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Since 1998 when the collaborative efforts of the NRC, DOT and Oak Ridge National Laboratory issued NUREG-1608, Prairie Island along with most of the utilities and Westinghouse has been using WMG, Inc. RAMSHP shipping software that utilizes 3.3.1 of NUREG-1608. This guidance represents one method of demonstrating compliance with the regulatory requirements for SCO material that has been found acceptable to NRC and DOT.
Prior to 1995, LSA material included as a subcategory, requirements for SCOs. SCOs are now defined as their own category.
Under the revised regulations it is expected that most equipment will be categorized for shipment as SCO-II, whereas most waste will be categorized as LSA-II.

Per NUREG 1608 (note condition 3 and basis below):

3.3.1 What is a practical method for categorizing object(s) as SCO for shipment under exclusive-use in a strong tight container [using 49 CFR 173.427(b)(3)]?

Demonstration of all of the following 4 conditions can be used to categorize a radioactive material as an SCO-II. It is expected that these conditions would allow categorization of a great majority of candidate SCO materials as SCO-II, without the need for detailed, quantitative measurement of fixed, accessible contamination or total inaccessible surface contamination.

(1) The shipment of the SCO-II is made pursuant to 49 CFR 173.427(b)(3), for domestic, exclusive-use transport of SCOs in strong-tight containers (STCs). Note that this requires that the radioactive material in the package totals to less than 1 A_2 quantity as determined using the sum of fractions method in 49 CFR 173.433.

(2) The non-fixed (removable) contamination on the accessible surfaces satisfies the SCO-II limits of 400 Bq/cm^2 beta/gamma and 40 Bq/cm^2 alpha averaged over each 300 cm^2 (46.5 in^2) area.

(3) The total activity on the object(s) (fixed and non-fixed), divided by the mass of the object(s), meets the specific activity limit for LSA-II solids (i.e., 10^{-4} A_2/g), and the activity is reasonably considered to be "distributed throughout" the object(s).

(4) The alpha-emitter contribution in the package totals to less than 0.025 A_2 quantities.

The method described here allows categorization of a material as SCO through reasoned arguments, without detailed measurements of inaccessible and fixed-accessible contamination.

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To verify condition #3 of 3.3.1 (which specifically states *"distributed throughout"*) the following case was developed.

Case with the Total Shipment Activity Applied to the Sipping Equipment

Total activity of equipment: 35.1 mCi
Activity of particle per Pete Wildenborg: 1.2 mCi
Displacement Volume of the Sipping Equipment per Waltz Mill: 3.8 ft^3

Convert to cubic centimeters:

$$\text{Volume} = \frac{2.83\text{ E +4 cm}^3 \times 3.8\text{ ft}^3}{1\text{ ft}^3} = 1.08\text{ E +5 cc}$$

Per condition (3) of the NUREG 1608 excerpt above:

4.2.3 What practical techniques can be used for demonstrating the activity in an LSA material is *distributed throughout* or *essentially uniformly distributed*, as applicable?

- For *distributed throughout*, the material can be divided into ten or more equal volumes. The volume of each portion should be no greater than 0.1 m^3. The specific activity of each volume should then be assessed (through measurements, calculations, or process knowledge) and compared. Specific activity differences between any two volumes should not vary by more than a factor of 10.

0.1 m^3 = 1 E +5 cc therefore; we will need to divide our total activity into ten equal volumes:

Average specific activity of each volume:

$$\frac{\text{Total activity of shipment}}{\text{10 volumes}} = \frac{35.1\text{ mCi}}{10} = 3.51\text{ mCi per volume}$$

$$\text{Ratio of activity: } \frac{\text{Activity of particle}}{\text{Average activity}} = \frac{1.2\text{ mCi}}{3.51} = 0.34$$

Therefore: 0.34 < 10.

The following excerpt from NUREG 1608 (see bulleted item) is why the shipment was SCO vs. LSA.

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4.2.4 Can compliance with NRC's "Branch Technical Position on Concentration Averaging and Encapsulation" be used to demonstrate that a mixture of candidate LSA materials are *distributed throughout* or *essentially uniformly distributed*, as applicable?

