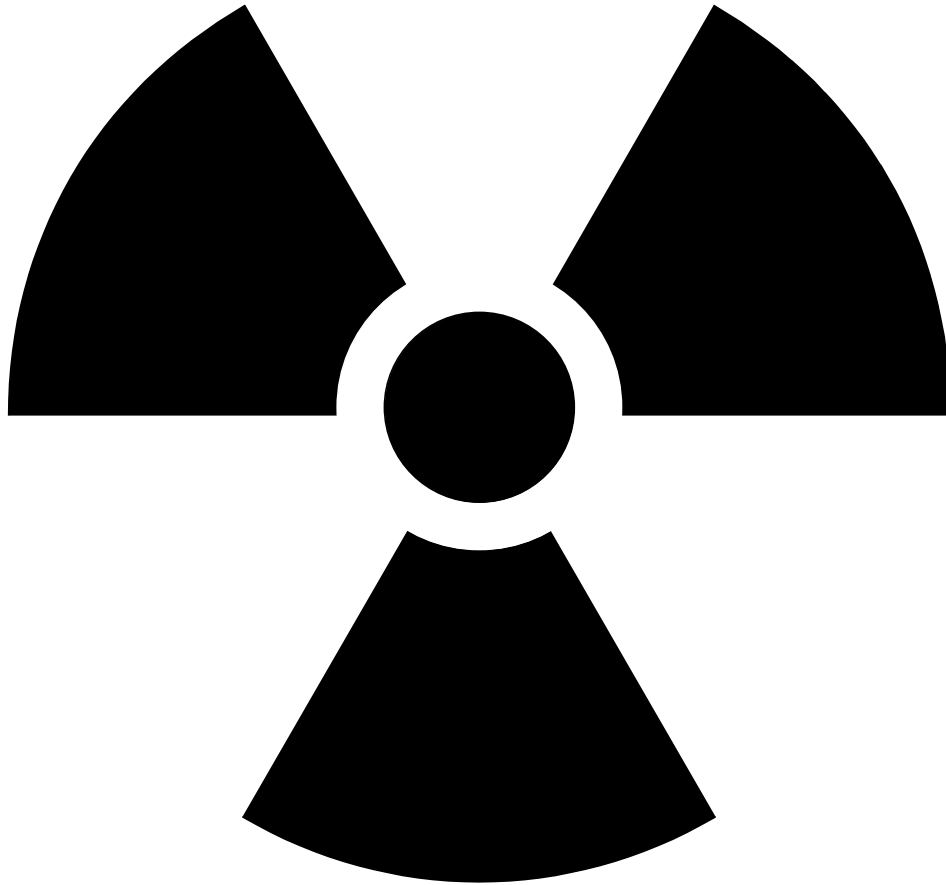
Of these agencies, the DOT and NRC are the primary ones issuing regulations based upon the standards developed by the International Atomic Energy Agency (IAEA).



The NRC and DOT share responsibility for the control of radioactive material transport based upon a Memorandum of Understanding (MOU).

In general, DOT regulations (49 CFR) are more detailed. They cover all aspects of transportation, including packaging, shipper and carrier responsibilities, documentation, and all levels of radioactive material from exempt quantities to very high levels.

