U.S. Department
of Transportation
Pipeline and Hazardous Materials Safety Administration

1200 New Jersey Ave., S.E.
Washington, DC 20590

JUL 9 2008

Mr. G.J. Borden
Washington Closure Hanford
2620 Fermi Avenue
Richland, WA 99354

Ref. No.: 08-0079

Dear Mr. Borden:

This responds to your letter dated February 26, 2008 requesting clarification of the Hazardous Materials Regulations (HMR; Parts 171-180). Specifically, you ask for clarification on describing Class 7 (radioactive) material as Low Specific Activity (LSA) material. Your questions are paraphrased and answered as follows:

Q1. Is it appropriate to mix LSA types and classify the aggregate as the highest class of material?

A1. It is acceptable to mix LSA types and to classify the aggregate at the highest classification of material, provided (emphasis added) that the individual types are properly classified. Each constituent must meet the appropriate LSA material definition and meet the regulatory requirements for that classification. Also, since you are dealing with items with varying dose rates, when commingling these material types, care must be taken to ensure compliance with the requirement in § 173.411 that there be no significant increase in the radiation levels at the external surfaces of the package under routine conditions of transport.

In your second example, it is not clear why you would choose to return items classified as LSA-II material to the soil mixture when they could be shipped separately in an Industrial Package Type 2 (IP-2) and the soil could then be transported in an Industrial Package Type 1 (IP-1).

In your third example, you indicate that the metal items in the soil have high dose rates (several orders of magnitude higher than the soil). In order for these high dose rate items to be shipped as LSA-II material, not only must they meet the LSA-II material definition with an average specific activity of less than 10^{-4} A_2 /g, but also the external radiation level from the unshielded material (the metal items)

must not exceed 10 mSv/h (1 rem/h) at 3 meters from the unshielded material (see § 173.427(a)(1)). Compliance with this requirement does not allow a person to take credit for shielding provided by the packaging or the soil. The inherent property of the material must be limited so that even without any shielding, the dose rate would not exceed the limit.

As there may be multiple high dose rate items in some of your packages, you should show that if all the high dose rate items that might be in a single package were aggregated into the worst-case configuration (such that it would result in the highest dose rate at 3 meters), the resulting configuration would not exceed 10 mSv/h (1 rem/h) at 3 meters from the unshielded material, without taking any credit for shielding provided by the soil or packaging.

For those items that do qualify as LSA-II material, they must be properly secured such that the package limits are still met and there is not a significant (20%) increase at any external surface of the package during routine conditions of transport (see § 173.411).

Q2: Is it acceptable to use the criteria in NUREG-1608 Section 4.2.3 to determine if a material has the radioactivity distributed throughout for material that may have significant variations in dose?

A2: The approach given in NUREG-1608 section 4.2.3, while generally appropriate, may not be appropriate when there are significant variations in dose. Since your examples deal with a mixture of soil and activated metal items, section 4.2.4 of NUREG-1608, which addresses mixtures of materials, should be considered. That section notes that materials which the Nuclear Regulatory Commission (NRC) "Branch Technical Position on Concentration Averaging and Encapsulation" recommends should be considered as discrete items for low-level radioactive waste (LLW) classification should also be considered discrete items and be evaluated individually against the LSA definitions, as appropriate. Section 3.3.1 of the Branch Technical Position states that a mixture of activated metal items containing primary gamma-emitters (such as Co-60 that you cited as the primary isotope of concern) should be averaged only if the individual items are within 1.5 of the respective averaged concentration value for each nuclide.

Your first two examples of localized "hot spots" would indicate the need for a closer examination of the situation to determine how the activity is distributed throughout the material. The analysis that shows less than a factor of 10 differences between sections that are no greater than 0.1 m^3 should be supplemented with consideration of the activity distribution of the activated metal. As the metal items are known discrete pieces, they should be considered separately from the soil and not averaged over a 0.1m^3 volume (which would have the soil composing more than 3 ft^3 of the 3.5 ft^3). The potential for multiple metal items in close proximity must also be considered.

Your third example relies on the soil to provide shielding around the activated metal items in order to meet the limits of § 173.411. This is only appropriate if the resulting package can be shown to meet all of the applicable requirements. First, as discussed above, the metal items in a package must have an aggregate unshielded dose rate that does not exceed 10 mSv/h (1 rem/h) at 3 meters. Also, as stated in § 173.411(b)(2) for an IP-2 package, there should be no significant increase in the radiation levels when subjected to normal conditions of transport (see § 173.410(f)) or the free drop test of § 173.465(c). It is not clear if the metal items would qualify as LSA-II material or if the package arrangement you describe would meet these requirements.

