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## CHAPTER 10

# REGULATION OF THE TRANSPORTATION OF NUCLEAR WASTE

Alfred W. Grella , CHP, Health Physics Fellow

### 1.0 INTRODUCTION

Regulations and other requirements for the packaging and transportation of radioactive material , including radioactive waste, are often perceived as being confusing and complex. The overall regulatory system for regulating nuclear transportation in the USA is in fact somewhat complex and fragmented, since a number of different agencies and jurisdictions are often involved . The sources of regulations and the structures of the primary regulatory organizations of the USA and their interfaces and responsibilities are described in this chapter.. The major features of the regulations of the principal regulators--The U.S. Department of Transportation and the U.S. Nuclear Regulatory Commission-- are also covered.. Although the nuclear transport regulations of the USA have, since 1968, been essentially based on the IAEA standards contained in Safety Series No. 6, a few notable differences do exist between the application of certain of those standards in the USA regulations and the IAEA Transport Safety standard..The basic requirements of the DOT transport regulations are summarized, with extensive discuss of the specific requirements for packaging and shipment of radioactive waste.

### 2.0 BACKGROUND OF NUCLEAR TRANSPORT REGULATIONS DEVELOPMENT

In the early 1950's, the ICC ("Interstate Commerce Commission", which no longer exists as a Federal Agency), first established regulations governing the safe shipment of radioactive materials. These regulations were intended to protect property, e.g. photographic film, and individuals from excessive exposure to radiation during the transport of radioactive materials. These early ICC regulations were designed to protect radiation-sensitive cargo, such as photographic film, which might also be transported in proximity to the radioactive materials packages. The ICC established limits on radiation levels that emanate from packages. By protecting such radiation-sensitive cargo, protection was also provided to the people who transported it or were passengers in the vehicle or aircraft.

In 1961, the International Atomic Energy Agency (IAEA) adopted *regulations* (which are actually considered to be *standards*) for the safe transport of radioactive materials. They were to some extent partially based on the adoption of rules similar to those of the ICC in the ICC regulations.

Those ICC regulations were in fact the source of the current package radiation limits and maximum transport index values which are now found in IAEA regulations. These IAEA regulations thus became the first international standards for the safe transport of radioactive materials. Since their initial publication, the IAEA continues to recommend that member States and international transport organizations adopt these regulations as a basis or standard for their own domestic national or modal requirements.

In 1967, a comprehensive revision of the IAEA transport regulations took place when IAEA Safety Series No. 6 (SS6-67) was substantially revised. This revision included consideration of a new category of materials--large radioactive sources. This category was considered special because of the large amount of radioactivity involved and the heat that might be generated by such very large sources. SS6-67 regulations then served as the basis for a major revision<sup>1</sup> of the DOT Hazardous Materials (Hazmat) Regulations which took place in 1968 relating to radioactive materials, and at the same time, was the basis for a major revision by AEC<sup>2</sup> (Now NRC) to its 10 CFR Part 71 transport regulations. Those 1968 amendments were instrumental in bringing both DOT and AEC regulations into *substantial* conformity with the existing international standards for the first time. This harmony between the domestic and international requirements existed until 1973, when the IAEA again made a complete revision of its regulations in Safety Series No. 6.(SS6-73). These changes included a new system for classifying radionuclides, known as the "A<sub>1</sub>/A<sub>2</sub>" system, replacing the former "transport group" system. Elimination of the "large source" designation was possible because the special characteristics of large sources were now considered routinely for all packages containing greater than a Type A quantity of radioactive material.

The SS6-73 standards also introduced the unilateral and multilateral concepts for Type B packages to determine the extent to which each country must approve a package design when an international shipment is involved. It was not until ten years later, in 1983, when DOT<sup>3</sup> and NRC<sup>4</sup> both adopted regulation revisions to again bring the U.S. regulations into essential conformity with SS6-73. Most of the differences that existed between international and U.S.domestic regulations that had existed since the SS6-73 was published were eliminated. Although the revisions adopted by DOT and NRC to conform to latest IAEA standards are always in "essential" conformity with the IAEA standards, there usually are certain exceptions and differences which remain between the DOT/NRC regulations and the IAEA standards. Several of the most notable of these differences are described later in this paper.

Just two years after the DOT and NRC revised the domestic regulations in the U.S. to conform to SS6-73 standards, IAEA again issued a comprehensive revision of Safety Series No. 6 in 1985. This edition was reprinted in 1990 with minor revisions. It is now referred to as the "1985 Edition, 1990 Printing". (referred to hereafter as "SS6-85/90").

In September, 1995, again taking about 10 years to accomplish compatibility with current IAEA standards, DOT<sup>5</sup> and NRC<sup>6</sup> finalized their regulatory amendments to again bring the regulations of the U.S. into essential conformity with the current international standards of SS6-85/90). These revisions were effective for the most part for mandatory compliance by U.S. shippers and

carriers on April 1, 1996.

Also, in 1996, the IAEA published its current Requirements, e.g. "Regulations for the Safe Transport of Radioactive Materials". It is no longer numbered as Safety Series No. 6, but has been renumbered to "ST-1". IAEA has urged member States and International Transport Organizations to adopt revisions based on ST-1 by 2001. Prediction of the date in the future for adoption of the ST-1 standards into U.S. regulations is difficult, since the last two major revisions (in 1983 to adopt SS6-73 standards and 1995 to adopt SS6-85/90) each took 10 years.. A Notice-of Proposed Rulemaking to adopt ST-1 standards is expected to be issued by DOT in late 2000, with final amendments expected sometime in 2001.

### 3.0 REGULATORY ORGANIZATIONS

#### 3.1 Federal Regulatory Agencies and Their Interfaces

The transport of radioactive materials in the USA is regulated by three federal agencies-The U.S. Department of Transportation (DOT), the U.S. Nuclear Regulatory Commission (NRC), and the U.S. Postal Service (USPO). The latter agency, USPO, is much less involved than DOT and NRC, since relatively small amounts of radioactive materials as "Mailable Radioactive matter" are allowed in postal shipments when in conformance with the provisions of the U.S. Postal Manual. Those provisions are essentially, but not totally, in conformance, with the provisions of and 477 international standards for mailing of radioactive matter.

Under the Department of Transportation Act of 1966 and other Federal legislation, including, most notably the Hazardous Materials Transportation Act <sup>7</sup> and the Hazardous Materials Transportation Uniform Safety Act of 1990 <sup>8</sup>, the DOT is mandated with wide-ranging and all-encompassing authority and responsibility for regulating the safe transport of all classes of hazardous materials, including United Nations (UN) Class 7 (radioactive) materials, in interstate and foreign commerce.. This includes regulation of shippers and carriers (not *receivers*, e.g.the "Consignees", who are regulated by Federal or State agencies who license the use, possession and transfer of *licensed* radioactive materials) by all modes, e.g. surface (highway and rail), water and air, and by all types of conveyances, e.g. truck, railcar, aircraft, barge and ocean vessels.

Under the Atomic Energy Act of 1954 <sup>9</sup>, as amended, and the Energy Reorganization Act of 1974, as amended <sup>10</sup>, the NRC also has major responsibility for regulating safety in the use, possession and "transfer" (including transport) of source, byproduct, and special nuclear (fissile) material, e.g. "Licensed material". Essentially, transport and carriage of such **licensed** materials by NRC licensees is therefore jointly regulated by both NRC and DOT.

Due to this obvious overlap in statutory authority to regulate the safe transport of radioactive materials in the U.S., the NRC and DOT (and their predecessor Agencies-AEC and ICC) have been signatories to a series of three memoranda of understanding. The most recent Memorandum

of Understanding was signed in 1979.. The purpose of the memoranda has been to avoid subjecting shippers and carriers to conflicting and duplicative regulations and clarify the areas in which Agency will establish and enforce its regulations.

