

Chapter 11

Transportation of Radioactive Material

Big Picture

- **Transportation inspections are conducted by NRC inspectors to ensure that licensed radioactive material is transported safely on public roads**
- **NRC and Agreement State personnel may attend the NRC-contracted course, “Transportation of Radioactive Materials,” (H-308) for more detailed information**

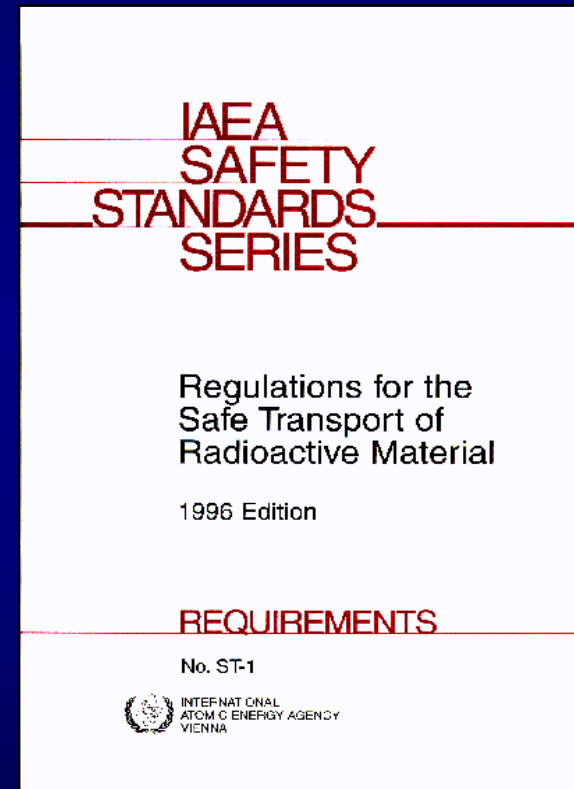
Objectives

- **Understand the role of NRC inspectors regarding the safe transport of radioactive material**
- **Determine the international governing body behind the transportation regulations**
- **State the two primary domestic regulatory agencies**

