LSA AND SCO DETERMINATIONS KEY TO MANAGING LOW-LEVEL WASTES

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ABSTRACT

Today's nuclear industry should be concerned that some waste shippers are improperly classifying low-level waste as low specific activity radioactive material for packaging and transportation to waste disposal facilities. If low-level waste is improperly classified, wrong packaging systems may be used, communication standards may not be met, and safety problems may be created.

BACKGROUND

Westinghouse Hanford Company conducts numerous hazardous material training courses at the Hanford Site for waste management personnel. These people generally work at a variety of waste-processing facilities, laboratories, and remediation sites where low-level waste (LLW) is generated. The courses also are delivered to U.S. Department of Energy (DOE) facilities across the country to help ensure that transportation personnel understand and execute correct procedures to meet applicable federal and state regulations. Questions raised by students at these training sessions demonstrate that low-specific activity (LSA) defining criteria are not well understood, particularly the difference between LSA radioactive materials and LSA surface-contaminated objects (SCO).

Additional evidence supporting this concern is available from recent site assessments, audits, and appraisals conducted at waste-generating facilities. These site evaluations indicate that many LLW generators frequently misapply LSA radioactive material criteria to non-radioactive SCOs. The impact of this error is that some LLW must be repackaged prior to shipment. If errors are not caught, regulatory violations can occur and shipment safety can be affected.

This paper discusses U.S. Department of Transportation (DOT) criteria used for classifying LLW as LSA materials or as SCOs. Waste management procedures to ensure that nuclear facilities use defining criteria correctly when preparing waste for shipment and disposal also are discussed.

Case studies are used to facilitate understanding of the requirements and assist LLW generators in setting up effective programs for handling LSA and SCO shipments. The units of measure used in discussing applicable regulations and the case studies that follow will reflect regulatory language in the 1991 edition of the referenced sources.

DEFINING CRITERIA FOR LOW-SPECIFIC ACTIVITY MATERIALS AND SURFACE CONTAMINATED OBJECTS

The DOT specifies five principal criteria for defining LLW as LSA material. The criteria are found in the DOT Hazardous Material Regulations, Title 49, Code of Federal Regulations (CFR), Part 173, specifically Sub-part I, Section 173.403(n), paragraphs (n)(1) through (n)(5). (1)

- Paragraph 173.403(n)(1) identifies, uranium or thorium ores and the physical and chemical concentrates of the ores as LSA material.
- Paragraph 173.402(n)(2) lists unirradiated natural and depleted uranium, and unirradiated thorium.
- Paragraph 173.403(n)(3) covers tritium oxide in aqueous solutions provided the concentration does not exceed 5.0 mCi/mL.
- Paragraphs (n)(4) and (n)(5) appear to create the greatest confusion and misunderstanding.
- Paragraph 173.403(n)(4) applies to radioactive materials in which the radioactivity is essentially uniformly distributed throughout the waste matrix and the estimated concentration of identified radionuclides does not exceed specified limits. The limits are based on radiotoxicity and activity levels per gram of waste. Examples of such materials include contaminated soil from a liquid spill, contaminated solutions, and irradiated metal reactor components. In each case, the activity per gram is very low, generally between 0.1 to 300 μCi/g, depending on the radionuclides involved. The reference paragraph gives specific limits.
- Paragraph 173.403(n)(5) applies to non-radioactive objects (e.g., tools, process equipment, and building materials) that may be internally and externally contaminated with radioactivity. The external contamination must not be readily dispersible, and the non-fixed contamination when averaged over an area of 1 m^2 must not exceed specified limits. Authorized limits vary with each radionuclide between 0.1 and 1 $\mu Ci/cm^2$. The referenced paragraph gives specific limits.

Some packaging and transportation professionals believe waste generators misapply the LSA criteria of paragraphs (n)(4) and (n)(5) when characterizing LLW for shipment. This results in inaccurate characterization of the waste, improper packaging, and misapplication of communication standards required for shipment and disposal.

EXAMPLES OF LOW-SPECIFIC ACTIVITY CRITERIA APPLICATION

The following case studies illustrate how these requirements are commonly misapplied to LSA waste shipments and possible corrective measures. These specific examples should not be considered all inclusive of problems that exist, nor do they fully represent the complex regulatory environment waste generators are forced to work within to characterize waste for shipment and disposal.