Q3: If dose rate is a determining factor in "distributed throughout", what is the applicable guidance? Is the factor of 10 in NUREG-1608 for specific activity also applicable to dose rate? Or is meeting the limitations of § 173.441 the only concern regarding dose rates?

A3: Dose rate is not a specific determining factor in "distributed throughout," except that it should be used to inform the analysis of the distribution of specific activity as described above.

In addition to § 173.441 regarding dose rates, as discussed above, § 173.427(a) requires a limit of 10 mSv/h (1 rem/h) at 3 m from unshielded LSA material. Also, as discussed above, for an IP-2 package, § 173.411(b)(2)(ii) requires that there not be a significant increase in the radiation levels during routine conditions of transport.

Q4: Can a determination of "distributed throughout" (assessed through measurements, calculations or process knowledge) as identified in NUREG-1608 Section 4.2.3 be made on a "bounding case" based on a worst case scenario from the same waste stream covering multiple shipments, or does a separate evaluation need to be made for each individual shipment?

A4: It is the shipper's responsibility to properly class and describe a hazardous material in accordance with the HMR for each shipment. A "bounding case" evaluation may be sufficient, provided the determination is adequately justified as being applicable to the individual shipments. Sufficient information would be needed to assure that the waste stream is uniform enough such that each individual shipment fits the bounding conditions.

In the example you provided, it is not clear what knowledge you would have about the distribution of metal pieces within the soil to be able to bound the number of pieces per package. Nor is it clear how uniformity of the soil or the metal items can be assumed.

Your questions reference the document NUREG-1608. Note that NUREG-1608 (RAMREG-003) was intended as general guidance to assist in applying the regulatory

requirements for LSA material and SCOs that were introduced in 1996. However, no single document can address all issues related to the transport of these materials and objects. Furthermore, nothing in that document should be construed as having the force and effect of DOT regulations, or as relieving any shipper from compliance with the requirements of 49 CFR Part 173 or any other applicable regulation.

Also, please note that if any fissile nuclides are present, any shipments of this material must meet at least one of the paragraphs (a) through (f) of § 173.453, as non-excepted fissile material is not permitted to be shipped as LSA material.

I hope this information is helpful. Please contact us if you require additional assistance.

Sincerely,

Susan Gorsky
Acting Chief, Standards Development
Office of Hazardous Materials Standards

Eichenlaub
§173.427
§173.441
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FEB 26 2008

U.S. Department of Transportation
Office of Hazardous Materials Standards (PHH-10)
Office of Hazardous Materials Safety
Pipeline and Hazardous Materials Safety Administration
Mr. John Gale
Chief, Standards Development
East Building, 2nd Floor
1200 New Jersey Avenue, SE
Washington, DC 20590-0001

Subject: **LOW SPECIFIC ACTIVITY SHIPMENT CLARIFICATION**

Dear Mr. Gale:

Washington Closure Hanford LLC (WCH) is performing remediation activities at radioactive waste burial grounds. This remediation involves excavating contaminated soil and miscellaneous debris from the burial grounds and packaging the waste for shipment. The waste consists primarily of soil contaminated with activation and fission products meeting the definition of Low Specific Activity (LSA)-I or LSA-II, as well as some activated metal meeting the definition of LSA-II material. Due to the presence of fission products in the soil, the activated metal can have a significantly higher dose rate than the soil for a similar specific activity. The activated metal pieces are usually small steel or aluminum components less than 0.5 ft^3 and approximately 2 pounds (e.g., hollow perforated pipe 6" x 1.5"), and the primary shipment method is transported in a 20-yd^3 meeting all applicable packaging requirements. The packaging system is made of carbon steel with no added shielding material. The primary isotope of concern is Colbalt-60. The aggregate load may exceed an A_2 value. Currently this practice takes place on a closed government installation to which the public does not have access. However, WCH will soon be applying these same practices to "in commerce" shipments and would like the U. S. Department of Transportation clarification regarding the following questions prior to proceeding:

1. Is it appropriate to mix LSA types and classify the aggregate as the highest classification of material?

Example 1:
Soil that meets the definition of LSA-I is co-mingled with pieces of activated metal that meet the definition of LSA-II material. Rather than attempting to remove the activated metal, the entire mass is classified as LSA-II.