Mixtures of LLW types or streams which meet the January 17, 1995, "Branch Technical Position on Concentration Averaging and Encapsulation," (NRC, 1995a) can be assumed to be either *distributed throughout* or *essentially uniformly distributed*, as applicable. This determination can be used in place of the determination described in Section 4.2.3, irrespective of the size of the container in which it is packaged for transport. Further, if averaging over the volume or mass of the waste is permitted by the concentration averaging Technical Position (TP) for disposal

classification purposes, similar averaging over the mass of the waste is generally acceptable for LSA specific activity determinations. However, materials which the TP recommends should be considered discrete items for LLW classification should also be considered discrete items and be evaluated individually against the LSA definitions, as appropriate. Further, it is assumed that nuclides important to transportation are distributed in the waste to the same degree as those important to waste classification. If it is believed that this assumption does not hold, a more detailed analysis would be expected by DOT and NRC.

Note that the TP contains guidance for classification and averaging of some materials (i.e., contaminated materials, encapsulated materials, and sealed sources), that should not be applied for LSA material determinations. Specifically:

- Nonradioactive, contaminated objects must be classed as SCO (see section 3).

Also, from NUREG 1608 Introduction:

Under the revised regulations, it is expected that most equipment will be categorized for shipment as SCO-II, whereas most waste will be categorized as LSA-II. There will probably be many exceptions to this generalization, including a variety of materials and objects whose characteristics (both physical and radiological) are uncertain or difficult to characterize.

The following is a paper from the DOT on the "*distributed throughout*" topic. See Question 1.

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U.S. Department
of Transportation

**Pipeline and
Hazardous Materials Safety
Administration**

JAN 17 2007

400 Seventh Street, S.W.
Washington, D.C. 20590

Mr. James H. Portsmouth
EnergySolutions
345 Hills Street
Richland, Washington 99354-5507

Ref. No.: 06-0238

Dear Mr. Portsmouth:

This is in response to your October 17, 2006 letter regarding the requirements for transporting Class 7 (radioactive) material under the Hazardous Materials Regulations (HMR; 49 CFR Parts 171-180). Your questions are summarized and answered as follows:

Q1: The definition of LSA-II material in § 173.403 includes "other radioactive material in which the activity is distributed throughout and the average specific activity does not exceed 10^{-4} A_2/g for solids and gases, and 10^{-5} A_2/g for liquids." What methods may be used to demonstrate that the activity of radioactive material is "distributed throughout" for the purpose of classifying a material as LSA-II? Is the guidance in NUREG-1608 for determining if the activity is "distributed throughout," still applicable since it was published in 1998?

A1: The HMR do not specifically define the phrase "distributed throughout" as it applies to the definition of LSA-II or LSA-III material. Furthermore, the HMR do not specify qualitative or quantitative techniques to determine if radioactivity is "distributed throughout" a material. In July of 1998, the Department of Transportation and the Nuclear Regulatory Commission published a guidance document titled, "Categorizing and Transporting Low Specific Activity Materials and Surface Contaminated Objects;" NUREG-1608. The guidance in NUREG-1608 remains applicable for classifying material in accordance with the current regulations. The guidance in NUREG-1608 clarifies that the term "distributed throughout" may include non-homogeneous materials and states that both qualitative and quantitative methods may be used to determine if the activity of the radioactive material is considered to be distributed throughout. The guidance states that qualitative techniques may generally be used for LSA materials having radioactivity in quantities less than 1 A_2, but for materials with radioactivity exceeding 1 A_2, quantitative techniques are more appropriate. This determination can be made through reasoned argument, reference, calculation, or measurement. An acceptable method to quantitatively determine if a material's radioactivity is "distributed throughout" is provided in NUREG-1608 as follows:

> "For *distributed throughout*, the material can be divided into ten or more equal volumes. The volume of each portion should be no greater than $0.1 m^3$. The

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specific activity of each volume should then be assessed (through measurements, calculations, or process knowledge) and compared. Specific activity differences between any two volumes should not vary by more than a factor of 10."