Regulation of transport of radioactive material which is not "licensed material", such as accelerator-produced and naturally occurring radioactive material. e.g. "NORM" materials, is therefore subject only to DOT regulations when the shipments are in interstate and foreign commerce. In those instances wherein the shipments are not in interstate and foreign commerce, and therefore not subject DOT regulation, *licensed* material is regulated by either NRC or a State Agency. Thirty of the States in the U.S. have entered into formal agreements with NRC under a provision (§274) of the Atomic Energy Act of 1954. In such cases, regulatory authority over certain *licensed* material in the form of source, byproduct and fissile materials (in less than critical mass quantities) has been transferred to that "Agreement State". When shipments and carriage involve non-NRC licensed material in intra-state commerce, e.g within the State only, and therefore not subject to DOT regulation, the State is the principal regulator in both Agreement States and non-agreement States

### **3.2 Organization of the U.S. Department of Transportation (DOT)**

The DOT is a large federal agency, headed by a Secretary of Transportation who is appointed by the President and is a member of his Executive Cabinet.. Regulation of the safe transport of hazardous materials is delegated by the Secretary to the Administrator of each of the four "modal operating administrations", e.g. U.S. Coast guard (water), Federal Aviation Administration (Air), Federal Highway Administration (Road) and the Federal Railroad Administration (rail). The Administrator of the Research and Special Programs Administration (RSPA) coordinates the issuance and processing of amendments to the DOT's Hazmat Regulations, and serves in a Secretariat function on safety matters relating to transport by more than one mode. RSPA also act as the Competent National Authority with respect to the approval and administrative requirements of IAEA Transport Safety Standards. The Competent National Authority function for the U.S. is performed by the Associate Administrator For Hazardous Materials Safety in RSPA and specifically within its the Office of Hazardous Materials Technology . The Associate Administrator For Hazardous Materials Safety is also the U.S. member of the IAEA's Transport Safety Standards Advisory Committee (TRANSSAC). Enforcement activities are carried out by all of the DOT administrations listed above, e.g. the four "modal" administrations and the RSPA, which has five regional field offices which carry out its inspection and enforcement activities.

NOTE: The DOT/RSPA Website on the World Wide Web is an excellent resource and source of information on DOT regulatory activities. Its address is:

<http://www.hazmat.dot.gov/>

### **3.3 Organization of the U.S. Nuclear Regulatory Commission (NRC)**

The NRC was created as a new independent agency of the U.S. Government by the Energy Reorganization Act of 1974, which abolished the former Atomic Energy Commission (AEC) and moved the AEC's regulatory function into the new NRC. NRC regulations are issued under the United States **Code of Federal Regulations** (CFR) Title 10, Chapter 1. The nuclear transport regulations of NRC are found in Title 10 CFR Part 71, "Packaging and Transportation of Radioactive Materials"(10CFR71).

The NRC is headed by a five-member Commission. Each Commissioner is appointed to a 5-year term by the US. President with confirmation by the US Senate. A Chairman is designated by the President. When compared to DOT, NRC is a relatively small Federal agency having a Staff numbering about 4000 employees. About two thirds of the Staff are based in its Washington DC area (Rockville, Maryland) Headquarters and the balance located in four regional offices. §10 CFR71 requires NRC licensees who consign radioactive materials to carriers for transport or transport materials in their own vehicles, to follow applicable DOT regulations for consignors and carriers in 49 CFR. NRC in its § 10 CFR71 establishes specific requirements for the design, testing, manufacture, certification and quality assurance of radioactive material packages for Type B quantities (e.g. exceeding Type A) of fissile and non-fissile radioactive materials. DOT regulations in 49 CFR authorize <sup>12</sup> such NRC-certified packages for domestic transportation . In the related activity involving the DOT's role as the U.S. Competent National Authority , the issuance of IAEA package/shipment certificates for international purposes is closely aligned and coordinated with the relevant NRC technical review and package certifications which are issued by NRC pursuant to its 10 CFR 71 requirements.

Note: The NRC Website on the World Wide Web is an excellent resource and source of news and information on NRC regulatory activities. Its address is:

<http://www.NRC.gov/OPA/>

The principal office in NRC involved with transport regulations oversight and package certification is the Office of Nuclear Materials Safety and Safeguards (NMSS) which reports at NRC Staff level to The Deputy Executive Director For Regulatory Programs. Within the NMSS, the principal office for transportation matters and package certifications is the Spent Fuel Project Office (SFPO).

### **3.4 The Role of the U.S. Department of Energy (DOE)**

The U.S. Department of Energy (DOE) is a very large Federal agency, headed by a Presidentially appointed Secretary of Energy, who is a member of the President's Executive Cabinet. Although the DOE is not a "regulatory" agency in the strict sense, it does perform a very significant role in controlling shipments of government-owned radioactive materials by DOE and its Operating

Contractors. Such shipments comprise a very large portion of the total of domestic shipments of radioactive materials in the U.S. and involve all types. e.g., excepted, Type A, Type B (fissile and non-fissile) packages and LSA/SCO materials.. DOT regulations <sup>13</sup> authorize DOE and its contractors to transport domestically such packages which have been essentially "self-certified" by DOE Headquarters. Such packages "..... when made by or under the direction of the DOE may be used for the transport of radioactive materials when evaluated, approved and certified by the DOE .....against packaging standards equivalent to those specified in 10 CFR Part 71.....packages shall be marked and otherwise prepared for shipment in a manner equivalent to that required .....for packages approved by the Nuclear Regulatory Commission.". In other words the DOE Certifications must be in accordance with DOE's Operating Manual and that manual's requirements technically must be essentially equivalent to the §10CFR71 requirements which apply to NRC licensees. As a practical matter, however, in recent years,, almost all package designs in most DOE programs have been routinely submitted for technical review to NRC for their certification (Using 10 CFR Part 71 as a standard) before DOE issues its own certification. In the author's view, it would appear that the day is coming in the distant future, when all packages of DOE origin will probably be required to have been certified by NRC. An excellent information source on DOE packaging and transportation programs, as well as its certification activities is found on the World Wide Web as "www.RAMPAC.com". It contains very useful information on DOE's system for certification of its Type A packages as DOT Specification 7A packages and it also provides current information on all DOE and many NRC certified packages, as well as DOT revalidation of packages against IAEA SS6 standards.

### **3.5 U.S. Postal Service (USPO) Provisions for Mailable Radioactive Matter**

The USPO provisions for "mailable radioactive matter" are found in U.S. postal Service Publication Number 6 <sup>14</sup> . The radioactivity content limits of such mailable packages are consistent with §310 of SS6-85/90. Although the USPO provisions are based largely on the Acts of the Universal Postal Union (UPU) as contained in Paragraphs 476-477 of SS6-85/90, there are two notable differences between that UPU/IAEA standard and its application by the USPO in its Publication No. 6. These differences are:

1. U.S. consignors of mailable radioactive packages destined for international Post are not required to be authorized by the competent national authority, e.g. the U.S. Postal Service, and;
2. Under international postal rules, the outer packaging of a mailable radioactive package is required to be marked with the words "RADIOACTIVE MATERIAL" However, this marking is not required on a package shipped in the U.S. Postal System..

In view of these differences it would be prudent for a mailer of a package in the U.S. to a foreign location consult U.S. Postal Publication # 6 <sup>(9)</sup> requirements before mailing a radioactive material package, as well as Postal requirements of the receiving country also be examined, since certain nations do not allow postal shipments of radioactive matter."