Washington Closure Hanford 2620 Fermi Avenue Richland, WA 99354 tel (509) 375-4640 fax (509) 375-4644

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Example 2:
Activated metal items are removed from soil that meets the criteria for LSA-I for characterization. The activated metal items are characterized as LSA-II material, returned to the soil, and the entire mass is classified as LSA-II.

Example 3:
Activated metal items are removed from soil that meets the criteria for LSA-I for characterization. These removed metal items were identified due to high dose rate thus activities of these metal items can be several orders magnitude higher than the contaminated soil. The activated metal items are characterized as LSA-II material, returned to the soil, and the entire mass is classified as LSA-II.

It is WCH's understanding that these examples would be acceptable based on the following:

Attached e-mail from Fred Ferate to Greg Borden dated June 12, 2007,

NUREG-1608 Section 4.2.3, which allows the use of the U.S. Nuclear Regulatory Commission branch Technical Position, which states in Section 3.3, "... in determining the classification of such a mixture, it is always permissible to conservatively base the mixture classification on the highest classification associated with any piece, section, or component within a disposal container or liner."

2. Is it acceptable to use the criteria in NUREG-1608 Section 4.2.3 to determine if a material has the radioactivity distributed throughout for material that may have significant variations in dose?

Example 1:
Soil and activated metal are co-mingled in a package for disposal. When the container is divided into sections no greater than 0.1 m^3, no two sections have a difference in specific activity that is greater than a factor of 10. However, the pieces of activated metal may create localized "hot spots" where the dose rate is greater than a factor of 10 more than areas with no activated metal.

Example 2:
Soil and activated metal are co-mingled in a burial ground. When excavated, the activated metal is separated for characterization (this activated metal is identified by their significant higher dose rate), and once characterized, the activated metal is returned to the soil. When the container is divided into sections no greater than 0.1 m^3, no two sections have a difference in specific activity that is greater than a factor of 10. However, the activated metal has a dose rate that is greater than a factor of 10 more than the soil.

Example 3:
Soil and activated metal are co-mingled in a burial ground. When excavated, the activated metal is separated for characterization, and once characterized, the activated metal is returned to the soil. The activated metal has a dose rate which if placed directly against the side of the packaging would result in a dose rate greater than 200 mrem/h on contact. To meet the dose rate limits, the item is strategically placed in the center of the soil so it is shielded and the resulting dose rate meets all of the limitations of 49 CFR 173.441. When the container is

divided into sections no greater than 0.1 m^3, no two sections have a difference in specific activity that is greater than a factor of 10. However, the activated metal has a dose rate that is greater than a factor of 10 more than the soil.

It is WCHs understanding that these examples would be acceptable based on the following:

The language in NUREG-1608 Section 4.2.3, in which the determination of "distributed throughout" is based on specific activity and not dose, and

The language in TS-G-1.1 section 226.7, which states:

> "In addition, LSA-II could include many items of activated equipment from the decommissioning of nuclear plants. Since LSA-II materials could be available for human intake after an accident, the specific activity limit is based upon an assumed uptake by an individual of 10 mg. Since the LSA-II materials are recognized as being clearly not uniformly distributed (e.g., scintillation vials, hospital and biological wastes, and decommissioning wastes), the allowed specific activity is significantly lower than that of LSA-III. The factor of 20 lower allowed specific activity as compared with the limit for LSA-III compensates for localized concentration effects of the non-uniformly distributed material."

This would indicate that the potential for some discrepancy in material was accounted for in the development of the limits for LSA-II material.

3. If dose rate is a determining factor in "distributed throughout", what is the applicable guidance. Is the factor of 10 in NUREG-1608 for specific activity also applicable to dose rate? Or is meeting the limitations of 49 CFR 173.441 the only concern regarding dose rates?

4. Can a determination of "distributed throughout" (assessed through measurements, calculations, or process knowledge) as identified in NUREG-1608 Section 4.2.3 be made on a "bounding case" based on a worst case scenario from the same waste stream covering multiple shipments, or does a separate evaluation need to be made for each individual shipment?

Example:
Based on available data, a piece of activated metal with the highest activity is evaluated with the activity of the soil in accordance with Section 4.2.3. If these are within a factor of 10, all shipments are considered to be distributed throughout, until or unless data are obtained that

would change that assumption (e.g., a piece of activated metal is found that is "hotter" than the bounding case evaluated).

If you have any questions regarding this inquiry, please feel free to contact me at (509) 528-3139.