Case Study 1

A 6-Ci, sealed ^{60}Co source is centered in a 210-L DOT 17C steel drum considered a strong-tight package. The source is surrounded by a concrete matrix necessary to provide shielding. The concrete matrix and sealed source weigh 272 kg. Total package weight is 295 kg. The drum is to be shipped under DOT "exclusive use" regulations to a disposal facility.

Incorrect use of LSA criteria: Paragraph 173.403(n)(4) is commonly misused. The shipper determines the A2 value of ^{60}Co to be 7 Ci. The LSA limit for a radionuclide with an A2 value greater than 1 Ci is 0.3 mCi/g (3.0 E-04 Ci/g). The shipper knows the source to be 6 Ci, and converts the 272 kg to 2.72 E+05 g. The shipper then divides the 6 Ci by 2.72 E+05 g to get 2.2 E-05 Ci/g, which appears to be less than the LSA limits in paragraph (n)(4). The shipper believes the waste qualifies as LSA material, marks the drum "Radioactive-LSA," and prepares it for shipment. Figure 1 depicts the container.

Correct application of LSA criteria: In this case paragraph 173.403(n)(4) cannot be used because the radioactivity is not uniformly distributed throughout the waste matrix. The concrete shielding and drum must not be considered part of the waste matrix for the shipping determination. Because the 6-Ci sealed source is less than the A2 value of 7 Ci, it does qualify as Type A under Section 173.431. The material then requires an authorized Type A package per Section 173.415. An acceptable package under paragraph 173.415(a) would be a DOT Specification 7A, Type A, general packaging. Figure 2 depicts a typical DOT 7A drum type container prepared for shipment. A test report, engineering evaluation, or summary of comparative data must be available to support shipping this package under the DOT 7A specification and must authorize payloads of this type.

Case Study 2

Contaminated soil and concrete rubble are placed into a 1.2-m by 1.2-m by 2.4-m heavily reinforced metal box, considered a strong-tight package. The contamination source was a spill of cesium carbonate solution leaked from a broken pipe used in the liquid transfer. The radioactivity is concentrated on two concrete pieces located in the lower left side of the box. Low levels of contamination are dispersed throughout the remaining waste matrix. The contamination is ^{137}Cs, and the total activity is estimated at 10 Ci. Eighty percent (80%) of the contamination is estimated as being associated with the two concrete pieces. The balance of the contamination is randomly distributed through the remaining waste matrix. The waste matrix in the box weighs 5,086 kg. The package will be shipped under DOT "exclusive use" regulations to a disposal facility.

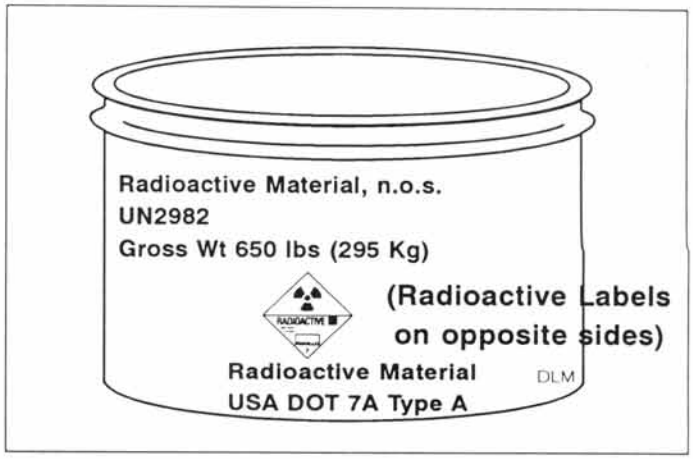

Fig. 2. Case study 1-Correct application, type A package.