#### 4.0 DOT HAZMAT REGULATIONS IN 49 CFR

The DOT Hazardous Materials Regulations (Hazmat Regulations) are republished each year as of October 1 by the U.S. Office of the Federal Register, National Archives and Records Administration. They are referred to as 49 CFR Parts 100-185. Chapter 1, Subchapter A thereof is titled "Hazardous materials and Oil Transportation". The relevant Parts of 49 CFR to regulating the transport of radioactive material are titled as follows:

49 CFR Part 106	Rule making procedures
49 CFR Part 107	Hazardous materials program procedures
49 CFR Part 171	General information, regulations and definitions
49 CFR Part 172	Hazardous materials table, special provisions, hazardous materials communications, emergency response information, and training requirements
49 CFR Part 173	Shippers-general requirements for shipments and packages
49 CFR Part 174	Carriage By Rail
49 CFR Part 175	Carriage by aircraft
49 CFR Part 176	Carriage by vessel
49 CFR Part 177	Carriage by public highway
49 CFR Part 178	Specifications for packages

#### 5.0 THE A<sub>1</sub>/A<sub>2</sub> SYSTEM OF LIMITING PACKAGE ACTIVITY

##### 5.1. Definition of Radioactive Material for Purposes of the Transportation (§173.403)

**For purposes of transportation**, radioactive materials are defined as those materials which spontaneously emit ionizing radiation and have a specific activity exceeding 70 Bq./gram (0.002 uCi/gm) of material. All materials are to some degree radioactive. *THE DEMARCATION OF 0.002 MICROCURIES PER GRAM ALLOWS A DISTINCTION BETWEEN MATERIALS OF EXTREMELY LOW RADIOACTIVITY WHICH ARE THEREFORE "EXEMPT" FROM REGULATION AND THOSE WHICH ARE REGULATED AS RADIOACTIVE MATERIAL FOR PURPOSES OF TRANSPORTATION.* Materials with a specific activity lower than 0.002 microcuries per gram and in which the activity is **essentially uniformly distributed** are not regulated by DOT or NRC. The IAEA Safety Series No. 6 standards contain the same definition of "radioactive material" for **purposes of transportation**.

Materials which do not meet this definition of radioactive material **ARE NOT SUBJECT TO THE RADIOACTIVE MATERIAL PROVISIONS OF THE DOT REGULATIONS.** A **word of caution**, however, some such materials which are exempt from regulation during transportation **might** still be subject licensing requirements of NRC, EPA or an Agreement State

with respect to use, possession, materials control or waste disposal, or to EPA requirements as a hazardous substance or hazardous waste.

## 5.2 Determining Activity Limits of Packages

THE primary consideration for achievement of safety in the transportation of radioactive materials is the use of proper packaging for the specific radioactive material to be transported. In order to determine the packaging requirements, a prospective shipper or package designer should first consider the following three questions:

**What radionuclides are being shipped?** § 49 CFR 173.435 and Appendix A of §10 CFR 71 contain identical listings of almost 400 specific radionuclides. In that listing, the "A<sub>1</sub>" and A<sub>2</sub>" values are given for each radionuclide. Certain "ground rules" for developing the values for unlisted or unknown radionuclides, or with mixtures of radionuclides, are provided in § 49 CFR 173.433. In using those ground rules, it is important to keep in mind that the shipper must obtain approval from DOT/RSPA for the use of any A<sub>1</sub>/A<sub>2</sub> value which has been derived by a shipper for an unlisted radionuclide [See §173.433(b)]

**What quantity of the radionuclides is being shipped?** The packaging requirements are related to the maximum quantity (activity of material) to be placed in the package terms of activity e.g Becquerel or "Bq" (curies, millicurie, and microcuries).

### A NOTE ON S.I. UNITS

DOT has formally adopted the System Internationale (SI) units, e.g. "Becquerel" in lieu of the existing conventional unit "curie". U.S. policies and procedures for conversion to the metric system were formalized by the Metric Conversion Act of 1975 (Public Law 94-168, 15 USC 205a). The Act declared that U.S. policy shall be to coordinate and plan the increased use of the metric system . SI units are part of the metric system. From a safety standpoint, the need for consistency in radioactive materials package and activity identification is critical. All parties potentially having contact with the package must be able to understand the units used in order to establish proper controls. It is recognized that the US conversion to metric units can create special problems, particularly with education of carriers and package handlers in recognition and understanding of the new SI units. DOT presently allows the use of both SI and customary units, however , with SI units controlling (required SI units may be followed by customary units in brackets).

**What is the form of the radionuclide ?**

- a. **Is the material in special form** (quantity stated as A<sub>1</sub>) ? ; or
- b. **Is the material in normal form** (quantity stated as A<sub>2</sub>

### 5.3 Special Form Radioactive Materials (A<sub>1</sub>)

"Special form" materials are limited to those materials which, if released from a package, would present a hazard due to direct external radiation only. Therefore, due to their high physical integrity, radioactive material contamination is not expected even under severe accident conditions. This high physical integrity is the result of an inherent natural property of the material, such as its being in massive, nondispersable solid form. Most often, however, it is an acquired characteristic, such as being sealed by welding (encapsulation) into an extremely durable metallic capsule. Special form sources must have at least one external physical dimension which exceeds 5 mm. This minimum dimension requirement makes the capsule more easily seen and recovered in the event of its escape from containment in an accident.

Special form encapsulations are required to be constructed in a manner that they can only be opened by destroying the capsule. This requirement is intended to prevent the inadvertent loosening or opening of the capsule, either during transport or following an accident. Thus, "special form" materials are much less likely to spread contamination in the event of package failure. For certain radionuclides, the transport regulations allow substantially larger quantities of special form material to be placed in a package than when the material is in "normal form", i.e., "non-special form". The testing requirements for determination of whether a radioactive material qualifies as "special form" are found in § 173.469.

Special form package activity limits are stated in terms of "A<sub>1</sub>".

For purposes of export, a shipper must furnish to the carrier and to the foreign consignee a certificate of competent authority for the special form material. For purely domestic shipment purposes DOT does not routinely issue special form certificates. Upon request, however and after receipt of a specific petition, DOT/RSPA will issue an IAEA Certificate if such a certificate when required by a shipper to fulfill a potential future need for an export shipment.. The administrative requirements in the U.S. for special form material certificates are found in § 173.476, which are quoted as follows:

#### **" 173.476 Approval of special form Class 7 (radioactive) materials".**

(a) Each offerer of special form Class 7 (radioactive) materials must maintain on file for at least one year after the latest shipment, and provide to the Associate Administrator For Hazardous Materials Safety on request, a complete safety analysis, including documentation of any tests, demonstrating that the special form material meets the requirements of § 173.469, An IAEA Certificate of Competent Authority issued for the special form material may be used to satisfy this requirement."

NOTE: The supplier/<sup>4</sup>manufacturer of a special form source will frequently furnish to the purchaser a special form certificate for the specific special form material. This certificate

should state which tests or analysis that have been performed to demonstrate that the material meets the requirements of § 173.469.

"(b) Prior to the first export shipment of a special form class 7 (radioactive) material from the United States, each offerer shall obtain a U.S. Competent Authority Certificate for the specific material. For special form material manufactured outside the United States, an IAEA Certificate of Competent Authority from the country of origin may be used to meet this requirement.

© Each request for a U.S. Competent Authority Certificate as required by the IAEA regulations must be submitted in writing, in triplicate, to the Associate Administrator for Hazardous Materials Safety.

*NOTE: Shipments of radwaste involve mostly non-special form (normal form) material*

#### **5.4 Quantity Limits and the $A_1/A_2$ Package Activity Limit System**

After considering the type, quantity, and form of the radioactive material, a shipper must then consider the applicable quantity limits for various types of packages. The regulations use the  $A_1/A_2$  values as points of reference for quantity limits for each radionuclide. Every radionuclide is assigned an  $A_1$  and an  $A_2$  value. These two values (in becquerels or curies) represent the maximum activity of that radionuclide that may be transported in a TYPE A package. The following table lists examples of  $A_1$  and  $A_2$  values for a number of typical radionuclides. The  $A_1$  value is the limit of activity for a particular radionuclide in a Type A package when the material qualifies as special form. The  $A_2$  value is the number of curies if the radionuclide is not in Special Form, i.e. when the material is in "normal form,". Multiples of these values are also used to determine the package activity limit of excepted packages, low specific activity (LSA) concentrations and activity of surface contaminated objects (SCO). These  $A_1$  and  $A_2$  values are also used in the regulations as a measure of radiological risk in other limits within the regulations such as the allowable leakage from Type B packages after regulatory performance testing and limits on total activity contents of vehicles. The values are also used as a benchmark for routing and other shipment controls for "Highway Route Control Quantities" (HRCQ) such as spent nuclear fuel..