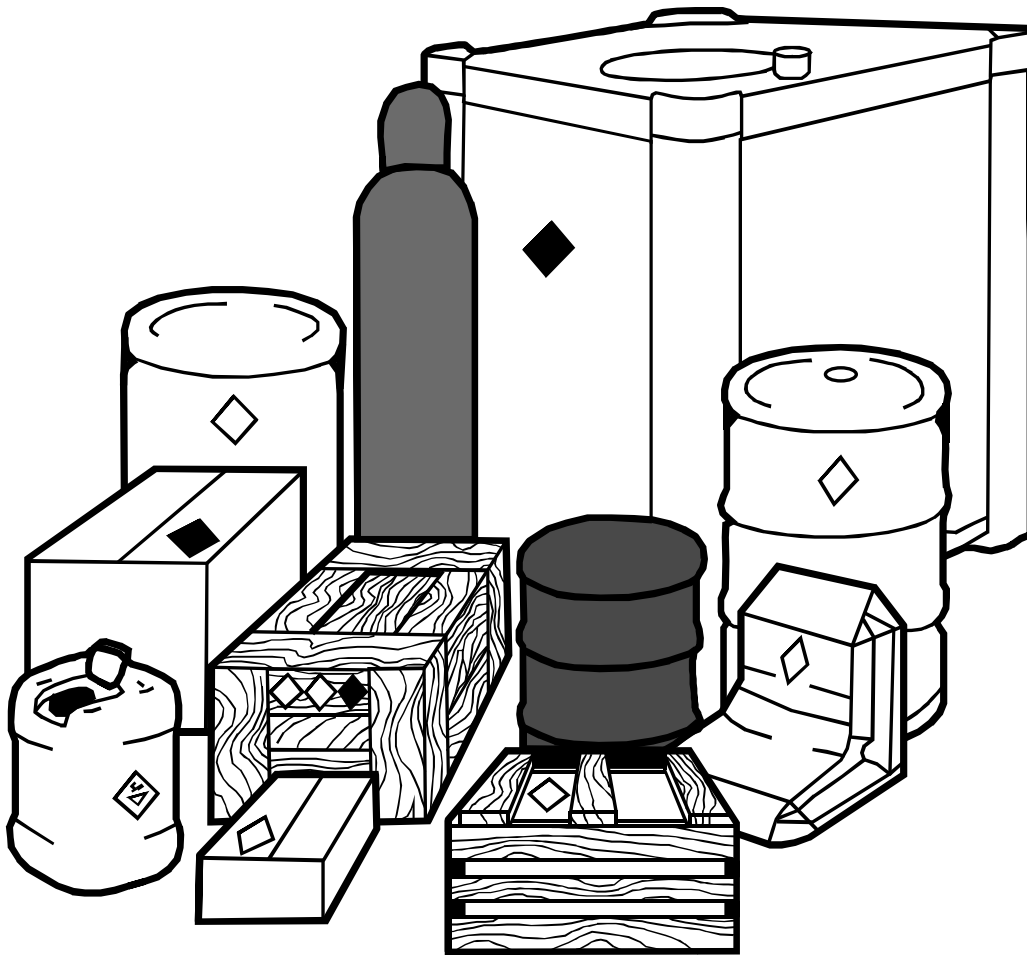
The NRC regulations (10 CFR 71) are primarily concerned with special packaging requirements for higher level quantities. NRC regulation 10 CFR 71.5 requires NRC licensees transporting radioactive material to comply with DOT regulations when NRC regulations do not apply.



For transportation purposes, radioactive material is defined as any material which has a specific activity greater than 0.002 microcuries per gram. This definition does not specify a quantity, only a concentration. As an example, pure cobalt-60 has a specific activity of 1,000 curies per gram, which is about 500 billion times greater than the definition. However, uranium-238 has a specific activity of only 0.3 microcuries per gram, which is only 150 times greater than the definition.

Although both exceed the definition of radioactive material in their pure form, either of these materials could be uniformly mixed with enough substance, such as dirt, which would cause the concentration to fall below the definition. In the case of uranium-238, if one gram were mixed with about 150 grams of dirt (about 1/3 of a pound), the concentration could be classified as non-radioactive.

Remember, however, that the definition of radioactive material above only applies for transportation.



Since transport accidents cannot be prevented, the regulations are primarily designed to:

- Insure safety in routine handling situations for minimally hazardous material and
- Insure integrity under all circumstances for highly dangerous materials.

These goals are accomplished by focusing on the package and its ability to:

- Contain the material (prevent leaks),
- Prevent unusual occurrences (such as criticality), and
- Reduce external radiation to safe levels (provide shielding).

Packages

Strong Tight Container

Type A Packages

Type B Packages

The three basic types of packages are strong tight containers, whose characteristics are not specified by regulation, followed by Type A containers, and finally Type B containers, both of which have very specific requirements in the regulations.

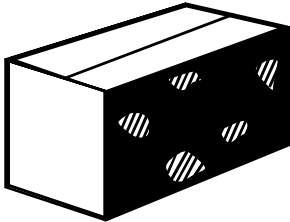
A strong tight container is designed to survive normal transportation handling. In essence, if the material makes it from point X to point Y without being released, the package was a strong tight container.

A Type A container, on the other hand, is designed to survive normal transportation handling and minor accidents.