Incorrect use of LSA criteria: Paragraph 173.403(n)(4) is again commonly misused. The shipper determines the A2 value of ^{137}Cs to be 10 Ci. The LSA limit for a radionuclides with a A2 value greater than 1 Ci is 0.3 mCi/g (3.0 E-04 Ci/g). The shipper assumes for calculation purposes that the total 10 Ci is distributed throughout the 4,086-kg waste matrix. The shipper converts the 4,086 kg to approximately 4.0 E+06 g. The shipper divides the 10 Ci by the 4.0 E+06 g to get 2.5 E-06 Ci/g, which appears to meet LSA limits specified in paragraph (n)(4). The shipper believes the waste meets LSA criteria, marks the box "Radioactive-LSA," and prepares it for shipment. Fig. 3 depicts the container.

Correct application of LSA criteria: In this case also, paragraph 173.403(n)(4) cannot be used because the radioactivity is not uniformly distributed through the waste matrix.

To determine if the uniform distribution criteria is met, guidance can be found in International Atomic Energy Agency (IAEA) Safety Series 37, "Advisory Material for the IAEA Regulations for the Safe Transportation of Radioactive Material" (2). This guidance suggests that specific activity

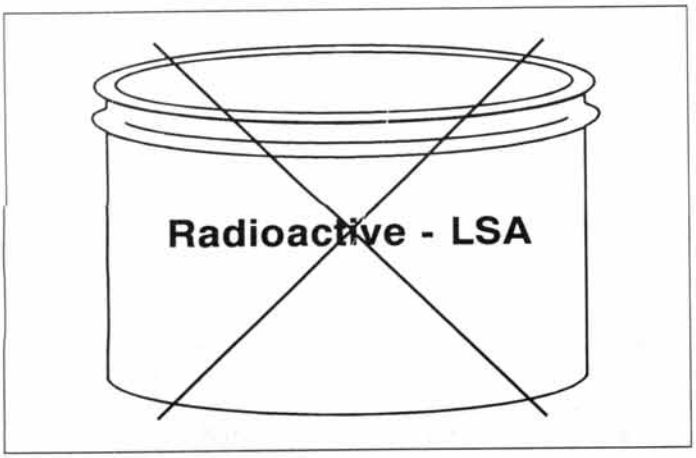

Fig. 1. Case study 1-Incorrect application of LSA criteria.

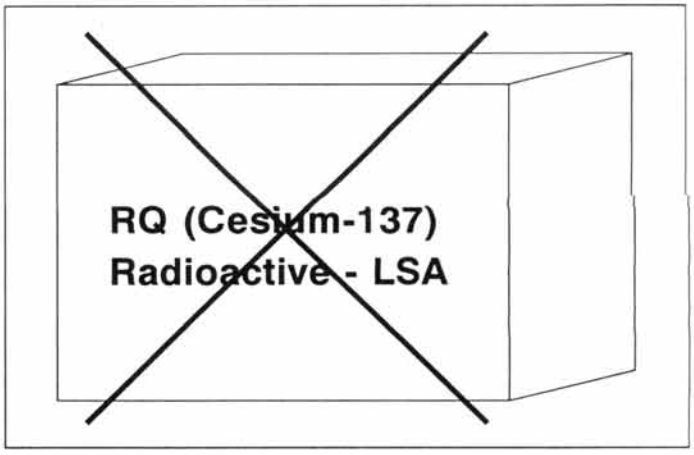

Fig. 3. Case study 2-Incorrect application of LSA criteria.

becomes meaningful if a large amount of the activity is confined to a small percent of the waste matrix volume. It suggests dividing the waste matrix into defined portions to assist in comparing specific activities of each portion. If the specific activity difference between portions exceeds a factor of ten, uniform distribution becomes an issue. The guidance also suggests that if the matrix exceeds 1 m^3, the volume should be divided into ten equivalent portions for the assessment. In this example the contamination (80%) is concentrated in one defined area of the box on two pieces of concrete rubble. Using the IAEA guidance eliminates this load as LSA under paragraph 173.403(n)(4).

Because the total activity for the waste matrix is 10 Ci, it qualifies as Type A under Section 173.431 by not exceeding the A2 (10 Ci) limit specified for ^{137}Cs. The waste requires an authorized Type A package per Section 173.415. An acceptable package under paragraph 173.415(a) is a DOT Specification 7A, Type A, general packaging. Figure 4 depicts a typical DOT 7A metal box container prepared for shipment. A test report, engineering evaluation or summary of comparative data must be available to support shipping this package under the DOT 7A specification and must authorize payloads of this type.