The derivation of the  $A_1/A_2$  values in the IAEA regulations is based on a series of dosimetric models e.g. the "Q-system", wherein the limiting value for  $A_1$  results from certain worst case assumptions of external direct gamma radiation levels from an unshielded source at a certain distance. The  $A_2$  value, however, is based on the applicability of the most conservative of worst case value for five different scenarios, which include the  $A_1$  scenario plus external beta radiation to skin, inhalation, ingestion and external gamma radiation from immersion in a gaseous cloud of material released from a breached package. A complete description of the details of the modeling techniques for derivation of the values is provided in IAEA Safety Series No. 7, "**Explanatory**

**Material on the IAEA Regulations for the Safe Transport of Radioactive Material (1985 Edition).**

Activity in a package which **exceeds** the applicable  $A_1$  or  $A_2$  value is a "Type B quantity".

The following table lists  $A_1/A_2$  values from §173.435 for some typically transported radionuclides.

<b>SYMBOL</b>	<b>Element And Atomic Number</b>	<b><math>A_1</math> TBq (Ci) Special Form</b>	<b><math>A_2</math> TBq (Ci) Normal Form</b>
$C^{14}$	Carbon (6)	40 (1080)	2 (54.1)
$Cs^{137}$	Cesium (55)	2 (54.1)	0.5 (13.5)
$Ra^{226}$	Radium (88)	0.3 (8.11)	0.02 (0.541)
$Co^{60}$	Cobalt (27)	0.4 (10.8)	0.4 (10.8)
$Ir^{192}$	Iridium (77)	1 (27)	0.5 (13.5)
Thorium (Natural)	Thorium (90)	Unlimited	Unlimited
Uranium (natural)	Uranium (92)	Unlimited	Unlimited
Uranium (Enriched 5% or less)	Uranium (92)	Unlimited	Unlimited
Uranium (Enriched more than 5%)	Uranium (92)	10 (270)	0.001 (0.027)
$Mo^{99}$	Molybdenum(42)	16.2	13.5 <sup>(a)</sup>

(a) 640 Gigabecquerels (20) Ci for domestic shipments

NOTE 1: A package quantity which exceeds  $A_1/A_2$  is a Type B quantity and therefore requires Type B Packaging

NOTE 2: A "Highway Route Control Quantity (HRCQ) also requires Type B packaging, plus additionally, certain highway routing limitations and other requirements [See §§ 173.403 and also 397.101(b) (Federal Motor Carrier Safety Regulations)]

## 5.5 Highway Route Controlled Quantities (HRCQ)-See §173.403

A "Highway Route Controlled Quantity" means a quantity within a package which exceeds:

- (1) 3000 times the  $A_1$  value of the radionuclide as specified in §173.435 for special form Class 7 material; or
- (2) 3000 times the  $A_2$  value of the radionuclides as specified in § 173.435 for normal form Class 7 materials;
- (3) 1000 TBq.(27,000 Curies), whichever is least.

Packages containing a Highway Route Controlled Quantity of radioactive material are subject to specific routing controls which apply to the highway carrier. The carrier must operate on "preferred routes" that conform to § 397.101(b) of the Federal Motor Carrier Safety Regulations. The carrier is required to prepare a written route plan and furnish a copy to the driver and the shipper (before departure for exclusive-use shipments and within 15 days following departure for all other shipments). Also, the driver of a HRCQ shipment must be provided with certain training every two years and must have in his possession a certificate of such training.

NOTE: Pursuant to NRC regulations the carrier must also provide to a designated State agency(s) advanced notification of the shipment and its route. (See §§ 10 CFR 71.97 and 73.72).

Except for shipments made in compliance with the physical security requirements of § 10 CFR 73 of NRC, carriers of HRCQ must also file detailed reports within 90 days of accepting the packages for shipment. The report must include route plans, shipping papers, names of shippers, carriers and consignees, etc. [See §397.101(g)]

## 6.0 CATEGORIES OF RADIOACTIVE MATERIALS PACKAGES

### 6.1 Basic Principle of Radioactive Material Packaging

Fundamental to a good understanding of radioactive materials transportation safety and packaging requirements is the basic premise that:

***SAFETY IN TRANSPORTATION OF RADIOACTIVE MATERIALS PRIMARILY DEPENDS UPON USE THE PROPER PACKAGING, CONSIDERING THE TYPE, QUANTITY AND FORM OF THE RADIOACTIVE MATERIAL AND THE EXPECTATIONS OF HOW THE PACKAGE IS TO PERFORM IN THE ROUTINE AND ACCIDENT ENVIRONMENTS DURING TRANSPORTATION.***

There are essentially five categories of radioactive materials packages. Development of the

technical criteria for each packaging category is correlated to certain performance requirements and general requirements. The categories include;

- Excepted packaging (formerly referred to as "strong tight" packaging)
- Type A packaging
- Type B packaging
- Fissile material packaging (Type A and Type B)
- Industrial Packaging (IP-1, IP-2., IP-3)

NOTE: Low specific activity (LSA) and Surface contaminated objects (SCO) are sometimes categorized by some persons as packaging types. In this Chapter, LSA and SCO are treated as material types rather than as packaging types, and are described in Section \_\_\_\_ Several types of packaging are authorized for shipments of LSA and SCO materials including Industrial packaging, excepted packaging, and Type A packaging.

## 6.2 General Packaging Requirements

Unless excepted, all radioactive materials packages are subject to applicable general requirements in §§ 49 CFR 173 Subparts A and B, as well as the §173.410 "General Design Requirements".

**Part 173, Subparts A and B** It is important that the shipper and package designer specifically review §§ 173.24 (General design requirements for packages and packages) and 173.24a (Additional Design Requirements for non-bulk packages and packages) to determine which requirements therein are applicable.

**§ 173.410 (General design requirements).** It is also important that the shipper and package designer review this Section to assure that the applicable requirements therein have also been met. One of the significant requirements which is sometime overlooked is the vibration effect standard of §§173.410(f) and 178.608.

## 6.3 EXCEPTED PACKAGES

§173.425 is the "Table of Activity Limits-excepted quantities and articles". These limits apply to instruments, articles and limited quantities which are subject to the exceptions in §§ 173.421 and 173.424. In this table, multiples of the  $A_1/A_2$  values are again used as the basis for defining the package activity limits. Packages containing materials within these quantity limits are excepted from many of the requirements which apply to Type A and Type B packages. These include exception from specification packaging, marking, labeling, and shipping paper requirements. (It is important to recognize that although not highly regulated excepted packages are still regulated. They are not exempt from regulation during transportation as would be materials having a specific activity of less than 70 Bq/gm. (0.002  $\mu$ Ci/gram), e.g. not meeting the definition of "radioactive

material" for purposes of transportation.

***NOTE: Excepted package shipments are NOT excepted from the incident reporting requirements of §§49 CFR 171.15 and 171.16 and also are NOT excepted from the Hazardous Material Training Requirements of §49 CFR 172, Subpart H***

### §173.425

#### ACTIVITY LIMITS FOR EXCEPTED PACKAGES

Excepted packages must meet the following:

1. the general design requirements of §173.410;
2. non-fixed contamination limits on package surfaces must not exceed the limits of §173.443(a);
3. The radiation level at any point on the surface of the package must not exceed 0.005 mSv/hour (0.5 mrem/hour)

4. The outside of the inner packaging, or if there is no inner packaging, the outside of the package itself must bear the marking "RADIOACTIVE";
5. For instruments or articles, the radiation level at four inches from any point on the surface of the unpackaged instrument or article may not exceed 0.1 mSv/hour (10 mrem/hour).
6. In lieu of a specific shipping paper, a prescribed certification statement referencing the

The specific 49 CFR paragraphs for the various categories of excepted radioactive packages include:

- § 173.421 Excepted packages for limited quantities of Class 7 (radioactive) materials
- § 173.422 Additional requirements for excepted packages containing Class 7 (radioactive) materials
- § 173.423 Requirements for multiple hazard limited quantity Class 7 (radioactive) materials
- § 173.424 Excepted packages for radioactive instruments and articles
- § 173.426 Excepted packages for articles containing natural uranium or thorium
- § 173.427 Transport requirements for low specific activity (LSA) Class 7 (radioactive materials and surface contaminated objects (SCO)
- § 173.428 Empty Class 7 (radioactive) materials packaging

### **A WORD ABOUT "EMPTY PACKAGES"**

The provisions of § 173.428 for EMPTY radioactive materials packages are frequently misunderstood and often incorrectly applied in practice. The EMPTY package provision is intended to provide exceptions from certain requirements for a radioactive materials packaging which has been emptied of its radioactive contents as far as practicable, but still contains residual radioactivity. This residual radioactivity limit, however, is not quantified or stated in terms of activity content, but rather in terms of internal contamination. Such internal contamination is limited to 100 times the contamination limits of §173.443 which are the usual limits for removable (non-fixed) contamination on exterior package surfaces. Sampling the interior of the containment system of a radioactive materials package for contamination by the use of wipe sampling techniques is often not practical or feasible. A practical alternative to use of the EMPTY label would be to make a reasonable estimate of the radioactivity content. If it is found not to exceed a "limited quantity" pursuant to §173.425, simply use the proper shipping name "Radioactive material, excepted package-limited quantity of material".