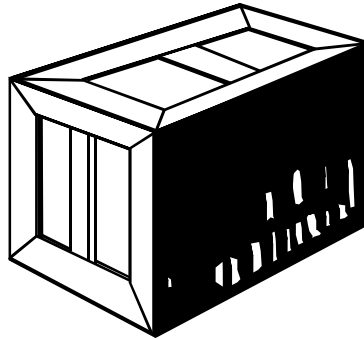
Type B containers must be able to survive severe accidents.

Fissile materials, which could be involved in a criticality accident, also have additional requirements.

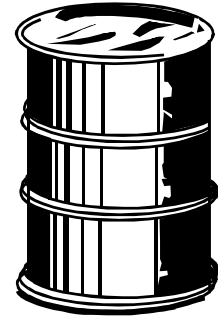
Type A



FIBERBOARD BOX



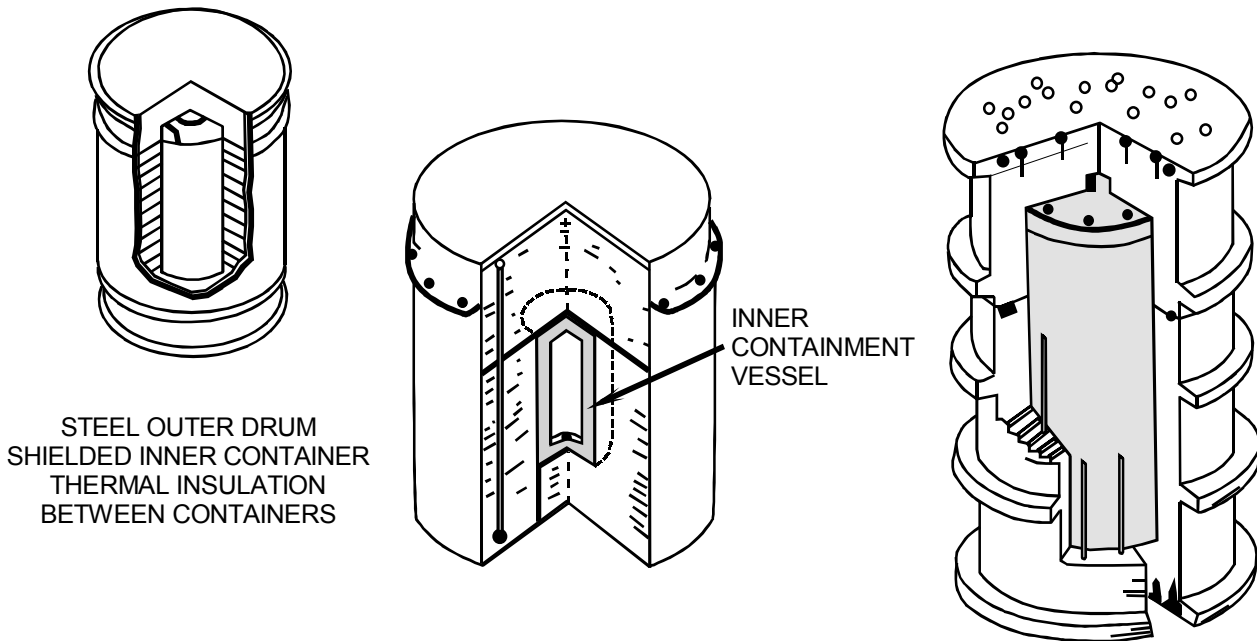
WOODEN BOX



STEEL DRUM

Type A packaging is based on performance requirements which means it must withstand or survive certain tests. The shape of the package or material from which it is constructed is irrelevant. A Type A package may be a cardboard box, a wooden crate, or a metal drum. The shipper must have documentation which shows that the specific design being used has passed the required tests.

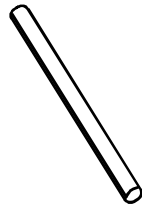
Type B



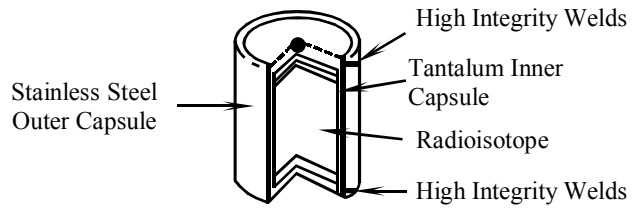
A Type B package may be a metal drum or a huge, massive shielded transport container. Like Type A packages, Type B packages must pass certain tests. However, the Type B tests are considerably more rigorous than those required for Type A packages. Most Type B packages have been issued a Certificate of Compliance by the NRC.