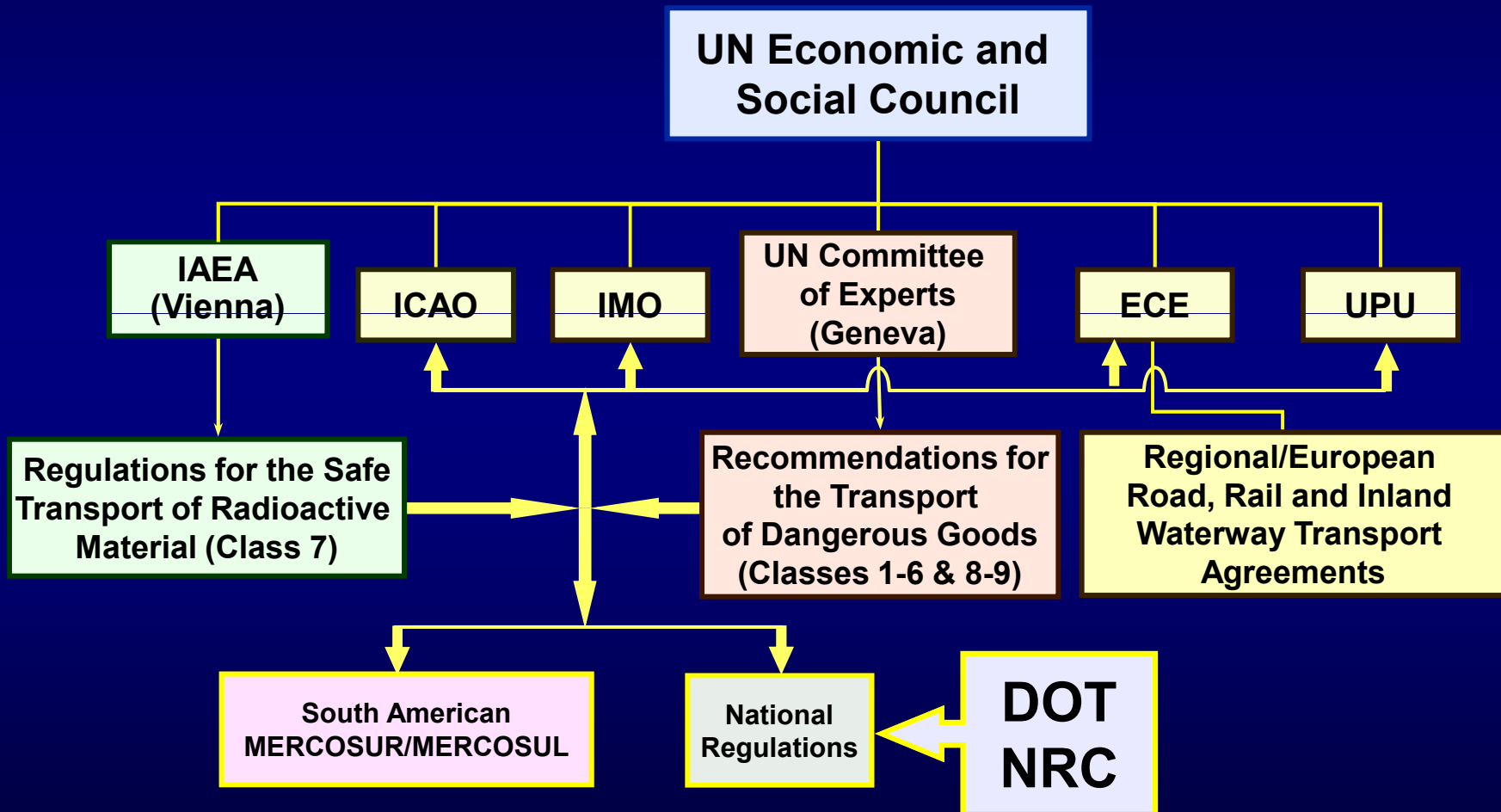
Basis for Regulations

IAEA Regulations for the Safe Transport of Radioactive Material

“These Regulations establish standards of safety which provide an acceptable level of control of the radiation, criticality and thermal hazards to person, property and the environment that are associated with the transport of radioactive material.”



The Regulating Agencies



Primary US Regulatory Agencies

➤ DOT (49 CFR 170-178)

- Agency, by Congress, to establish domestic hazardous materials packaging and transport regulations (FHMTL)
- Full enforcement capability
- Preemptive authority

➤ NRC (10 CFR 71)

- Regulates in conjunction with DOT (via MOU):
 - Establishes Type B and fissile material package designs
 - Approves package QA program of licensees
 - Provides technical support to ensure consistency in radioactive material transport regulations
 - Inspects licensees in accordance with DOT requirements

The Basic Steps of Radioactive Material Transport

1. Identify
2. Classify
3. Proper Shipping Name
4. Authorized Packaging
5. Hazard Communications
 - Marking and Labeling
 - Documentation
 - Placarding
6. Shipment Controls



Controls for Transport

- **To protect persons, property and the environment by:**
 - **Controlling external radiation levels**
 - **Preventing a criticality event**

- **Controls used to manage these hazards:**
 - **Conveyance activity limits**
 - **Use of exclusive use conveyance**
 - **Transport index and radiation levels**
 - **Contamination limits**
 - **Separation and segregation**
 - **Fissile material controls**

Identification and Classification

- Radioactive Material means any material containing radionuclides where both the activity concentration and the total activity in the consignment exceed values specified by DOT
- Under DOT regulations, the hazard class assigned to radioactive material is **Class 7**

Proper Shipping Name

➤ **Hazardous Materials Table**

➤ **PSN selection based on:**

- **Shipping category**
- **Packaging type**

Example:

UN 3328 - “Radioactive material, Type B(U) package, fissile,” Class 7

Sym- bols	Hazardous materials descrip- tions and proper shipping names	Hazard class or Di- vision	Identifica- tion Num- bers	PG	Label Codes	Special provisions (\$172.102)	(8) Packaging (\$173.***)		
							Excep- tions	Non- bulk	Bulk
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8A)	(8B)	(8C)
I	Radioactive material, excepted package-articles manufactured from natural uranium or depleted uranium or natural thorium.	7	UN2909		None		422, 426.	422, 426.	422, 426.
D	Radioactive material, excepted package-empty package or empty packaging.	7	UN2910		Empty		428	428	428
I	Radioactive material, excepted package-empty packaging.	7	UN2908		Empty		422, 428.	422, 428.	422, 428.
D	Radioactive material, excepted package-instruments or articles.	7	UN2910		None		422, 424.	422, 424.	422, 424.
I	Radioactive material, excepted package-instruments or articles.	7	UN2911		None		422, 424.	422, 424.	422, 424.
	Radioactive material, excepted package-limited quantity of material.	7	UN2910		None		421, 422.	421, 422	421, 422.
D	Radioactive material, fissile, n.o.s..	7	UN2918		7		453	417	417

Types of Packages

Excepted / IP-1 / IP-2 / IP-3/ Type A

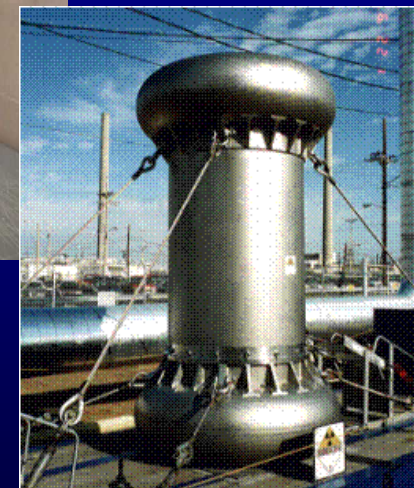
UF₆ / Fissile / Type B / Type C

INCREASINGLY SEVERE TEST REQUIREMENTS

MAY NOT SURVIVE ACCIDENTS

SURVIVES MINOR ACCIDENTS

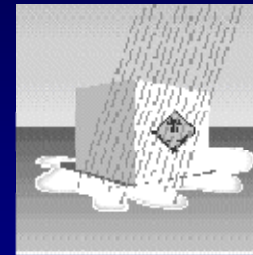
SURVIVES SEVERE ACCIDENTS



Type A Package Performance Tests

- **Water Spray**
 - 2" of water/hr for 1 hour
 - First test in series
- **Stacking**
 - 5 x mass of package for 24 hours, or
 - Vertical height calculation
- **Puncture**
 - 6 kg bar with 32 mm spherical head dropped from 1 meter
- **Free Drop**
 - Graduated drop height based on mass
 - Corner drop based on type or content
- **Vibration**
 - NRC test; DOT capability

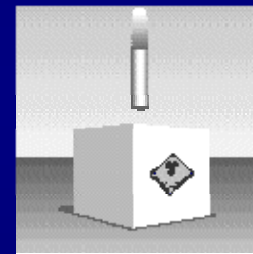
Type A Tests:



Water spray for 1 hour (2.0 mm/min rainfall at 10 centimeters of height per hour).