Some shippers also mistakenly apply an EMPTY label to a packaging which has no residual internal radioactivity or contamination. Such a package is not regulated as an EMPTY package. As an example, certain types of shielded shipping packages for radiography and teletherapy sources utilize built-in shielding materials of either lead or depleted uranium. When the contained sealed source, typically special form Ir<sup>192</sup> or Co<sup>60</sup> has been removed, there should be essentially no internal contamination. Instead of shipping such a package as an EMPTY radioactive package, it is more appropriate to consider the package with the uranium shielding as an excepted package describing the shipment as "Radioactive material-excepted package-article manufactured from

depleted uranium" and ship it under the provisions of §173.426. The package with the lead shielding and no contained source would not be regulated at all as a hazardous materials package.

#### 6.4 TYPE A PACKAGES

Type A packaging is that which must be designed so as to comply with the applicable general packaging/design requirements (§§ 173.24, 173.24a. and 173.410), plus the additional design requirements for Type A packaging (§ 173.412). It must be adequate to prevent the loss or dispersal of its radioactive contents and to maintain its radiation shielding properties if the package is subjected to the normal conditions of transportation. These normal conditions are essentially performance tests and environmental conditions intended to simulate normal rigors and physical stresses such as rough handling conditions. (See §173.465).

Essentially, the only authorized DOT specification Type A package in the U.S., and consequently the most widely used, is the DOT-7A [See §§ 173.415(a) and 178.350] which is based totally on performance test conditions rather than on hardware or design requirements. The DOT-7A provides the package designer with maximum latitude in the use of engineering creativity to produce optimally useful and economic designs. However, with this freedom comes attendant responsibility to ensure that the package design meets all specification requirements and is properly used. Using any of the methods authorized in §173.461, each shipper of a DOT-7A package must perform his own assessment of the ability of his DOT-7A design to meet the performance requirements and must document and maintain on file this "self-approval". DOT-7A designs are not required to be approved by either DOT or NRC. Additionally, Type A packages of foreign origin which are marked "Type A" and meet the standards of IAEA SS6-85/90, may be used provided that the shipper obtains and maintains on file the applicable Type A evaluation and documentation performed by the foreign shipper.

A major area of misunderstanding is the DOT-7A Type A certification and safety analysis of the package design. The Type A certification is a result of demonstrated performance (through testing or analysis) of a package, including its specific contents. Consequently, each design must be specifically certified as meeting the DOT-7A requirements. Each time the contents change or the packaging components change (i.e. content weight, material form, closure, etc.) the ability of the modified package must be re-evaluated with respect to the performance criteria, before the Type A designation may be assigned.

A useful reference document <sup>(51)</sup> in evaluating whether an existing DOT-7A design meets the specification requirements is DOE/RL-96-57 (formerly AC-EP-0558). This report, by a DOE contractor, is the fourth in a series of DOT-7A evaluation documents <sup>(52)(53)</sup> which have been used by many shippers as a basis for making certifications of their own designs. Reference is frequently made to relevant supporting information in this and earlier such reports. CAUTION should be exercised since the information in that document should be supplemented with the shipper's additional comparative analysis of his specific contents relative to the surrogate contents of the test document and other package parameters, e.g. weights, closures, etc. of the test document.

#### **6.4.1 Liquid Packaging for Type A Packages (§ 173.412(k))**

A package intended for liquid Type A radioactive materials must be designed to provide for ullage (expansion) to accommodate variations in the temperature of the contents, dynamic effects and filling dynamics. Liquid radioactive material must also be packaged in a leak-resistant inner container. In addition, the packaging must be adequate to prevent loss or dispersal of the radioactive contents from the inner container if the package were subjected to the 9 meter (30-foot) drop test prescribed in Section 173.466(a)(1). For the penetration test of §173.465(e), the drop height of the penetrator must be 1.7 m (5.5 ft), and sufficient absorbent material must be provided to absorb at least twice the volume of the radioactive liquid contents. Care should be exercised by the package designer to assure that the positioning of the absorbent material about the liquid-containing vessel is such that the "absorber will absorb" in the event of leakage from the vessel. Optionally, an alternative which may be used in lieu of using the double absorbent is a double containment design feature. The package also requires a marking indicating the upward orientation position of the inside packaging (See §172.312).

### **6.5 TYPE B PACKAGES**

#### **6.5.1 Package Test Standards**

Type B packaging must meet the general packaging and performance standards for Type A packages and additionally must have the ability to survive certain serious accident damage tests (hypothetical accident conditions). After the tests, there may be only a very limited loss of shielding capability and essentially no loss of containment, as measured by leak-rate testing of the containment system of the package. The performance criteria which the package designer must use to assess his Type B package design against the empirically established hypothetical accident conditions are prescribed in 10 CFR Part 71 of the U.S. Nuclear Regulatory Commission (NRC) regulations (§ 10 CFR 71.73) and include the following sequential tests:

1. A 30-foot free fall of the test package onto a totally unyielding surface;
2. If applicable, for certain contents and package density, subjecting the test specimen to a dynamic crush test by positioning the specimen on a flat, essentially unyielding, horizontal surface so as to suffer maximum damage by the drop of a 500 kg. (1100 lbs.) steel plate mass from 9 meters (29.5 ft) onto the test package.
3. A puncture test as a free drop of the test package from a height of 1 m (39.4 in) onto a 15 cm (5.91 in) diameter vertical steel peg;
4. Exposure to a thermal environment of 800°C(1475°F) for 30 minutes;
5. Water immersion of the test package under at least 15 meters (50 ft.) depth; and

5. For fissile packages where water in-leakage is not assumed in the criticality analysis, immersion of the test package under a head of water of at least 0.9 meters (3 ft)

NOTE: Several of the NRC Regulatory Guides<sup>(23)</sup> in Division 7-Transportation are useful reference resources relative to the engineering tests listed above, specifically, Regulatory Guides 7.3, 7.4, 7.6,7.8, 7.11 and 7.12. Another valuable document is NUREG-1609 "Standard Review Plan for ransportation Packages for Radioactive Materials."

Type B packages cover a wide range of physical size, from small radiographic devices to large waste casks and spent nuclear fuel casks.

### **6.5.2 Authorized Type B Packages**

Except for just a few DOT Specification Type B packages described in § § 49 CFR 173 and 178, such as the DOT-6M and the DOT-20WC, (See §10 CFR 71.14 for NRC authorization) the vast majority of other authorized Type B packages are those designs which have been certified by NRC and approved under a NRC Certificate-of-Compliance and General License issued pursuant to §10 CFR 71.12. The DOT authorization for use of NRC approved Type B packages is provided in §173.416(b) and the standard requirements applicable to their use are in §173.471. A significant number of authorized Type B packages in current usage are those approved by the U.S. Department of Energy (DOE) pursuant to the authority provided by DOT in §173.7. Many of these DOE-certified packages are also certified by NRC.

A useful reference for Type B packages which have been certified by NRC is NRC Report, NUREG-0383<sup>(22)</sup>, which is updated annually in three volumes. The three separate volumes include : a registry of authorized users who have registered with NRC, a registry of actual copies of each current Certificate-of-compliance and a registry of NRC-certified Quality Assurance programs which have been issued pursuant to § 10 CFR 71, Subpart H.