Special Form

Massive Solid Metal



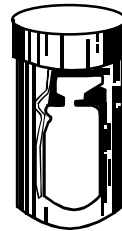
High Integrity Encapsulation as a Sealed Source



Normal Form



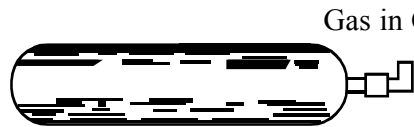
Waste Material in Plastic Bag



Liquid in Bottle Within Metal Container



Powder in Glass or Plastic Bottle



Gas in Cylinder

The system created to ensure safe transport of radioactive materials is based on the assignment of a number to each radionuclide, depending upon its form (i.e., its relative hazard if released from the package during transport). The number, or “A” value, represents the limit, in curies, permitted to be transported in a Type A package. There are two distinct categories established for this system.

Special form (A_1) radionuclides are usually encapsulated sources which would only pose an external radiation hazard, not a contamination hazard, if the package was ruptured.

Normal form (A_2) radionuclides are usually not securely encapsulated and could yield significant contamination if the package was ruptured. These materials could pose an internal hazard to people at the scene of an accident. Normal form materials are typically liquids and powders.

Since the “A” values provide the limit for the amount in a package, A_2 values cannot be greater than A_1 values, since A_2 values represent material in normal form, which makes it more “hazardous.” However, for some nuclides, the hazard may be the same in either form so that A_1 can be equal to A_2 . In any case, neither A_1 nor A_2 can be greater than 1000 curies.

Sample “A” Values (curies)

Material	Special Form A_1 Values	Normal Form A_2 Values	Ratio A_1/A_2
Plutonium-239	2	0.002	1,000
Strontium-90	10	0.4	25
Cobalt-60	7	7	1

When A_1 equals A_2 , the hazard is considered the same, whether the material is in normal or special form. This tends to be the case for gamma emitters. For alpha emitters, the normal form (unencapsulated) is considered to be 1,000 times more hazardous as the special form (sealed), so that the A_1 values are about 1,000 times lower. Beta emitters fall between the two.

Quantity of Radioactive Material will determine Classification

Non-Radioactive Limited Type A Type B Highway Route Controlled

The manner in which radioactive material is handled for transport depends upon the amount of material and its relative hazard:

- Non-Radioactive - If the amount of material is less than 0.002 microcuries per gram, it is not considered radioactive for transportation purposes
- Limited Quantity - If the amount is greater than 0.002 microcuries per gram but does not exceed one thousandth of the A_1 or A_2 value (depending on the form), then the material is considered a limited quantity and needs only a strong tight container, which should survive routine handling.
- Type A Quantity - If the amount is less than or equal to the A_1 or A_2 value (depending on the form) but greater than one thousandth of the value, then the material requires a Type A package, which should survive minor accidents.
- Type B Quantity - If the amount is greater than the A_1 or A_2 value (depending on the form) but less than or equal to 3000 times these values, then the material requires a Type B package, which should survive a serious accident.
- Highway Route Controlled Quantity - If the amount is greater than 3000 times the A_1 or A_2 value (depending on the form) but less than 27,000 curies, then the material is a highway route controlled quantity, which requires a Type B package, and the carrier must have special training. State officials must be notified if the material is radioactive waste.



The postal service has slightly different limits. They will only accept packages containing limited quantities, i.e., with amounts small enough such that they require only a strong tight package. Quantities requiring Type A and Type B packages are not acceptable to the postal service. To provide an additional safety margin, the postal service defines limited quantities differently from DOT. The USPS limits are lower, exactly one tenth of the DOT limits. In addition, the postal service has separate limits for liquids and gases.

Low Specific Activity Material

A special classification, low specific activity, is given to any radioactive material which is uniformly dispersed throughout a substance to such an extent that it poses little hazard even if released in an accident. To be classified as low specific activity, the concentration must be greater than 0.002 microcuries per gram (otherwise it would not be radioactive) but less than specified concentration limits, which are based on the “A” values.