Compression test of at least 4 times the weight of the package for at least 24 hours.



Puncture test by dropping a 6 kg bar with 32 mm spherical head 1 meter above the package from a height of 1 meter to the top.



Free drop test into a test, hard surface (7.6 m/sec (24.6 ft/sec) drop if the package weighs 4,500 g (10 lb) or less.



Vibration test for 4 hours on a platform vibrating so that the package will be raised high enough for a 100 m/sec (200 ft/sec) drop to be possible from the bottom of the package and the platform.

Typical Type A Packages

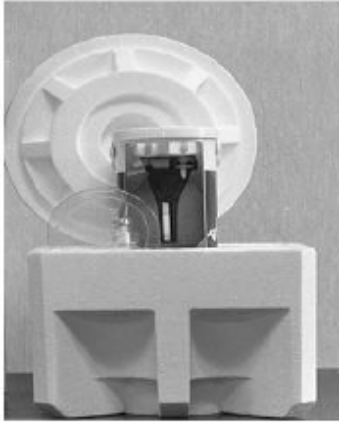


Figure A-Molybdenum 99 Generator

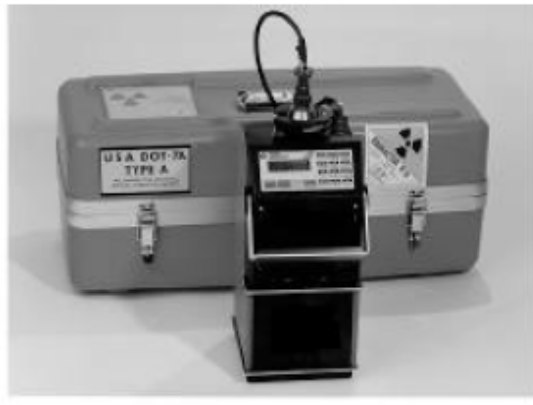


Figure B-Moisture Density Gauge & Carrying Case



Figure C-Steel Drum

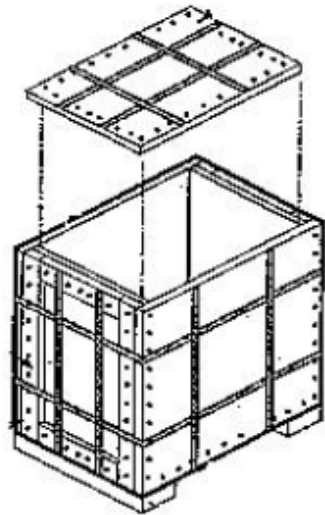


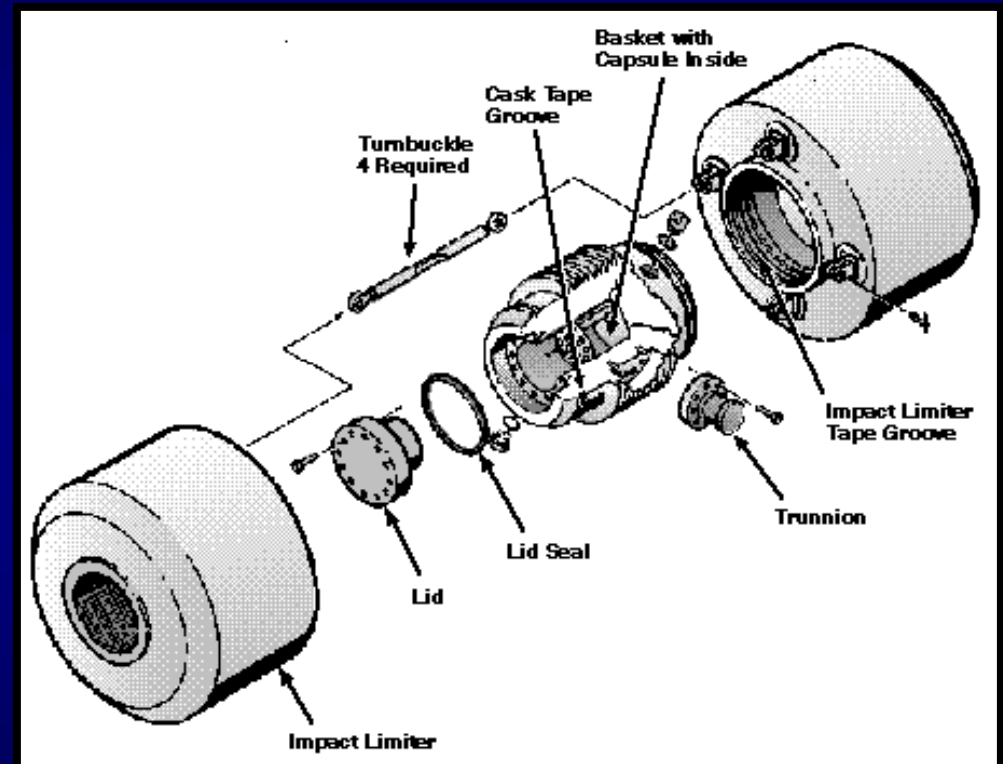
Figure D-Wooden Box