### **6.5.3 Foreign-Made Type B Packages**

Type B Packages of foreign-origin which meet the applicable requirements of IAEA SS6-85/90 and the certificate by the foreign competent authority must be revalidated by DOT pursuant to §173.473 (See also §10 CFR 71.16)..Such packages are authorized only for export shipments from and import shipments into the US. For purely domestic shipments of such packages, NRC Certification of the package must be obtained.

## 6.6 INDUSTRIAL PACKAGING (§173.411)

This new category "Industrial Packaging" (IP) was added to 49 CFR with the Docket-169A amendments in 1995. IP's are prescribed for use in certain shipments of LSA and SCO materials (See Section VI). Three categories are established, e.g. IP-1, IP-2 and IP-3. The requirements for each IP category are as follows:

- **IP-1** Each IP-1 must only meet the general design requirements prescribed in §173.410. Except for this specific requirement, IP-1 packaging is essentially equivalent to the former "strong tight packaging" previously prescribed in 49 CFR for excepted packages and LSA materials when shipped as exclusive-use. NOTE: Strong-tight packaging is still currently authorized for exclusive use domestic shipments of LSA and SCO materials with package activity not to exceed  $A_2$ .
  
- **IP-2** Each IP-2 must meet the general design requirements of an IP-1 and additionally, when subjected to the free drop and stacking (compressive load) tests specified in §§ 173.465© and (d) or evaluated against these tests by any the authorized methods of § 173.461(a), must prevent:
  - (I) loss or dispersal of the radioactive contents, and;
  - (ii) A greater than 20% increase in the radiation levels recorded or calculated at the external surfaces for the condition before the test.

**(IP-2 packaging is therefore, in effect, a "limited Type A Package")**

- **IP-3** Each IP-3 must meet the requirements of an IP-1 and IP-2 and must additionally meet the requirements specified in §§173.412(a) through (j).

**(IP-3 packaging is therefore, in effect, an "almost type A package" or a "Type A package for solids only")**

## 6.7 FISSILE RADIOACTIVE MATERIAL PACKAGES AND SHIPMENTS

As defined in §173.403, "**fissile material** means plutonium <sup>238</sup>, plutonium <sup>239</sup>, plutonium <sup>241</sup>, uranium<sup>233</sup>, uranium<sup>235</sup> or any combination of these radionuclides. Unirradiated natural uranium and depleted uranium and natural uranium or depleted uranium that has not been irradiated in thermal reactors only, are not included in this definition. Certain exclusions are provided in §173.453."

In addition to considerations for radioactive content (radiological safety), a shipper of fissile radioactive material must also take into account certain other requirements to insure against accidental nuclear criticality (Nuclear safety). Packagings for fissile radioactive materials may be either fissile Type A or fissile Type B. For instance, unirradiated low-enriched uranium fuel assemblies have low radioactivity content and may be shipped in Type A packaging which requires

little shielding, whereas irradiated spent fuel assemblies have very high radioactivity content and must be shipped in heavily shielded Type B casks.

As is the case for non-fissile Type B quantities, except for several DOT Specification packagings, e.g. DOT-6M, DOT-6L, DOT-20PF and DOT-21PF, all other Type A and Type B fissile packagings in use are those which have been certified by NRC under the authority of §173.417 (a)(4) and (b)(3) or by DOE, pursuant to the authority of §173.(7)(b). Fissile packages of foreign origin are subject to the same DOT revalidation requirements as non-fissile Type B packages.

Prior to the 1996 DOT amendments (HM-169A), fissile material shipments were grouped into three classes, e.g. Fissile Class I, II and III. Administrative control of Fissile Class I shipments was based on the radiation-based transport index (TI), with virtually no limits on the number of packages in a shipment for nuclear criticality safety purposes. Fissile Class II packages were limited to a single package TI of 10 (based on radiation or criticality, whichever was higher) and the 50 TI/vehicle limit. Fissile Class III shipments were limited to a specified number of packages in an exclusive-use vehicle. Now, with the elimination of the three fissile classes, administrative control of all packages during transport is now based on the TI and the 50 TI/vehicle limit. However, for those fissile packages previously designated as Fissile Class III and limited to a specified number of packages per vehicle, a new term "Fissile material controlled shipment" has been developed which means

"....any shipment that contains one or more packages that have been assigned transport indices greater than 10 in accordance with §173.457".

Although that Section allows certain other controls, the primary means of administrative control for a "fissile material controlled shipment" to preclude co-mingling of that shipment with another fissile shipment and prevention of an accidental criticality during transport is the exclusive use vehicle.

## **6.8 LOW SPECIFIC ACTIVITY (LSA) AND SURFACE CONTAMINATED OBJECTS (SCO)**

By far the most important categories of DOT transport regulations relating to radwaste shipments are LSA (Low Specific Activity) and SCO (Surface Contaminated Objects). Historically, the transportation category of Low Specific Activity (LSA) has been one of the most frequently misunderstood areas of DOT/NRC regulations. With the DOT and NRC amendments of 1996, a previous inconsistency in the LSA requirements of the two agencies has been eliminated. LSA was redefined and grouped into three categories, LSA-I, LSA-II and LSA-III. A new category, similar to LSA, has also been defined and is termed "Surface-contaminated objects or "SCO", which has two categories, e.g. "SCO-I" and "SCO-II".

LSA and now SCO are extremely important radioactive material classifications applicable to shipments of lower and medium level radioactive waste materials. A majority of shipments of such wastes originating from the nuclear fuel cycle, as well as the industrial, institutional and academic communities are in the form of LSA materials of varying forms of solid materials. The new SCO category was developed in the regulations and intended be an extremely important category for shipments of solid waste materials or objects which are not radioactive but have quantifiable amounts of contamination on their surfaces. Such materials involve materials originating from cleanup, remediation and decontamination activities.

LSA materials are those which present a relatively low hazard as a result of their limited concentration, i.e. specific activity. Some LSA materials are inherently designated as LSA-I, regardless of their specific activity, such as unirradiated uranium and thorium. Also, tritiated water at a specified activity limit per liter is also designated as LSA-II. The majority of LSA materials, however, are those which are limited in multiples of  $A_2$  per gram as solids or liquids.

### 6.8.1 DEFINITION OF LSA

As defined in §173.403 and §71.4, "Low Specific Activity (LSA) Material" means radioactive material with limited specific activity which satisfies the descriptions and limits set forth below. Shielding materials surrounding the LSA material may not be considered in determining the average specific activity of the package contents. LSA materials must be in one of three groups:

#### LSA-I

- (i) Ores containing only naturally occurring radionuclides (e.g, uranium, thorium) and uranium or thorium concentrates of such ores; or
- (ii) Solid unirradiated natural or depleted uranium or natural thorium or natural thorium or their solid or liquid compounds or mixtures; or
- (iii) Class 7 (radioactive) material, other than fissile material, for which the  $A_2$  value is unlimited; or
- (iv) Mill tailings, contaminated earth, concrete, rubble, other debris, and activated material in which the Class 7 (radioactive) material is essentially uniformly distributed and the average specific activity does not exceed  $10^{-6}A_2/g$ .

#### ( LSA-II

- (I) Water with tritium concentration up to 0.8 TBq/liter (20.0 Ci./liter); or material in which the radioactive material is distributed throughout and the average specific activity does not exceed  $10^{-2}A_2/g$  for solids and gases and  $10^{-5}A_2/g$  for liquids

**LSA-III** Solids (e.g. , consolidated wastes, activated materials) that meet the requirements of §173.468 and which:

(i) The Class 7 (radioactive) material is essentially uniformly distributed throughout a solid or a collection of solid objects, or is essentially uniformly distributed in a solid compact binding agent (such as concrete, bitumen, ceramic, etc); and

(ii) The Class 7 (radioactive) material is relatively insoluble, or it is intrinsically contained in a relatively insoluble material, so that, even under loss of packaging, the loss of Class 7 (radioactive) material per package by leaching when placed in water for seven days would not exceed  $0.1 A_2$ ; and

(iii) The average specific activity of the solid does not exceed  $2 \times 10^{-3} A_2/g$ .