Although the concentrations permitted are low (300 microcuries per gram or less), the total amount of material may be quite high, depending upon how much total mass there is. Therefore, although the definition of low specific activity considers only the concentration, not the total quantity, the type of package required for the low specific activity material (either strong tight container or Type A) will depend upon the total quantity of activity (curies) rather than the concentration (microcuries/gram).

Markings



Markings are designed to provide an explanation of the contents of a package by using standard terms and codes.

Labeling



Labels are used to visually indicate the type of hazard and the level of hazard contained in a package. Labels rely principally on symbols to indicate the hazard.

Although the package required for transporting radioactive material is based on the activity INSIDE the package, the label required on the package is based on the radiation hazard OUTSIDE the package. Radioactive material is the only hazardous material which has three possible labels, depending on the relative radiation levels external to the package. Also, labels for radioactive material are the only ones which require the shipper to write some information on the label. The information is a number called the Transport Index (TI), which, in reality, is the highest radiation level at 1 meter from the surface of the package.

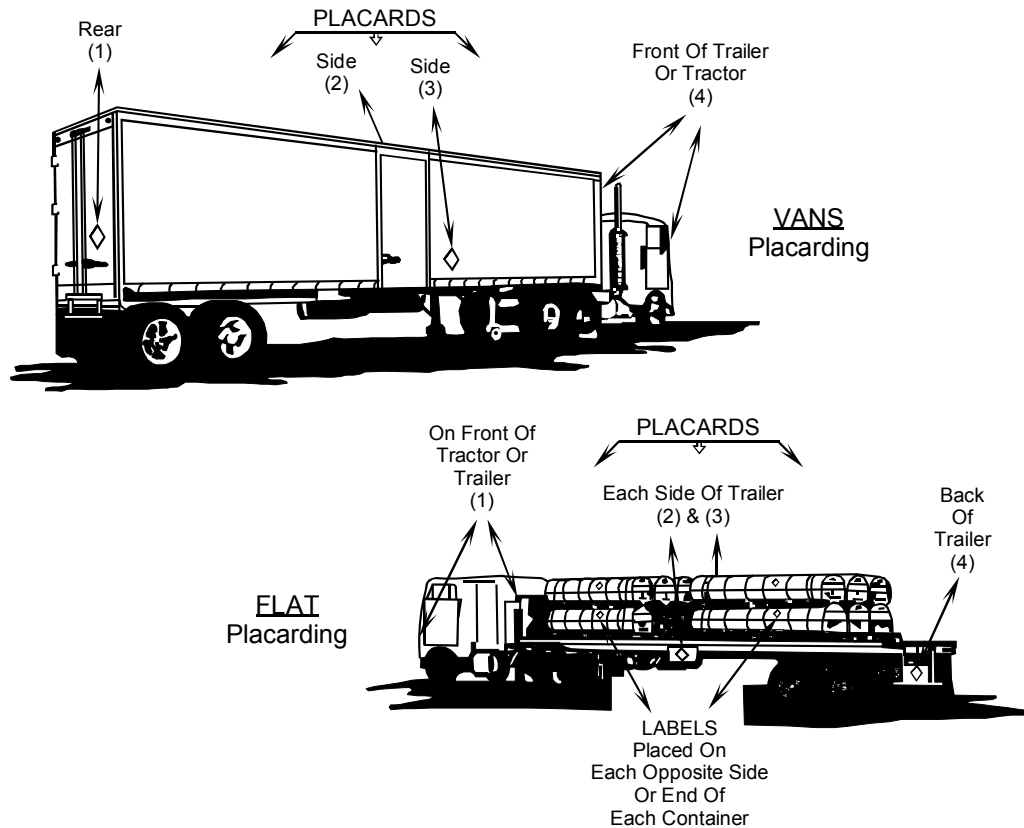
The three labels are commonly called, White 1, Yellow 2, and Yellow 3, referring to the color of the label and the roman numeral prominently displayed. A specific label is required if the surface radiation limit and the limit at 1 meter satisfy the following requirements:

<u>Label</u>	<u>Surface Radiation Level</u>	<u>Radiation Level at 1 Meter</u>
White 1	Does not exceed 0.5 millirem/hour	Not applicable
Yellow 2	Does not exceed 50 millirems/hour	AND Does not exceed 1 millirem/hour
Yellow 3	Exceeds 50 millirems/hour	OR Exceeds 1 millirem/hour

Since the TI is the radiation level at 1 meter, it is clear that a White 1 label has no TI. A Yellow 2 must have a TI no greater than 1, and a Yellow 3 may have a TI greater than 1.