Figure E-Nuclear Pharmacy Unit Dose(s) Package

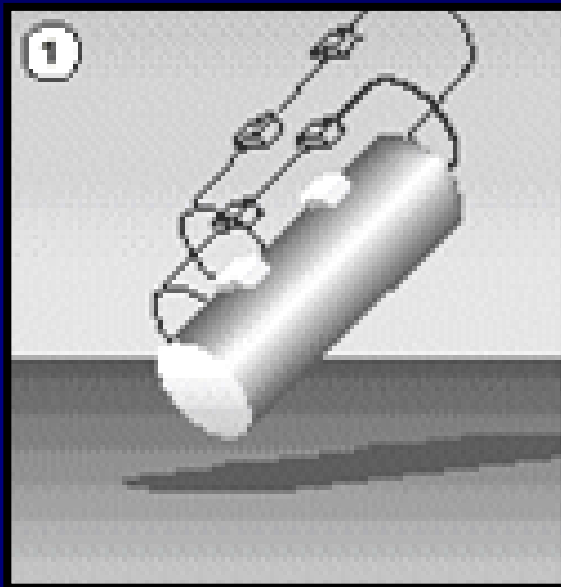
Type B Packages

- Designed to survive the most severe accidents
- Design Requirements:
 - Excepted package req't
 - Type A package req'ts
 - Heat generation - structure
 - Thermal surface protection
 - Extreme pressures
 - Venting
 - Integrity in test environment



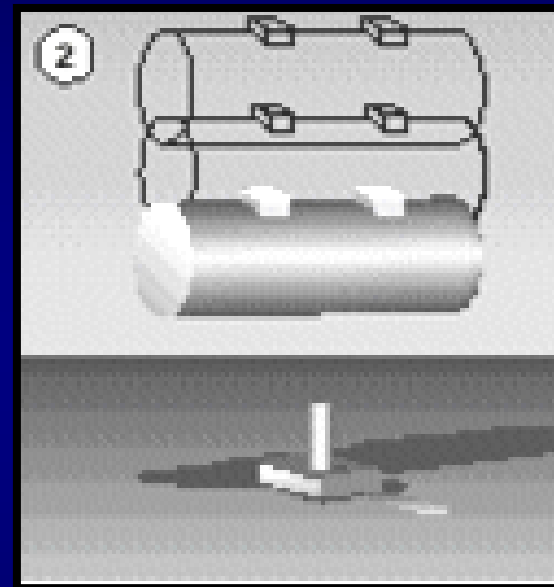
Type B Package Physical Testing

Drop Test



- **30-foot drop onto flat unyielding surface**
- **Crush test for small, low density packagings**

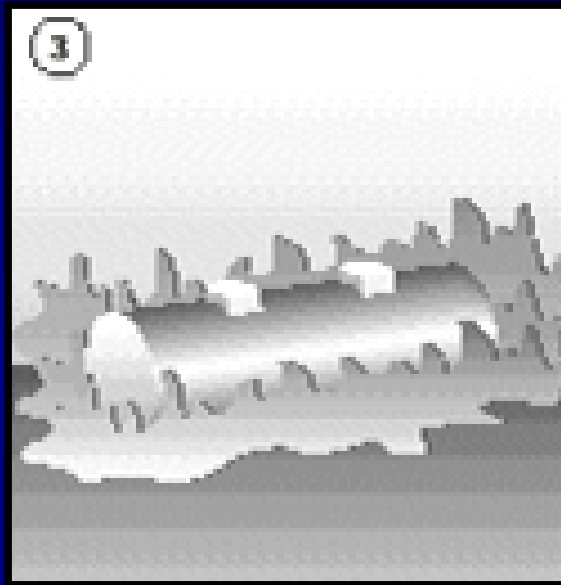
Puncture Test



- **40-inch free drop onto a 6-8 inch steel bar**

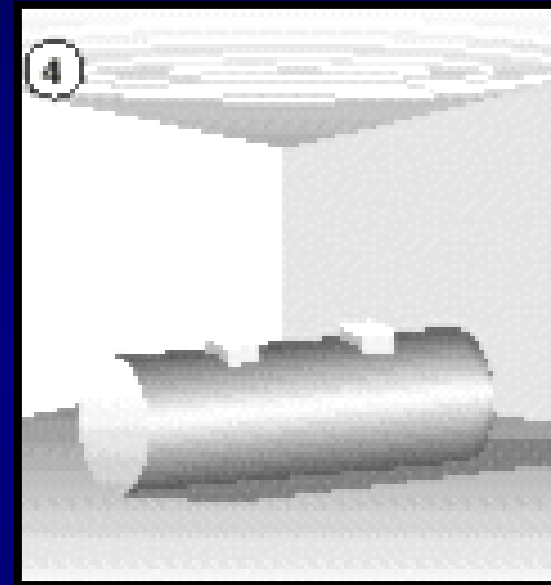
Type B Package Physical Testing

Thermal Test



- Exposure to fire exceeding 1475°F
- 30 minutes

Immersion Test



- Immersion under 50 feet of water (150 kPa)
- Enhanced to 2 MPa for contents $>10^5 A_2$