Case Study 3

A maintenance task involves removing small pumps and piping from a contaminated radiation zone. The failed equipment is disconnected and placed into a DOT 17C, 210-L metal drum, considered a strong-tight package. The total activity is estimated at 0.2 Ci. The waste matrix weighs 90 kg, and the loaded drum weighs 114 kg. The package will be shipped to a disposal facility under "exclusive use" provisions of the DOT regulations.

Incorrect use of LSA criteria: Paragraph 173.403(n)(4) is used incorrectly again. The shipper determines the A2 value of ^{90}Sr to be 0.4 Ci. The LSA limit for a radionuclide with an A2 value greater than 0.05 Ci but not more than 1 Ci is 0.005 mCi/g (5.0 E-06 Ci/g). The shipper estimates the total ^{90}Sr contamination to be 0.2 Ci. The shipper converts the 90-kg waste matrix to 9.0 E+04 g. The shipper then divides the 0.2 Ci by the 9.0 E+04 g to get 2.2 E-06 Ci/g, which appears to meet the LSA limits of paragraph (n)(4). The shipper believes the waste qualifies as LSA material, marks the drum "Radioactive-LSA", and prepares it for shipment. Figure 5 depicts the container.

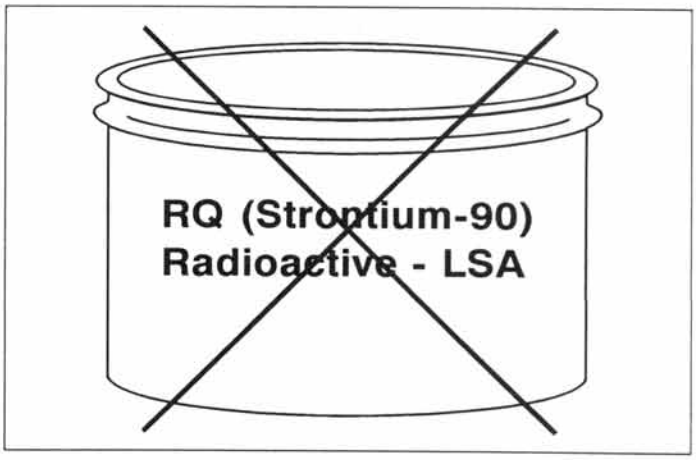

Fig. 5. Case study 3-Incorrect application of LSA criteria.

Correct application of LSA criteria: In this case Paragraph 173.403(n)(4) cannot be used because the radioactivity is not uniformly distributed through the waste matrix. Actually several objects of non-radioactive material (steel, copper, brass, etc.) which are externally contaminated are being prepared for shipment. Each SCO must be evaluated against criteria found in paragraph 173.403(n)(5). The external contamination must not be readily dispersible; and the contamination, when averaged over a surface area of 1 m^2, must not exceed 0.001 mCi/cm^2 (2,200,000 disintegrations per minute). This is the limiting value for radionuclides having an A2 value greater than 0.05 Ci. ^{90}Sr has an A2 value of 0.4 Ci.

In this specific situation the pumps and piping must be surveyed for fixed and non-fixed contamination before loading into the drum. The surveys have to be performed using calibrated radiation detection instruments and approved procedures. The surveys must demonstrate that the SCO criteria of paragraph 173.403(n)(5) are met.

If the contamination can be shown to be not readily dispersible, and the non-fixed contamination meet the 0.001 mCi/cm^2 criteria, the resulting package can be correctly shipped as LSA. See Fig. 6.