Referring to the radiation limits on page 11-19 for vehicles, it can be seen that the maximum TI for nonexclusive use vehicles (common carriers) and for exclusive use (contract carriers) open vehicles is 10. The radiation level at 1 meter from the surface of a package can exceed 10 mrem/hour only if the package is transported in an exclusive use (contract carrier), closed vehicle.

Placarding



Placards are just bigger labels which are placed on the outside of the vehicle. Unlike labels, there is only one placard and no information needs to be written on it (i.e., no TI). In fact, a placard on a vehicle is only required if the vehicle is carrying a package bearing a Yellow 3 label or low specific activity material. If the amount of material being transported constitutes a highway route controlled quantity, the diamond-shaped placard has a black square border surrounding it.

Carriers:

Common Contract Private

There are essentially three classes of carriers:

- Common,
- Contract, and
- Private.

Common and contract carriers provide a service to others. They carry other peoples' materials. Common carriers have published rates for hauling material, while contract carriers negotiate a specific contract with the shipper. Common and contract carriers are not licensed by the NRC. The responsibility for safety rests with the shipper.

Private carriers own the radioactive material which they carry. The transport of material is accomplished in direct support of the radioactive material user's business. These carriers are licensed by the NRC.

Some examples of private carriers who transport their sources from one job site to another are:

- Industrial radiographers,
- Portable gauge users, and
- Well loggers.

In addition to the above, radiopharmacies deliver their own radiopharmaceuticals to nuclear medicine clinics.

Radiation Limits

<u>Type of Transport</u>	<u>Maximum Radiation Limit</u>
Common carrier non-exclusive use:	
<i>Open or closed transport</i>	200 millirems/hour on the surface of the package and 10 millirems/hour at 1 meter from any surface of the package
Contract carrier exclusive use:	
<i>Closed transport</i>	1000 millirems/hour on the surface of the package, 200 millirems/hour at the surface of the vehicle, 10 millirems/hour at 2 meters from any surface of the vehicle, and 2 millirems/hour in the vehicle cab
<i>Open transport</i>	200 millirems/hour on the surface of the package, 200 millirems/hour on any imaginary surface of the vehicle, 10 millirems/hour at 2 meters from any imaginary surface of the vehicle, and 2 millirems/hour in the cab of the vehicle

For non-exclusive use vehicles, that is, vehicles which may be carrying other non-radioactive material as well (common carriers), the radiation limit is imposed on the package.

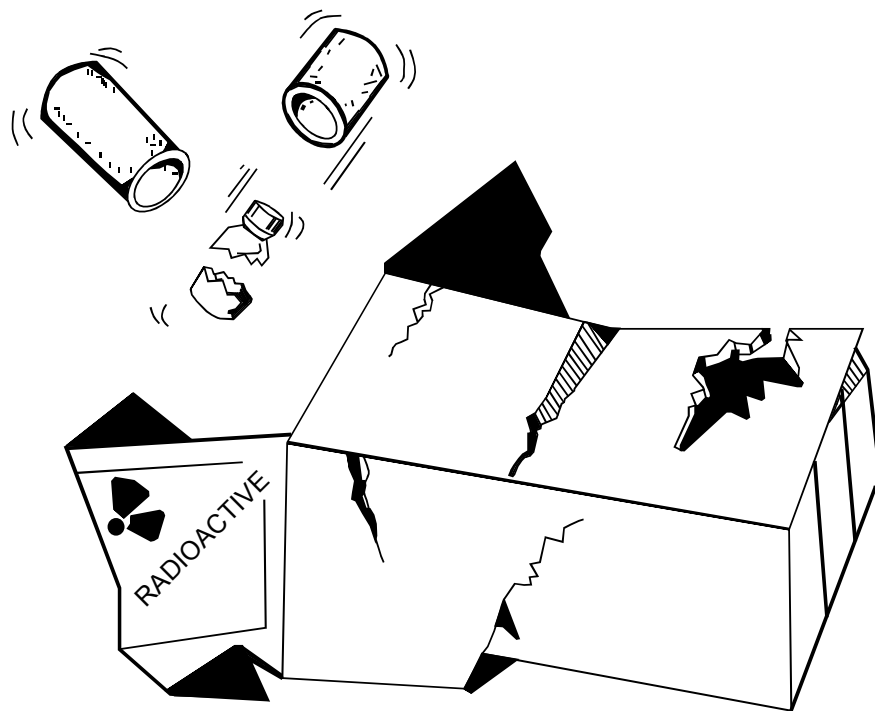
For exclusive use vehicles, that is, the vehicle is only carrying radioactive material for one shipper (contract or private carrier), the package limits are higher, but there are also limits on the outside of the vehicle.