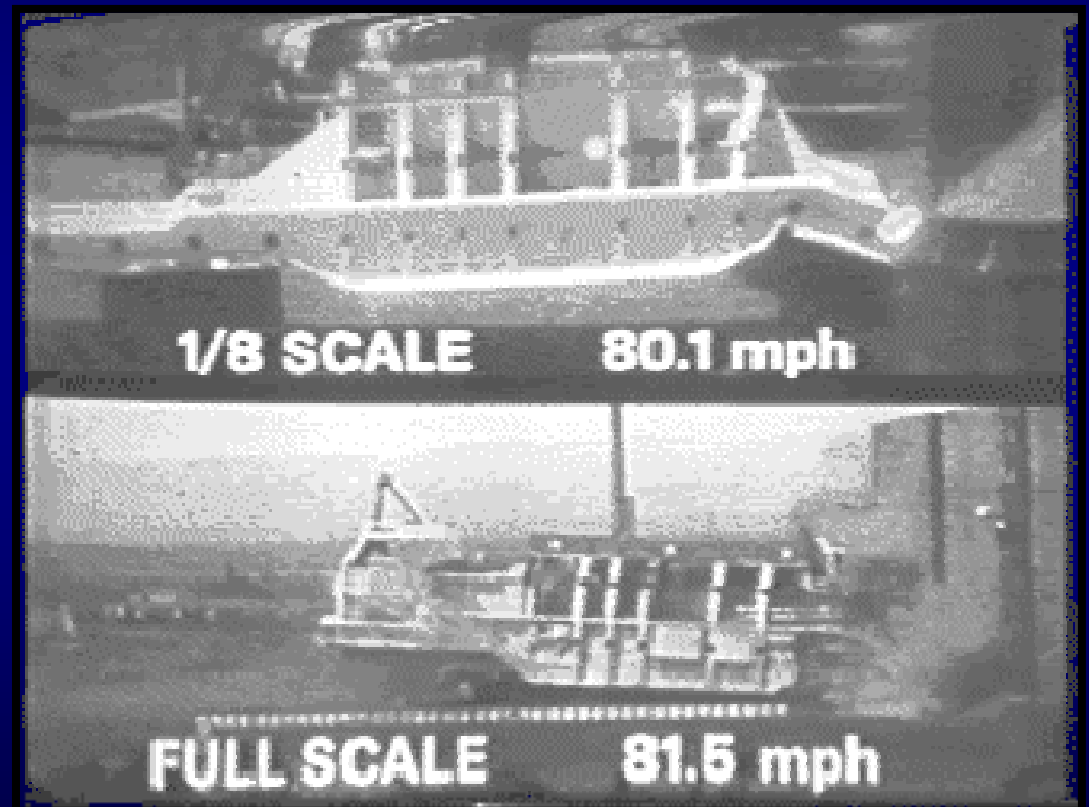
Type B Package Test Criteria

- **Radiation level at 1 m from the package ≤ 10 mSv/hr**
- **After Normal Conditions**
 - Same as Type A package except:
 - Loss of radioactive content restricted to $\leq 10^{-6} A_2$ /hr
- **After Accident Conditions**
 - Accumulated loss of radioactive content restricted to $\leq A_2$ for one week (not more than $10 A_2$ for Kr-85)



Other Methods for Demonstrating Compliance

- Reference to previous test(s)
- Testing on scale models
- Calculations or reasoned evaluation
- Combination of all methods



Type B(U) and B(M) Packages

- **Competent authority approval(s)**
- **Valid package certificate of approval (not expired)**
- **Licensee registered with NRC (non-government)**
- **Additional package requirements if transported by air**



Hazard Communications

- **The regulations require that the hazards posed by the material and the consignment are clearly communicated to all parties concerned to facilitate:**
 - **Complete radiation protection at all phases**
 - **Correct emergency response for accidents**



Hazard Communications

➤ Hazard Communications are accomplished by:

- Marking material and packages
- Labels on packages
- Placards on freight containers, tanks, road and rail vehicles
- The transport document
- Emergency response information