If the surface contaminated proves to be dispersible, and if the non-fixed contamination exceeds the 0.001 mCi/cm^2

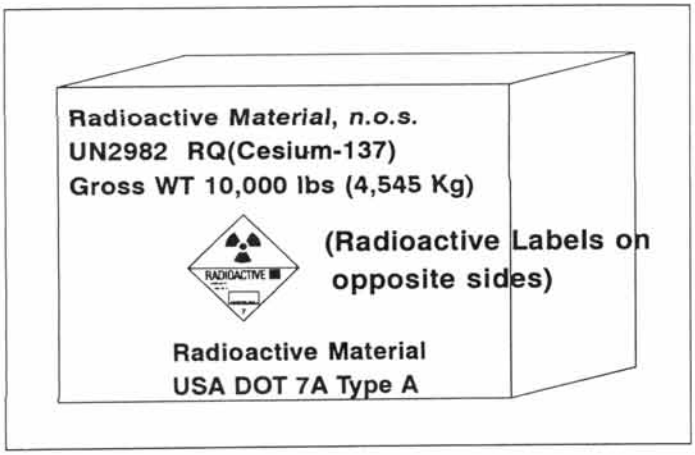

Fig. 4. Case study 2-Correct application, type A package.

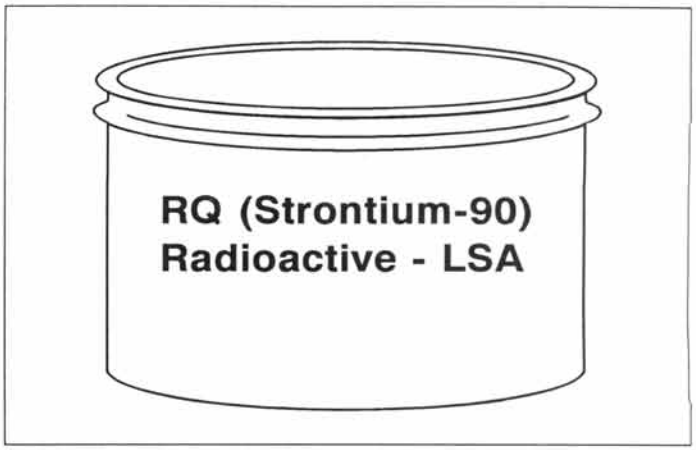

Fig. 6. Case study 3-Correct application of LSA criteria.

criteria, the resulting package cannot be shipped as LSA. The ^{90}Sr activity in this example is 0.2 Ci. This is less than the A2 (0.5 Ci) limit for ^{90}Sr; therefore, it qualifies as Type A under Section 173.431. This quantity of material requires a Type A package per Section 173.415. An acceptable package in paragraph 173.415(a) is a DOT Specification 7A, Type A general packaging. Figure 7 depicts a typical DOT 7A drum type container prepared for shipment. A test report, engineering evaluation, or summary of comparative data must be available to support shipping this package under the DOT 7A specification and must authorize payloads of this type.

SOME HELP ON THE WAY?

The DOT Docket HM-169A "Transportation Regulations; Compatibility with International Atomic Energy Agency Standards (IAEA)" dated November 14, 1989 (3) should be finalized sometime in 1993.

When this Notice of Proposed Rule-making is enacted, it will redefine LSA radioactive materials in the United States into five separate categories (LSA I, LSA II, LSA III, SCO I, and SCO II). The division is based on the 1985 Edition of the IAEA Safety Series No. 6, "Regulations for the Safe Transportation of Radioactive Material" (4). The new regulations will help clarify the distinction between LSA materials and SCOs as discussed in the case studies.

In addition, the five categories will be required to be packaged in new industrial packagings (IP) identified as IP-1, IP-2, IP-3. The three IPs will be performance-based to ensure containment of materials during normal handling and transport. The IPs will replace what we in the United States have traditionally termed "strong-tight packages" having no formal performance criteria.

The rule making also will impact radiation protection programs at federal facilities and general design requirements for all packages. The list of radionuclides found in Section 173.435 and their respective A1 and A2 values also will change.

WASTE SHIPMENT PROGRAM ENHANCEMENTS NEEDED

To ensure that LSA wastes are properly characterized, packaged, and otherwise prepared for shipment several key regulatory functions must be addressed. The following is a brief summary of those functions as related to the LSA and SCO determinations.