### 6.8.2 DEFINITION OF SCO

1) As defined in §173.403 and §71.4, "Surface contaminated object (SCO) means a solid object which is not itself radioactive but which has Class 7 (radioactive) material distributed on any of its surfaces. SCO must be in one of two groups with the surface activity not exceeding the following limits:

(1) SCO-I: A solid object on which:

(i) The non-fixed contamination on the accessible surface when averaged over  $300 \text{ cm}^2$  (or the area of the surface if less than  $300 \text{ cm}^2$ ) does not exceed  $4 \text{ Bq/cm}^2$  ( $10^{-4}$  microcurie/ $\text{cm}^2$ ) for beta and gamma and low toxicity alpha emitters, or  $0.4 \text{ Bq/cm}^2$  ( $10^{-5}$  ) for alpha emitters.

(ii) The fixed contamination on the accessible surface averaged over  $300 \text{ cm}^2$  (or the area of the surface if less than  $300 \text{ cm}^2$ ) does not exceed  $4 \times 10^4 \text{ Bq/cm}^2$  (1.0 microcurie/ $\text{cm}^2$ ) for beta and gamma and low toxicity alpha emitters, or  $4 \times 10^3 \text{ Bq/cm}^2$  (0.1 microcurie/ $\text{cm}^2$ ) for alpha emitters; and

(iii) The non-fixed contamination plus the fixed contamination on the inaccessible surface averaged over  $300 \text{ cm}^2$  (or the area of the surface if less than  $300 \text{ cm}^2$ ) does not exceed  $4 \times 10^4 \text{ Bq/cm}^2$  (1 microcurie/ $\text{cm}^2$ ) for beta and gamma emitters and low toxicity alpha emitters, or  $4 \times 10^3 \text{ Bq/cm}^2$  (0.1 microcurie/ $\text{cm}^2$ ) for all other alpha emitters."

### 6.8.3 Practical Application of SCO-I and SCO-II Limits

Differentiation is made in the SCO-I and SCO-II categories, in terms of their allowable contamination levels. SCO-II materials are allowed to have the higher levels of fixed and non-

fixed contamination. This differentiation defines which type of industrial packaging is required for SCO. Whether it be exclusive or non-exclusive use shipments, SCO-I are required to utilize IP-1 packaging and SCO-II are required to utilize IP-2 packaging. IP-3 packaging is expected to be infrequently required since its use is required only for non-exclusive use shipments of LSA-II liquids and gases and LSA-III.

For SCO-I, the fixed contamination level is  $10^4$  times the non-fixed contamination level. For SCO-II since there may be 20 times as much fixed contamination than non-fixed, higher integrity IP-2 packaging is required for SCO-II. The largest practical problem anticipated with the use of the SCO provisions appears to be the determination of what constitutes "inaccessibility" with respect to the limits for non-fixed plus fixed contamination on inaccessible surfaces. . Examples of inaccessible surfaces on an SCO type of material would be:

- inner surfaces of pipes, the ends of which are securely closed by conventional methods;
- inner surfaces of maintenance equipment, such as under water pool cutters, contaminated pumps, etc;
- glove boxes with access ports blanked off.

The measurement of the fixed and non-fixed contamination on such inaccessible surfaces may sometimes prove to be an intuitive and somewhat inexact science. In many cases the levels will have to be estimated from historical data derived after cleanup or dismantling of the item in question. From such data, formulas or ratio methods may be developed which will enable the prediction and estimation of the levels before the shipment. In any case, the methods used to convert an area from an "accessible" to an "inaccessible" area will probably be quite conventional, but should provide reasonable assurance is provided that the contamination is retained in the inaccessible position during normal transport.

In the event of shifting or migration from its inaccessible position, contamination must be retained within the interior of the inner packaging. Thus, the use of suitable liners or wrapping between the SCO item and the exterior packaging may be appropriate. Another important consideration is whether the "shifted contamination", although remaining "inaccessible", might possibly cause external dose rates on the exterior of the package or vehicle to exceed the limits of §173.441.

#### **6.8.4 Radiation Level Limit for Unshielded LSA/SCO Materials**

§173.427(a) imposes a very important additional condition for LSA and SCO which is based on the limitation of §422 of SS6-85/90). Simply stated, the quantity of LSA or SCO material in a single authorized package or object or collection of objects must be so restricted that the external radiation level at 3 m. from the unshielded material or object does not exceed 10 mSv/h (1 rem/h).

***COMPLIANCE WITH THIS REQUIREMENT IS NOT POSSIBLE BY  
SIMPLY ADDING SHIELDING TO THE PACKAGING—THE INHERENT  
PROPERTY OF THE MATERIAL MUST BE SO LIMITED THAT OUTSIDE***

***OF ANY SHIELDING, THE DOSE RATE MUST NOT EXCEED THE LIMIT OF 1 REM/HR AT THREE METERS—IF IT DOES, THE MATERIAL MAY NO LONGER BE CONSIDERED LSA OR SCO AND WILL LIKELY REQUIRE TYPE B PACKAGING !***

The addition of the 1 rem/h limiting dose rate at 3 meters from unshielded LSA/SCO materials was adopted with the intent to limit the accident consequences associated with LSA and SCO to essentially the same level as that associated with Type A packages. For a Type A package, the  $A_1$  value is based on the unshielded contents of a Type A package creating a radiation level of 100 mSv/h (10 rem/h) at a distance of 1 m.

### **6.8.5 Authorized LSA/SCO Packaging**

With the issuance of the HM-169A amendments and the 10 CFR 71 revisions in 1995, DOT regulations now effectively authorize the following packages for shipment of LSA and SCO materials:

1. For domestic transportation only, strong tight packaging [§173.427(b)(3)] when transported as exclusive-use in a closed transport vehicle, not exceeding an  $A_2$  quantity in each packaging.
2. For domestic transportation only, in DOT Specification 7A Type A packaging [§173.427(b)(2), §173.412 and 178.350], except that the requirements of §§173.412(a), (b), (c) and (k) do not apply;
3. IP-1, IP-2 and IP-3

**NOTE: The former "NRC-certified Greater Than Type A LSA Packages" are no longer authorized as such.** These packagings included about forty designs, formerly listed in NUREG-0383 <sup>(22)</sup> which had been previously certified and approved by NRC for greater than Type A (e.g. Type B) quantities of LSA material. Pursuant to §10 CFR 71.52 after April 1, 1999, these packagings are no longer authorized for LSA contents wherein the dose rate from the unshielded material exceeds the 1 rem/hr at 3 m limit. If the dose rate does not exceed this limit, the packages are being continued in use when redesignated as DOT-7A Type A packages

### **6.8.6 Conveyance Activity Limits for LSA Materials and SCO**

The international activity limits for conveyances and vehicles, as stated in §426 of SS6-85/90 were adopted by DOT in 1995 and are in a table at § 173.427. In these limits, special attention has been given to the greater potential hazards of dispersibility presented by full loads of LSA-II and III as combustible solids and liquids and gases in the event of an accident involving package failure and fire.

**NOTE: An important reference resource which provides guidance on implementation of the current LSA/SCO requirements is a jointly prepared NRC/DOT document: NUREG-1608 (RAMREG-003) "Categorizing and Transporting Low Specific Activity Materials and Surface Contaminated Objects", July 1998**

## **7.0 HAZMAT COMMUNICATIONS AND OTHER REQUIREMENTS §49 CFR PART 172**

An essential component of the total system for providing safety in transport of radioactive materials is the requirement for communication of information on the specific hazards of the materials. The "Hazmat Communications" requirements of 49 CFR Part 172 are designed so as to complement the basic requirements for package activity limitation and package integrity. Historically, Part 172 has addressed the "conventional" communications requirements, such as proper shipping names, shipping papers, package marking, package labeling, and vehicle placarding. In recent years, additional subparts have been added to Part 172 to address emergency response information and hazmat employee training.