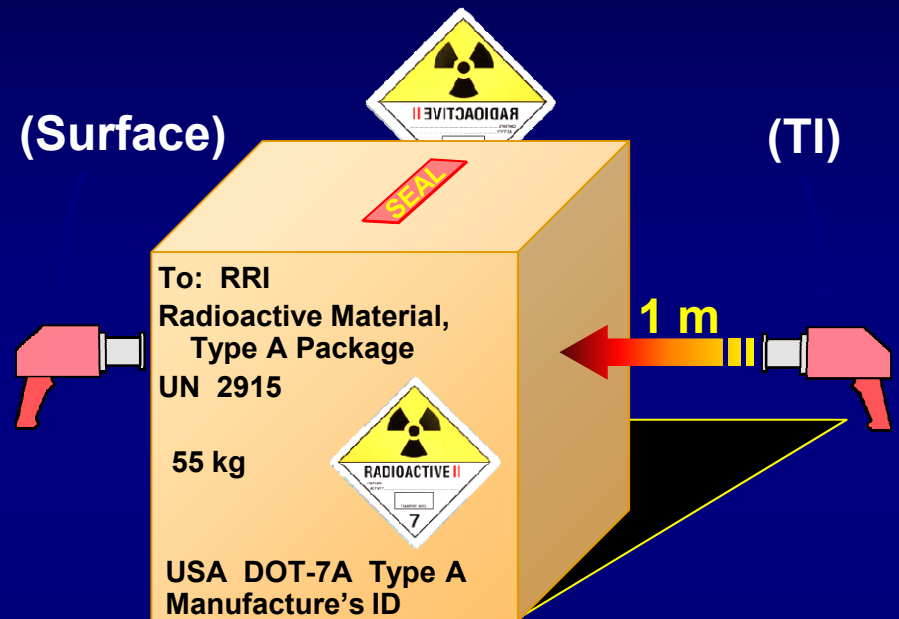
Labeling Categories

➤ Three label categories:

- Radioactive White-I
- Radioactive Yellow-II
- Radioactive Yellow-III

➤ Selection of appropriate category

- Based on Table, §172.403
- Highest category assumes precedence
- Package transported as Highway Route Controlled Quantity (HRCQ) is always a Radioactive Yellow-III regardless of above criteria



Primarily based on surface radiation level and TI

Transport index	Maximum radiation level at any point on the external surface	Label category ¹
0 ²	Less than or equal to 0.005 mSv/h (0.5 mrem/h).	WHITE-I.
More than 0 but not more than 1	Greater than 0.005 mSv/h (0.5 mrem/h) but less than or equal to 0.5 mSv/h (50 mrem/h).	YELLOW-II.
More than 1 but not more than 10	Greater than 0.5 mSv/h (50 mrem/h) but less than or equal to 2 mSv/h (200 mrem/h).	YELLOW-III.
More than 10	Greater than 2 mSv/h (200 mrem/h) but less than or equal to 10mSv/h (1,000 mrem/h).	YELLOW-III (Must be shipped under exclusive use provisions; see 173.441(b) of this subchapter).

¹Any package containing a "highway route controlled quantity" (§[173.403](#) of this subchapter) must be labelled as RADIOACTIVE YELLOW-III.

²If the measured TI is not greater than 0.05, the value may be considered to be zero.

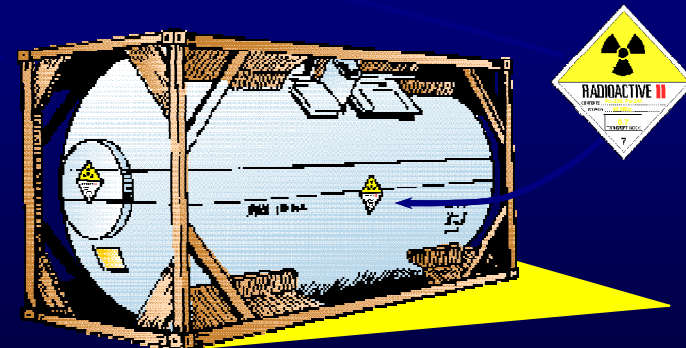
Applying the Labels

➤ Label configuration on the package shall be affixed on two opposite sides of the outside of a:

- package
- overpack
- freight container

➤ Freight containers must have one label affixed near the opening

➤ Labels shall not cover the markings



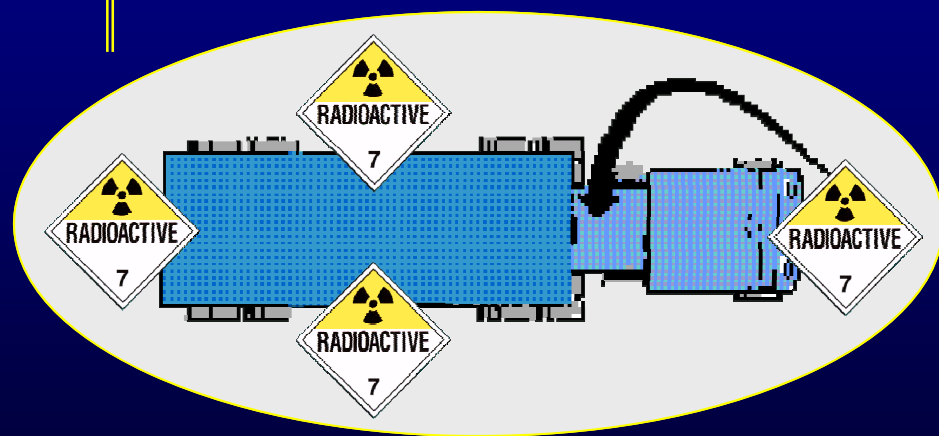
Placarding

- Rad Yellow-III labeled packages
- LSA material and SCO consigned as Exclusive Use per 173.427(a)(6)