Sincerely,

G. J. Borden, Subject Matter Expert
Waste Services/Environmental Protection

Attachment: e-mail from Fred Ferate to Greg Borden dated 06-12-2007

cc: J. J. Waring (RL) L1-02, w/a
D. W. Claussen (RL) A5-17, w/a

Attachment

e-mail from Fred Ferate to Greg Borden, dated June 12, 2007

Bickford, Joan A

From: Borden, Gregory J
Sent: Monday, February 25, 2008 2:14 PM
To: Bickford, Joan A
Subject: FW: Information Center Comments/Questions

Attachments: NUREG 1608 Chapter 4.pdf

NUREG 1608
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-----Original Message-----
From: fred.ferate@dot.gov [mailto:fred.ferate@dot.gov]
Sent: Tuesday, June 12, 2007 3:09 PM
To: Borden, Gregory J
Cc: erin.jarman@dot.gov
Subject: FW: Information Center Comments/Questions

Hello Mr. Borden,

Some of the sources I would look to for information to answer your questions are

a) the definitions of LSA-I and LSA-II;
b) explanatory material in TS-G-1.1, "Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material"
(downloadable at
http://www-pub.iaea.org/MTCD/publications/PDF/Pub1109_scr.pdf).
c) the somewhat out-of date NUREG-1608, "Categorizing and Transporting Low Specific Activity Materials and Surface Contaminated Objects" (I have attached a pdf copy of Chapter 4). NUREG-1608 was published jointly by the NRC and DOT in 1997.

You say that separately the soil can be classified as LSA-I and the activated metal as LSA-II. You also say that in some cases the specific activity for the activated metal may exceed an order of magnitude difference (which I take to mean a factor of 10) in activity from the specific activity of the soil, and the activated metal (reactor components) are randomly distributed in the soil.

Paragraph 226.13 of TS-G-1.1 claims that the use of the phrase "distributed throughout" (found in the definitions of LSA-I (up to 30 times the exemption activity concentrations) and LSA-II) "puts no requirement on how the activity is distributed throughout the material."
It goes on to say that it is still important to note that the concept of LSA is not very meaningful if the activity is confined to a small portion of the total volume.

From your description it appears that the activity in your shipments is not confined to a small portion of the total volume, even though within that volume there will be sometimes be spikes in the local specific activity, so I would say that conceptually you are still clearly within the intended realm of low specific activity material.

1. You ask whether it is permissible to utilize the total mass and activity of the container including both the soil and activated components to determine the LSA classification as long as the individual items all meet the definition of LSA.

Generally the mass of the packaging is not to be included when calculating the average specific activity (although I don't think this is what you were asking).

I think you are saying "Can I put everything - soil and whatever activated components are present - in the container, add up the total activity, determine the total mass of the contents of the container, and divide the former by the latter to determine an average

activity per unit mass, and then see what LSA category that falls in?" Assuming that that is your question, I will try to answer that below:

Paragraphs 226.14 and 226.15 of TS-G-1.1 suggest a method for assessing the average [specific] activity of LSA material. That is to imagine the material in the container divided into ten parts of equal size and to compare specific activities of the parts; if the average specific activities of the parts differ by no more than a factor of 10, they suggest, this "would cause no concern." I take this to mean that in that case you could just average the averages for the ten parts to determine the average specific activity for the entire contents of the container, and from there select the LSA category.

Additional guidance is found in paragraph 4.2.3 of NUREG-1608. There it says that it is permissible to apply qualitative techniques for LSA materials in quantities less than 1 A2, and to apply more quantitative techniques if you have more than 1 A2. It goes on to say that "if it is known that the material has a highly-stratified or significantly non-uniform distribution, . . . , a more rigorous assessment will be required." It goes on to describe a technique, if you have more than an A2 quantity, similar to, but somewhat more restrictive, than that described in TS-G-1.1 to determine the average specific activity of the material in the container. The NUREG-1608 criterion (which is essentially our DOT criterion) is to conceptually divide your material into AT LEAST ten parts, with each part having a volume NO GREATER THAN 0.1m3. To be "distributed throughout," specific activity differences between any two volumes should not vary by more than a factor of 10.

It sounds to me like you can't always be sure that the average specific activities of the ten parts will never differ by more than a factor of 10. In this case I suggest that the more conservative and more appropriate path would be to ship all the material as LSA-II.