**7.1 Subpart B, §172.101 List of Hazardous Materials and Proper Shipping Names for radioactive materials.** This Hazardous Materials Table in §172.101 classifies those materials which DOT has designated as hazardous materials for purposes of transportation, and prescribes the requirements for shipping papers, marking, labeling and transport vehicle placarding applicable to the shipment and transportation of those hazardous materials. For each listed material, the Table also identifies the hazard class, UN Identification number and gives the "proper shipping name" or directs the user to the correct proper shipping name. In addition, the table specifies or references other regulatory requirements pertaining to labeling, packaging, quantity limits aboard aircraft and stowage of hazardous materials aboard vessels.

In using the §172.101 table, it is important that the "ground rules" which explain the application of the information in the 10 columns of the table, as well as the explanatory symbols be taken into account. [See §§ 172.101 (a) through (l)].

The most commonly used Proper shipping names for radioactive materials are listed below. The proper shipping names for the less frequently encountered radioactive materials, all of which are of a comparatively low order of radioactivity, but have a secondary hazard characteristic, are also listed.

**MOST COMMONLY USED PROPER SHIPPING NAMES FOR RAM**  
(From §172.101)

- Radioactive material, excepted package-articles manufactured from natural uranium or depleted uranium or natural thorium, UN 2910
- Radioactive material, excepted package-limited quantity of material, UN 2910
- Radioactive material, surface contaminated object or Radioactive material, SCO, UN 2913
- Radioactive material, low specific activity or Radioactive material, LSA, n.o.s., UN 2912
- Radioactive material, special form, n.o.s., UN 2974
- Radioactive material, fissile, n.o.s., UN 2918
- Radioactive material, n.o.s. UN 2982

**LESS FREQUENTLY USED PROPER SHIPPING NAMES FOR RAM**  
(From §172.101)

**(All are low order of radioactivity, but have a secondary hazard characteristic)**

- Thorium metal, pyrophoric UN 2975
- Thorium nitrate, solid UN 2976
- Uranium metal, pyrophoric UN 2979
- Uranyl nitrate hexahydrate solution UN 2980
- Uranyl nitrate, solid UN 2981
- Uranium hexafluoride, fissile (*containing more than 1 % U-235*), UN 2977
- Uranium, hexafluoride, *fissile excepted or non-fissile* UN 2978

**7.2 Subpart C. Shipping Paper Requirements (§§172.200-172.205)**

As with other hazardous materials shipments, certain essential elements of information must be included on shipping papers. The availability of a complete and correct shipping paper description for a hazardous material shipment is vital not only to the carrier and the consignee, but also to emergency response personnel in the event of an incident.

**1. Basic Shipping Paper Requirements** The shipping paper description must include the following, in the order listed below:

- a. The proper shipping name from §172.101;
- b. The UN hazard class or division-radioactive materials are hazard class 7;
- c. The UN Hazard Identification number

- d. The net quantity of material by weight or volume. For most radioactive materials, it is not required to list the weight or volume, since the additional requirements of §172.203(d) provide better information, e.g the radioactivity content in becquerels (curies). A listing of weight or volume is usually needed only with respect to establishing freight charges;
- e. The letters "RQ", if the shipment is a "hazardous substance". (see §172.101, Appendix A, Table 2 for RQ values of radionuclides).
- f. An emergency response telephone number (see Subpart G,172)

2. Additional Shipping Paper Description, the shipping paper description for radioactive materials must also include the following [§172.203(d)]:

- a. The words "RADIOACTIVE MATERIAL", unless these words are contained in the proper shipping name;
- b. The name of each radionuclide in the material as listed in §173.435; For mixtures of radionuclides only the radionuclides that constitute 95% of the mixture as derived in §173.433(f) need be listed on shipping papers and package labels.
- c. A description of the physical and chemical form of the material, unless the material is "special form". A generic description of the material, such as protein, carbohydrate, enzyme etc., is authorized if the exact chemical form is difficult to specify;
- d. The activity contained in each package in the shipment in appropriate SI units (e.g. Becquerel, Terabecquerel, etc.) or in terms of appropriate SI units followed by customary units (e.g. curies, millicuries, etc.). Curie units are allowed following the required SI units. Except for Pu-238, Pu-239 and Pu-241, the weight in grams or kilograms of fissile radionuclides may be inserted instead of activity units. For Pu-238, Pu-239 and Pu-241, the weight in grams or kilograms may be inserted in addition to the activity units. If the package contains a "Highway Route Controlled Quantity", those words must also be shown with the basic description;
- e. The category of RADIOACTIVE label applied to each package in the shipment, for example : "RADIOACTIVE-WHITE I".
- f. The transport index assigned to each package in the shipment bearing RADIOACTIVE-Yellow II and RADIOACTIVE YELLOW-III labels;
- g. For a shipment of fissile material, the additional information required in §172.203(d)(7); e.g. the words "fissile excepted", "Warning fissile material-controlled shipment...etc";

NOTE: For a package containing a fissile nuclide having an activity content less than the definition of "radioactive material" (70 Bq/g or 0.002 Uci/g), the term "Fissile Excepted" need not be added, since materials having activity content less than the transport definition of radioactive material are not subject to transportation regulation.

h. For a shipment required to be consigned as exclusive use, an indication that the shipment is consigned as exclusive use, along with any appropriate special instructions to the carrier relative to maintenance of exclusive use shipment controls.

i.. For a shipment of LSA or SCO materials, the appropriate group notation, e.g. LSA-I, SCO-II, etc.

j.. The certificate identification marking required on the package must also be noted on the shipping papers if the package is one which is approved and certified by the NRC or DOE, or is a package of foreign origin which has been revalidated by DOT.

### 3. Other Information and Examples of Shipping Papers Entries

As indicated above, a great deal of specific information is required on shipping papers for radioactive materials. While there is no precise prescription for the shipping paper format, the first three entries must be in a specific order.

NOTE: Regulations of international transport organizations such as ICAO and IATA effectively do prescribe the format for shipping documents, airbills, shippers declaration, etc.

Other descriptive information is allowed, such as the functional description of the product. This additional description must not confuse or detract from the required description. The following are some example entries of different ways radwaste shipments might be described on shipping papers:

- Three (3) drums, Radioactive material, LSA, n.o.s., Class 7, UN 2912, non-compacted solid debris and waste, Cs<sup>137</sup>, Co<sup>60</sup> and Sr<sup>90</sup>, solid as inorganic salts or elemental, 0.04, 0.01 and 0.005 mCi. respectively. Drum Nos. 731, 680, and 541 are IP-2 packaging. See attached Radwaste Manifest (NRC Form 540) attached. Exclusive-use shipment instructions attached for more details. In emergency, contact (24-hour) 1-800-000-000

This entry is appropriate for describing IP-2 packages in the form of drums that are shipped in an "exclusive use" vehicle. Drums must be marked "Radioactive LSA"

and the vehicle must be placarded RADIOACTIVE. Package labels are not required, but are not forbidden. The detailed contents of each drum would be on an attached NRC Form 540 "Radwaste Manifest".

**4. Documentation for excepted packages** Packages shipped pursuant to the exceptions provided in §173.421, 173.424, 173.426 and 173.427 (for Limited Quantity Packages, Instruments or Articles, Articles Manufactured from Natural or Depleted Uranium or Natural Thorium and empty radioactive materials packaging) are excepted from the detailed shipping paper description requirements.

Such excepted packages must, however have a certification statement or notice "in" or "on" the package or forwarded with the package. That notice must include the name and address of the consignor or consignee and a specific statement which is selected on the basis of the proper shipping name for the package.

**8.0. RADIATION AND CONTAMINATION LIMITS**  
(See §§173.441 and 173.443)

**8.1 PACKAGE RADIATION LIMITS**

The limits on radiation levels of a package offered for transportation are found in §173.441. Subparagraph (a) thereto reads as follows:

"Except as provided in paragraph (b) of this section, each package of Class 7 (radioactive materials offered for transportation shall be designed and prepared for shipment so that under normally incident to transportation the radiation level does not exceed 2 mSv/hour (200 mrem/hour) at any point on the external surface of the package and the transport index does not exceed 10."

*UN finished from this point*

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*still Need to add sections on  
contamination limits  
Typical Radwaste packaging  
future regulatory revisions (ST-1)  
More on Emergency response into aspects*