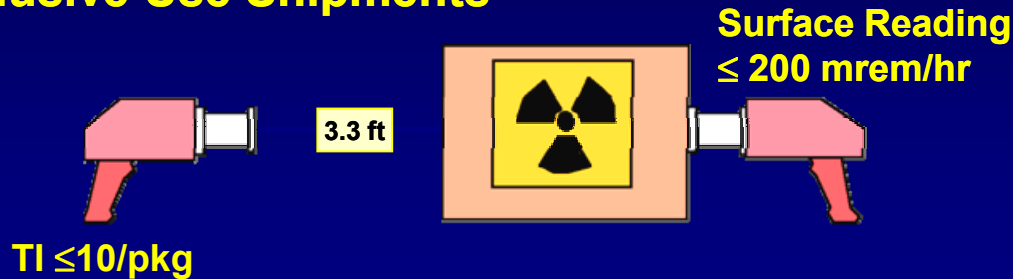
Display of placards consistent with other hazard placards

- Highway route controlled quantity placard
- UF_6 subsidiary hazard (8) if >454 kg



Shipment Controls

Non-Exclusive Use Shipments

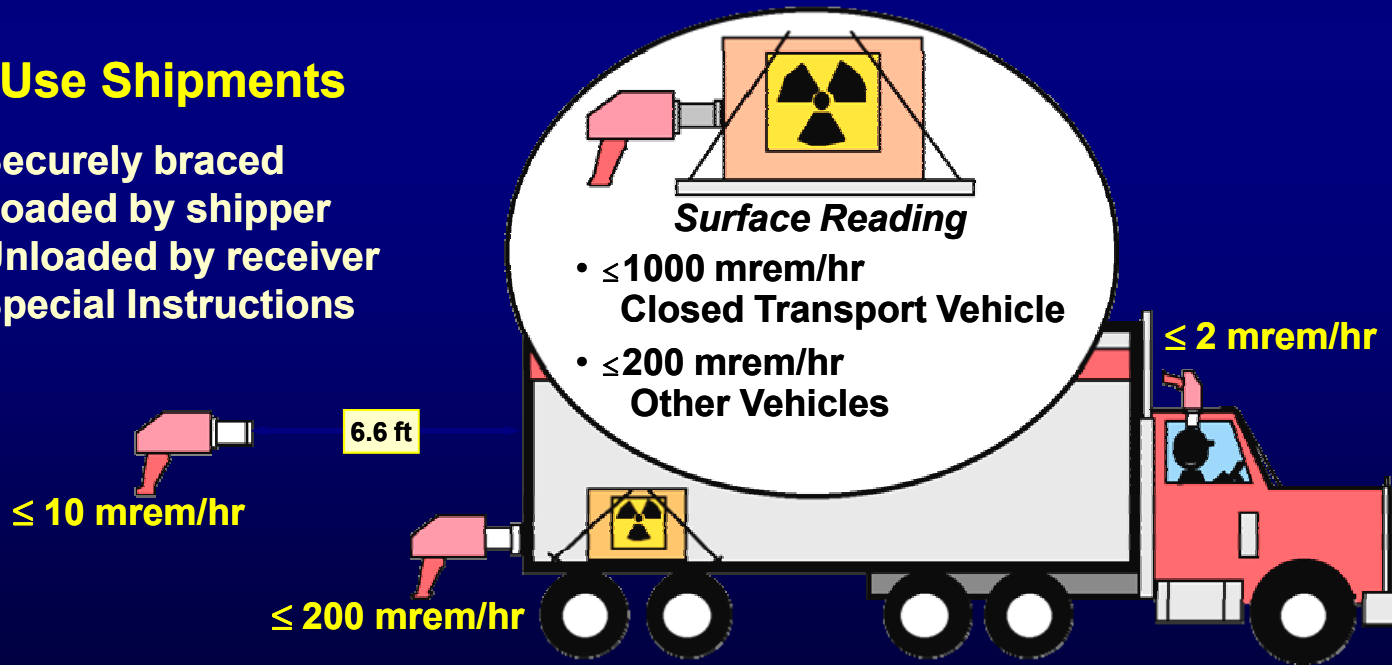


Total TI per Transport Vehicle limited to 50

Exclusive Use Shipments



- Securely braced
- Loaded by shipper
- Unloaded by receiver
- Special Instructions



Radioactive Waste

- **10 CFR 20 Subpart K**
 - Licensee's general requirements
 - Disposal options
 - Sanitary sewer
 - Incineration
 - Specific waste
 - NRC disposal manifest

- **10 CFR 61**
 - Requirements for land disposal
 - Licenses
 - Facility requirements
 - Waste classification
 - Records and QA



Modal Specific Requirements

➤ **Radioactive materials transport requirements incorporated into various modal regulations:**

- **Rail: 49 CFR 174**
- **Aircraft: 49 CFR 175**
- **Vessel: 49 CFR 176**
- **Highway: 49 CFR 177**