2. I think my last statement answers your question 2. We at DOT have no objection to your shipping a hazardous material in such a way as to offer a greater level of safety. It is true that in some cases your activity is still not "distributed throughout," in the quantitative sense described above (and so could not be called LSA-I or LSA-II); however, I think that it would less dangerous to ship all the material as LSA-II than to ship part as LSA-I and part as LSA-II. Thus my suggestion is that, unless you can show that a particular shipment is definitely LSA-I, it would be better to ship it as LSA-II.

3. You ask if the answers to your other questions are dependent on the relationship to an A2 value.

The A2 value plays an important role in determining the type of package you must use to ship the material. 49 CFR 173.427(b)(4) allows you to ship domestically less than an A2 quantity of LSA material (under exclusive use) in a packaging which meets the requirements of 173.24, 173.24a, and 173.410. If you have an A2 quantity or greater, LSA-II must now be shipped (see 173.427(b)(1) and the corresponding Table 6) in a Type IP-2 packaging. According to 173.411(b)(2), an IP-2 packaging must be such that the loaded package satisfies the performance requirements in 173.465(c) and (d); i.e., the Type A package drop test and stacking test.

(Note, however, that 173.411(b)(6) allows the use of an appropriate ISO freight container, and 173.411(b)(7) allows the use of an appropriate ISO IBC, as a Type IP-2 packaging. This comes with the caveat of 173.411(c), which requires the availability of documentation showing that the packaging being used satisfies the stated performance standards.)

What I have given you is my opinion, based on what you have told me, and my interpretation of the regulations. There is leeway for differences in judgment, and you are more familiar with your operations than I.

I hope this helps.

Sincerely,

Fred Ferate, Ph.D., CHP
PHMSA/Radioactive Materials Branch
U.S. Department of Transportation
East Building, 2nd Floor, PHH-23
1200 New Jersey Avenue, S.E.

Washington, D.C. 20590-0001
Phone: 202-366-4498
Fax: 202-366-3753

-----Original Message-----
From: INFOCNTR <PHMSA>
Sent: Tuesday, June 12, 2007 11:24 AM
To: Ferate, Fred <PHMSA>
Subject: FW: Information Center Comments/Questions

Fred,

Do you think there is any chance that you could look at this e-mail and see if you can assist this gentleman? Several of us have looked at what he is asking and this is so far into RAM that we think it is a little over our heads. So, I figured I would get your input. I don't mean to dump this on you, but these questions seem a little more technical than what we typically handle with radioactives over here. Let me know if you are too busy or cannot help and I will bark up another tree. Thank you so much for looking at it.

Erin Jarman
HMIC

-----Original Message-----
From: gjborden@wch-rcc.com [mailto:gjborden@wch-rcc.com]
Sent: Monday, June 11, 2007 12:26 PM
To: INFOCNTR <PHMSA>
Subject: Information Center Comments/Questions

Below is the result of your feedback form. It was submitted by Greg Borden (gjborden@wch-rcc.com) on Monday, June 11, 2007 at 12:26:06.

Email: gjborden@wch-rcc.com

Name: Greg Borden

Category: Shippers-General Requirements for Shipments and Packagings (Sections 173.1 - 173.476)

Organization: Washington Closure, LLC

Street: 2620 Fermi Avenue

City: Richland

State: Washington

Zip Code: 99354

Phone: 509 531 0750

Fax: 509 373 4130

Comments: My company is involved in the remediation of past practice radioactive waste burial grounds. The waste being shipped is generally soil, with activated reactor components randomly distributed in the soil. The specific activity of the soil is relatively consistent (deviations are well less than an order of magnitude). Generally the material is excavated and shipped together without any segregation in large (15-25 cubic yard) containers.

The soil meets all of the definitional and other requirements for classification as LSA 1 material.

The activated metal meets all of the definitional and other requirements for

classification as LSA 2 material.

In some cases the specific activity for the activated metal may exceed an order of magnitude difference in activity from the specific activity of the soil.

The total activity of the containers is usually (~85-90%% of the time) less than an A2 quantity.

I have the following three questions regarding the classification of these shipments:

1) Is it permissible to utilize the total mass and activity of the container including both the soil and activated components to determine the LSA classification as long as the individual items all meet the definition of LSA?

2) Is it permissible to classify the combined load in accordance with the highest classification of any individual item (i.e., if the soil was LSA-1 and the activated metal LSA-2, the total load would be classified as LSA-2).

3) Are the answers to these questions dependent on the relationship to an A2 value?

If you could please respond in an e-mail, I would appreciate it.

Thanks for the assistance.