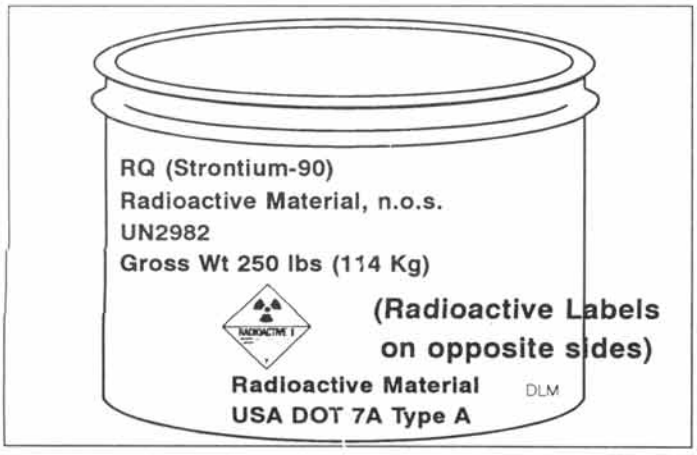

Fig. 7. Case study 3-Correct application, type A package.

Waste Characterization

The most important and sometimes most difficult task in determining correct packaging and transportation requirements is characterization.

The generator must know what radionuclides are present, the quantity of each radionuclide, their physical and chemical form, and the radioactive distribution in the waste matrix. To make these determinations effectively, the generator must have a comprehensive knowledge of the waste source, inventory and material balance data, radiological survey and source term information, and analytical data from laboratory analysis.

A knowledge of the waste source contaminants and use of dose rate conversions is necessary for conservative estimates of activity levels within each waste package. A formal program and procedures for evaluating waste as LSA and SCO must be in place to ensure proper regulatory application.

For transportation purposes, the generator must identify the DOT hazard class and select a proper shipping name, using hazard class criteria found in

49 CFR 173 and the Hazardous Materials Table (HMT) 49 CFR 172.101. Secondary hazards must be considered for compatibility within the transport package and must be addressed through container marking and labeling as well as shipping paper entries.

Packaging

The authorized packaging for the LSA/SCO waste is determined from the HMT based on the hazard class and proper shipping name selected. Most radioactive wastes are described as either Radioactive Material, Low Specific Activity N.O.S. or Radioactive Material N.O.S. The packaging references are 49 CFR 173.425, 173.415, and 173.416, respectively. For many LSA/SCO wastes, the material can be packaged in strong-tight packages that retain the contents during normal transport conditions. When DOT rule-making HM-169A is finalized, these materials must be placed into appropriate IPs meeting the IP-1, IP-2, and IP-3 standards.

Communication Requirements for Transportation

Container marking and labeling, vehicle placarding, shipping paper, and emergency response information are required by 49 CFR 172, Sub-parts C, D, E, F, and G. These standards communicate potential hazard information to handling and transportation personnel, the public, and emergency responders. The information provided is necessary for personnel protection, public safety, and protection of the environment during transportation operations. LSA wastes shipped under "exclusive use" requirements have unique communication standards applied as defined in 147.425 paragraphs (b) and (c).

RECOMMENDATIONS

Effective waste management procedures must be set up and used to ensure LLW is properly characterized under DOT regulations. To use the DOT defining criteria properly, waste management personnel must understand the differences between LSA radioactive materials and SCOs. They must understand and implement the correct methodology and

procedures for making these determinations. This can be accomplished through the following methods: clarification of the applicable regulations by the DOT, DOE issuance of standardized procedures and regulatory guides, enhanced contractor training to qualify shippers and waste generators, and effective use of management controls to ensure regulatory compliance before release for shipment.

REFERENCES

1. Title 49, Code of Federal Regulation, Parts 100-177, U.S. Department of Transportation, Washington D.C. (1991).
2. International Atomic Energy Agency (IAEA), Safety Series No.37, "Advisory Material for the IAEA Regulations for the Safe Transportation of Radioactive Material," Third Edition (As amended 1990).
3. DOT Docket HM-169A, Transportation Regulations; Compatibility with International Atomic Energy Agency Standards(IAEA)" dated November 14, 1989. Notice of Proposed Rule-making (NPRM), U.S. Department of Transportation, Washington D.C.
4. International Atomic Energy Agency (IAEA), Safety Series No.6, "Regulations for the Safe Transportation of Radioactive Material," 1985 Edition (As amended 1990).