Q2: Because of the Department of Energy radioactive materials safety considerations for keeping worker exposure to radioactive materials As Low As Reasonably Achievable (ALARA), it is not always feasible to make extensive direct radiation or contamination measurements. When using the NUREG-1608 techniques, what are the DOT expectations for a shipper of LSA materials to document that they have in fact met the requirement of showing that the specific activity in the waste matrix does not vary by more than a factor of ten from one portion to another in the total volume of waste?

A2: It is the shipper's responsibility to properly class and describe a hazardous material in accordance with the HMR. The recommended techniques in NUREG-1608 for determining if radioactivity is "distributed throughout" a material are guidance only; the HMR do not require that these techniques be applied. Alternative methods of determining if radioactivity is "distributed throughout" a material may be acceptable for the purpose classing an LSA material, provided the determination is adequately justified.

The techniques described in NUREG-1608 provide a conceptual framework for determining whether the radioactivity is "distributed throughout" a given LSA material. In applying those techniques, the shipper may use any information available to estimate whether the criteria stated there are satisfied. In most cases it would not be expected that the shipper physically divide up the material in 0.1 m^3 (or smaller) volumes and measure the average specific activity in each. However, if the total activity of the material exceeds 1 A_2 some quantitative analysis is expected.

Q3: How is "void space" in a waste matrix of LSA material considered in the above question? Must it be included in the quantitative calculation of radioactivity?

A4: Under the method described in A1, void space does not have to be included in the calculation of activity distribution for the purpose of determining if a material is LSA under the HMR.

I hope this information is helpful. If you have further questions, please do not hesitate to contact this office.

Sincerely,

John A. Gale
Chief, Standards Development
Office of Hazardous Materials Standards

The following excerpt from NUREG-1608 states that "although pre-shipment determinations are required to demonstrate compliance with the applicable SCO definition, the regulations do not require measurements of contamination and/or radiation levels as the only means of accomplishing

the determinations. Alternate methods or combinations of methods may be used to demonstrate compliance." Using the reasoned argument approach of this section "the first step in any shipment should be to determine the A_2 fraction in the package in accordance with 49 CFR 173.433."

3.3 Quantity-Based Method for Compliance With the SCO Definitions

Although pre-shipment determinations are required to demonstrate compliance with the applicable SCO definition, the regulations do not require measurements of contamination and/or radiation levels as the only means of accomplishing the determinations. Alternate methods or combinations of methods may be used to demonstrate compliance. These methods may include—in addition to measurements—calculations, reasoned arguments, and reference to previous shipments of similar materials or objects (see section 3.4.1). This section describes a reasoned argument approach to categorizing SCOs.

The level of detail in these determinations is expected to be commensurate with the potential hazard that the contamination represents. The potential hazard is based on the quantity (i.e., activity) and radiotoxicity of the Class 7 (radioactive) material to be shipped, and the

combination of these two factors is associated with the relevant multiple or fraction of A_2 of the contaminants involved. Therefore, the first step in any shipment should be to determine the A_2 fraction in the package in accordance with 49 CFR 173.433.

For an SCO, the A_2 fraction would typically be determined by analyzing representative swipes of the accessible surface, gross gamma counts, the total surface area, and assuming the fixed and inaccessible contamination had a similar radionuclide distribution from a previously determined facility-specific sample data base. The techniques for determining radionuclide content used in the previous regulations remain acceptable under the revised regulations (note, however, that the number of nuclides in the Table of A_1/A_2 values has increased, and the values have changed).

It is possible to make SCO determinations in a manner consistent with 10 CFR Part 20 requirements to maintain occupational exposures as low as is reasonably achievable (ALARA). In practice, NRC and DOT anticipate that almost all SCO packages will contain less than 1 A_2 quantity, and therefore qualify for shipment in strong-tight containers (STCs) pursuant to 49 CFR 173.427(b)(3). A reasoned argument could be used to categorize the great majority of these candidate SCOs, without the need for detailed, quantitative measurement of fixed, accessible contamination or total (fixed plus non-fixed) inaccessible surface contamination. Both the beta-gamma A_2 fraction and the alpha A_2 fraction must be determined. The materials characterized using this reasoned argument would be shipped as "Radioactive - SCO."