4 LOW SPECIFIC ACTIVITY MATERIAL

The previous regulations contained provisions for shipment of LSA material. While the specific activity limit allowed in LSA material was significantly lower for essentially all radionuclides, there was no upper limit to the amount of LSA material that could be shipped in a non-accident resistant package. The LSA limits in the previous rules were basically: 0.1 μCi/g for nuclides with an $A_2 \leq 0.05$ Ci (most alpha emitters); 5 μCi/g if $0.05 < A_2 \leq 1$ Ci (i.e., mixed fission products, Sr-90, Cm-242, Pb-210, Po-210, Pu-241, Ra 223, Ra-224, and uranium isotopes); or 0.3 mCi/g for nuclides with an A_2 greater than 1 Ci (most gamma emitters).

The new limits are tied, on a nuclide-specific basis, to the A_2 values. In addition, the permissible concentration for almost all nuclides has more than doubled under the widely-applicable LSA-II solids limit of 10^{-4} A_2/g. For example, the previous limit for Co-60 was 0.3 mCi/g, whereas the LSA-II limit is now 1.08 mCi/g. Similarly, the previous limit for Sr-90 was 5 μCi/g, whereas the LSA-II limit is now 270 μCi/g. And the previous limit for Pu-239 was 0.1 μCi/g, whereas the LSA-II limit is now 0.54 μCi/g.

LSA material has been divided into groups in the 1996 domestic regulations (DOT, 1996; NRC, 1996a). It has retained its own proper shipping name and United Nations identification number, UN2912, in the hazardous material table [49 CFR 172.101 (DOT, 1996)]. Specific activity limits for the LSA material category are now specified for three different subcategories (i.e., LSA-I, LSA-II, and LSA-III), which are explicitly related to the A_2 of the material involved. Finally, the LSA definitions now distinguish between two types of distribution of activity in the material, *essentially uniformly distributed* (used in the definitions of LSA-I and LSA-III) and *distributed throughout* (used in LSA-II and LSA-III).

Section 4.1 provides guidance on grouping materials as LSA-I, LSA-II, or LSA-III. Section 4.2 clarifies some of the technical terms used in the LSA definitions, including specific guidance for complying with the distribution of radioactivity in the LSA material.

4.1 Categorizing a Class 7 (Radioactive) Material as LSA

Shipping a Class 7 (radioactive) material as LSA material is an option to shipping the material as "Radioactive material, n.o.s.," with identification number "UN 2982." LSA packaging requirements and communications requirements provide for some relief from the corresponding requirements for "Radioactive material, n.o.s." This relief is based primarily on the inherently safe nature of the quantity and distribution of activity in the LSA material.

4.1.1 What general categories of materials are intended to be shipped as LSA?

As in the past, LLW which have the activity incorporated into the waste matrix are the materials which will most likely satisfy the LSA material definitions. However, any radioactive material which can be demonstrated to satisfy the LSA definitions and the unshielded dose rate could be categorized as LSA and shipped in accordance with 49 CFR 173.427 (DOT, 1996). To be categorized as such, it must either be nonfissile or fissile excepted (49 CFR 173.427(a)(3).

Low Specific Activity Material

Note that any radioactive material which meets the requirements in 49 CFR 173.421, for excepted packages of limited quantities of Class 7 (radioactive) materials, can be shipped as "Radioactive Material, excepted package, limited quantity of material," with an identification number of "UN2910." The activity per package in a normal form excepted package shipment (such as an activated or a contaminated object) would be limited to 10^{-3} A_2 as given by Table 7 of 49 CFR 173.425 (DOT, 1996). In such cases, there is no need to evaluate for compliance with the LSA definitions.

It is expected that much the of waste from nuclear power plant operations will be categorized as LSA-II material. Examples of candidate LSA-II materials from process waste streams would be dewatered ion exchange media (i.e., resins), evaporator bottoms, mechanical filters and filter media, absorbed liquids, and other similar process waste types. Other examples of LSA-II would be demolition rubble which exceeds LSA-I limits, activated metals, organic liquids (e.g., scintillation fluids or oils), removed paint, and biological wastes. Thus, the great majority of material that has previously been shipped as LSA material can continue to be shipped as LSA-II material under the revised regulations.