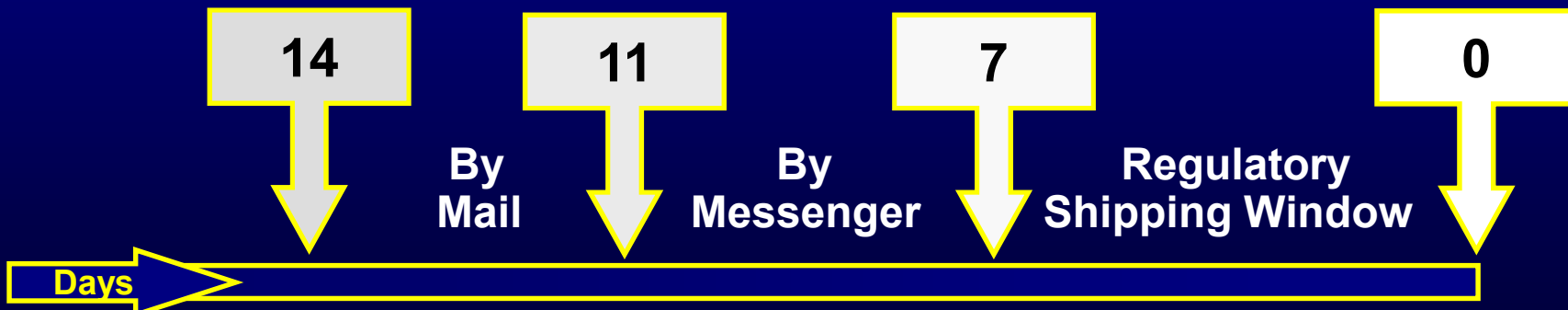
Shipment Requiring Notification Irradiated Nuclear Fuel & HRCQ

➤ Notification to States if:

- In Type B package
- Transported to or across State boundary
- Destined for a disposal facility

➤ Notification

- Sent to governor or designee in writing
- 3-year record retention
- Within required timeline:



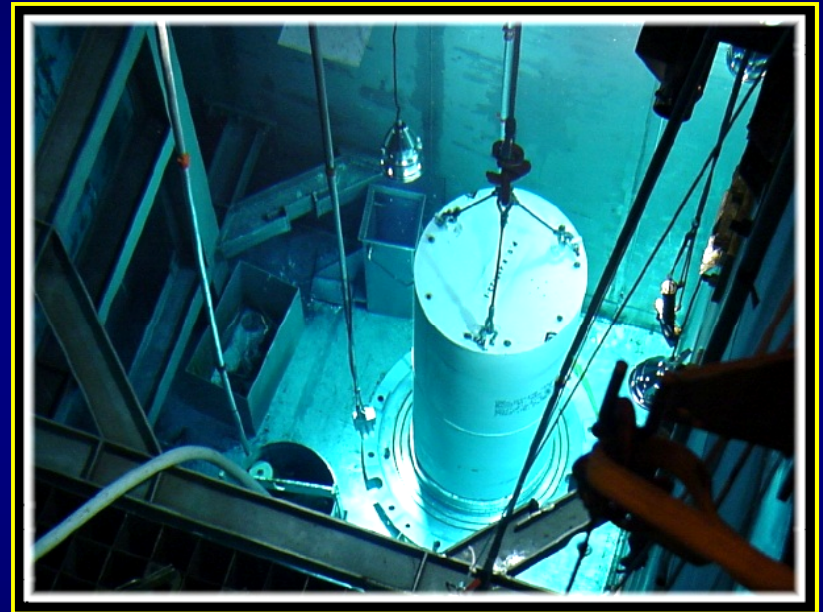
Special Shipment Requirements – Irradiated Reactor Fuel –

- **Subject to 10 CFR 73.37 if:**
 - **NRC licensee, and**
 - **>100 grams of irradiated fuel, and**
 - **>100 rem/hr @ 3' from unshielded material**

- **If shipment not subject**
 - **Carrier report filed <90 days with FMCSA if shipment NOT subject to 10 CFR 73**

- **Advanced notification to NRC and States**

- **Safeguard and security requirements must be met**



Transportation Incidents

- **AGREEMENT STATE REPORT:**
- **"A truck caught fire and burned. A S.P.E.C. camera, serial # 98, source serial # HS1210 containing Ir-192 was on board. The source remained intact and was not leaking. The device and source were returned to the manufacturer."**



Transportation Incidents

MISSISSIPPI AGREEMENT STATE REPORT: TROXLER GAUGE RUN OVER BY A BULLDOZER.

On 06/21/04 at 1800 CDT an Alabama licensee, Gallet Associates, had one of their Troxler gauges; Model # 3401, gauge serial number 12283; run over by a bulldozer in Flowood, Mississippi. The rod was broken off. Surveys taken of the rod was 10 mrem/hr at one foot. The gauge has been stored and the licensee will call Troxler. The gauge contained 8.6 milliCuries of Cesium-137 and 40 milliCuries of Am-241/Be.

Transportation Violations

- **The following findings were identified as being of low safety significance (Green) by the ROP:**
 - **Browns Ferry: Shipment of radioactive material had a dose rate of 300 mrem/hr, limit is 200 mrem/hr.**
 - **St. Lucie: Shipment of spent resin was not sealed per manufacturers requirement.**
 - **Turkey Point: Shipping papers did not have the correct emergency response number on the shipping papers.**

QUESTIONS?

**END OF
TRANSPORTATION OF
RADIOACTIVE MATERIAL**

Review

- **What is the class designation for shipments of radioactive material?**
- **The maximum dose rate on the outside of a vehicle shipping radioactive material is _____ mrem/hr.**
- **The TI (Transportation Index) is equal to the dose rate at what distance from the vehicle?**
- **What is the highest labeling classification for a shipment of radioactive material?**

Review

- **The maximum dose rate in the cab of a vehicle (where the worker is not considered a radiation worker) is ___ mrem/hr?**
- **A placard is required for what type of shipment?**
- **What package type must meet severe accident conditions?**

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