Shipping Papers

SHIPPER'S CERTIFICATION FOR RADIOACTIVE MATERIALS								
Two completed and signed copies of this certification shall be handed to the carrier. (Use block letters)								
WARNING: Failure to comply in all respects with the applicable regulations of the Department of Transportation, 49-CFR, CAB 82 and, for international shipments, the IATA Restricted Articles Regulations may be a breach of the applicable law, subject to legal penalties. This certification shall in no circumstances be signed by an IATA Cargo Agent or a consolidator for international shipments.								
This shipment is within the limitations prescribed for (mark one) <input type="checkbox"/> passenger aircraft <input type="checkbox"/> cargo-only aircraft								
NATURE AND QUANTITY OF CONTENT					PACKAGE			
PROPER SHIPPING NAME	RADIONUCLIDE	GROUP	FORM	ACTIVITY	CATEGORY	TRANSPORT INDEX	TYPE	
FOR US SHIPMENTS SEE SECTION 2 CAB 82 TABLE 6-0	NAME OR SYMBOL OF PRINCIPAL RADIOACTIVE CONTENT	GROUP NUMBER OF GROUPS I TO VII	CHEMICAL FORM AND PHYSICAL STATE: GAS, LIQUID, SOLID OR SPECIAL FORM OR SPECIAL ENCAPSULATION	NUMBER OF CURIES OR MILLICURIES	NUMBER OF PACKAGES	I-WHITE OR II-YELLOW OR III-YELLOW LABEL	FOR YELLOW LABEL CATEGORIES ONLY	INDUSTRIAL OR TYPE A OR TYPE B
ADDITIONAL INFORMATION REQUIRED FOR FISSILE MATERIALS ONLY								
EXEMPTED FROM THE ADDITIONAL REQUIREMENTS FOR FISSILE MATERIALS SPECIFIED IN 1 OF PART 2 OF THE IATA RESTRICTED ARTICLES REGULATIONS NAMES PLUS QUANTITY IN GRAMS OR CONCENTRATION OR ENRICHMENT IN U235								
NOT EXEMPTED FISSILE CLASS I FISSILE CLASS II FISSILE CLASS III								
Additional certificates obtained by the Shipper when necessary N/A								
Special Form Encapsulation Certificate(s)					Certificate(s) for Large Radioactive Source			
Type B Packaging Certificate(s)					Government Approvals / Permits			
Certificates for Fissile Material								
Special Handling Information								
NONE								
I hereby certify that the contents of this consignment are fully and accurately described above by Proper Shipping Name and are classified, packed, marked, labeled and in proper condition for carriage by air according to applicable national governmental regulations, and for international shipments. The current IATA Restricted Articles Regulations.								
Name and full address of Shipper					Name and title of person signing Certification			
Date:					Signature of the Shipper (see WARNING above)			
Air Waybill No:			Airport of Departure:			Airport of Destination		

The only way for anyone to know what is being transported inside a vehicle is by reviewing the shipping papers. These documents, by words and codes, clearly specify what is being transported. They must be readily accessible to the driver and to emergency response personnel, if the driver is not available.

Accidents



Many packages containing radioactive materials have been involved in transport accidents. The statistics verify the degree of protection expected of each class of packaging.

For strong tight containers, which do not have to pass any integrity tests, about 10% of those involved in accidents have failed. Of those, about 90% have released their contents.

For Type A packages, which must pass stringent tests, only 1% of those involved in accidents have failed. Of those, only 39% have released their contents.

For Type B packages, which must pass the most rigorous tests, several have been involved in accidents. However, there has been only one documented case of a package failure, and that involved an industrial radiography source.