Compactable and noncompactable trash (e.g., dry active wastes, or "DAW") is an ambiguous category, possibly candidate for categorization as either LSA material or SCOs. For example, materials that absorb or incorporate the radioactivity (e.g., towels, rags, labwipes, clay for absorbing spills, or tape) would be candidate LSA material. Contaminated objects (e.g., discarded gloves, tools, hardware, labware and glassware) might more appropriately be considered as candidate SCOs. However, it is not the intent of the transportation regulations to require segregation of these materials solely for purposes categorization as LSA material or SCOs. If qualitative judgement and experience indicates that there is no reason to believe that the SCO contamination limits on objects would be exceeded (this experience would be gained through operations knowledge and periodic health physics surveillance), then the objects could be mixed in a single package, along with materials which are clearly categorized LSA material by their nature (e.g., DAW or even LSA waste materials) and shipped according to the requirements of 49 CFR 173.427, as "Radioactive material, LSA, n.o.s." with identification number "UN2912." This practice is generally acceptable provided the LSA-II definition is otherwise satisfied, and the package contains less than 1 A_2 quantity (the great majority of DAW packages). In greater quantities, the practice may also be justified on a case-by-case basis. See section 6.1.1 for further details.

4.1.2 Is there a contamination limit for an LSA material's surfaces?

The current regulations do not place limits on contamination for LSA material. Therefore, there is no requirement to comply with the SCO surface contamination limits for LSA material. A contaminated, activated object may be categorized as LSA material insofar as it otherwise meets the requirements of the applicable LSA definition; however, an activated object may not be categorized as an SCO. Any contamination on the surfaces of LSA material must be accounted for in characterizing the material or object as LSA, and in determining the nuclides present in the package in accordance with 49 CFR §§ 173.433 and 173.435 (i.e., the "95%" A_2 sum of fractions rule), to be reported on shipping papers and labels (if not excepted from labeling). Also, since the contamination on the surface of LSA material may be from a different waste stream than the waste's (or object's) contained activity, it may not be accounted for in the sample data base used

to estimate nuclide concentrations. In this event, any such contamination should be identified and properly accounted for in categorizing the material for shipment.

4.1.3 When an unshielded LSA material exceeds 10 mSv/hr (1 rem/hr) at 3 m (9.9 ft), what is the proper shipping name?

The proper shipping name in these cases is "Radioactive material, n.o.s." with the identification number of "UN2982" and, with one exception described below, a Type B package is required due to the quantity of material. If a material can otherwise satisfy the LSA requirements, but the 10 mSv/hr (1 rem/hr) at 3 m (9.9 ft) unshielded dose rate limit is exceeded, then the material no longer meets the intent of the LSA material regulations justifying the use of less robust packaging that would otherwise be required for Type B quantities of material. Also, Type B packages are not excepted from DOT marking and labeling requirements, as other packages for LSA sometimes are [49 CFR 173.427 (DOT, 1996)].

NRC regulations [10 CFR 71.52 (NRC, 1996a)] allow that previously-certified NRC packages for LSA materials (i.e., NRC Type A-LSA packages) may continue to be used for LSA and SCO shipments until April 1, 1999. The "Directory of Certificates of Compliance for Radioactive Materials Packages," NUREG-0383 (NRC, 1996d) provides a compiled list of NRC certified package designs. These package designs can continue to be used as under previous regulations (see section 6.3.4), provided the conditions in the certificate of compliance (CoC) are complied with. They can be used for LSA material exceeding the 10 mSv/hr (1 rem/hr) at 3 m (9.9 ft) unshielded dose rate limit. The proper shipping name for LSA material shipped using these packages is "Radioactive material, LSA, n.o.s." with identification number "UN2912," and the packages are exempted from DOT marking and labeling requirements as specified in 49 CFR 173.427(a)(6)(vi) and (b)(4)[1].

4.1.4 Is there an object size below which collections of small contaminated objects may be categorized and shipped as LSA material (as opposed to SCOs)?

NRC and DOT staff believe that the best approach to the small contaminated object issue is to simplify the process for their categorization as SCOs, rather than to classify them as LSA material. Nonradioactive objects whose surfaces are contaminated with radioactivity are clearly candidate SCOs, not LSA material, regardless of size. Accordingly, when possible, the method described in Section 3.3.1 should be used to categorize collections of small objects as SCO. The contamination on each small object is not required to be measured. Rather, a representative sample of the small objects can be assessed, and the activity and surface contamination in the entire collection can then be estimated. Unless evidence suggests otherwise, it is generally acceptable to assume uniform contamination over the surfaces of collections of these small objects. If successfully characterized as SCO-I or SCO-II, the objects should be shipped using the proper shipping name, "Radioactive material, SCO" with identification number "UN2913." See also section 6.1 for guidance on the mixing of LSA materials with SCOs.

[1]Note: 49 CFR 173.427(b)(4) was issued in the corrections rule (61 FR 20747) to the initial rule (60 FR 50292).

4.1.5 Can activated metals, or a radioactive material which is solidified or absorbed on nonradioactive material, be categorized as LSA-II?

There are no restrictions which prohibit categorizing solidified, absorbed, or activated metal radioactive material as LSA-II, provided the definition is otherwise satisfied (i.e., specific activity limits, distribution requirement, and dose rate limits are met). Inclusion of the term *solid compact binding agent* in the LSA-III definition was not intended to preclude categorizing these materials as LSA-II. Similarly, activated metals are suitable for evaluation as possible LSA-II material, even though the term is explicitly cited as an example of a possible LSA-III material in 10 CFR 71.4 and 49 CFR 173.403.

Also, materials such as decommissioning wastes which exceed the LSA-I average specific activity limit, can also be evaluated as a possible LSA-II material.

4.1.6 Can the mass of grout or binding agents used in or on an object be included in the LSA specific activity or unshielded dose rate determinations?

In order to be considered in the determination of the average specific activity, or in the determination of unshielded dose rates, the radioactive material must be incorporated into the grout or binding agents.

If grout is used as shielding, structural support, or encapsulating material (i.e, the object or radioactive material is not incorporated into the grout), the grout should not be included in the LSA determinations. This situation would not meet the applicable LSA material definition's activity distribution requirement.

4.1.7 Can leach testing for disposal (10 CFR Part 61) substitute for the LSA-III leach test?

The LSA-III leach test is specified in 49 CFR 173.468 and 10 CFR 71.77 (DOT, 1996; NRC, 1996a). Radioactive waste forms that contain less than 1 A_2 quantity of radioactive material can be presumed to satisfy the LSA-III leach test requirements if they have been prepared under a process control plan (PCP) associated with an approved waste solidification recipe in accordance with NRC's Technical Position (TP) on Waste Form, Rev. 1 (NRC, 1991). However, since the TP on waste form only addresses Class B and Class C LLW, only LLW which is stabilized by solidification in order to satisfy the 10 CFR 61 (NRC, 1996c), in compliance with the TP, can use this method for satisfying the leach test requirement for LSA-III shipments.

4.1.8 Is it acceptable to use representative samples in the LSA-III leach test?

Yes, although the LSA-III leach test [49 CFR 173.468 and 10 CFR 71.77 (DOT, 1996; NRC, 1996a)] states that, "the specimen, representing no less than the entire contents of the package, must be immersed for 7 days in water at ambient temperature; ....", the wording is not intended to imply or require that the contents of each packaging being characterized must be leach-tested

prior to transport. Also, the requirement is not meant to imply that full-scale tests are necessary to comply with the regulations. If frequent LSA-III shipments are expected, use of a process control program (PCP), similar to that used for compliance with the TP on waste form (Rev. 1) (see section 4.1.7 above), is one acceptable means of demonstrating compliance with the LSA-III leach test. At a minimum, such a program would include periodic sampling (i.e., control specimens), address waste stream consistency, and correlate lab-scale test results to full-scale test results.

4.1.9 Is it necessary to leach test activated metals?

Activated metals are a likely candidates for categorization as LSA-III material. They typically will be inherently leach resistant. However, their surfaces could be contaminated.

If the activated metals are not surface contaminated, then they will not leach and completion of a leach test is not necessary.

Contaminated, activated metals will need to be assessed to determine their leach resistance. A simple assessment, which would not require the performance of tests, could assume that all surface contamination is leached and, based upon this assumption, determine whether the material satisfies the leach test requirements. If this assessment does not provide a satisfactory result, then the shipper should consider either decontaminating the material or conducting a leach test for LSA-III categorization.

4.2 Clarification of Terms Used in the LSA Definitions

The definitions of LSA-I, LSA-II, and LSA-III in 49 CFR 173.403 and 10 CFR 71.4 (DOT, 1996; NRC 1996a) contain several technical terms which are not explicitly defined. There is some guidance in the IAEA advisory material, Safety Series No 37 (IAEA, 1990c). This section provides additional clarification of the intent and meaning of these terms as used in the regulatory definitions. The terms include: *other debris* and *activated material* in the LSA-I definition, *distributed throughout* as used in the LSA-II and LSA-III definitions, and *essentially uniformly distributed* as used in the LSA-I and LSA-III definitions. The IAEA advisory material is used for clarification of the terms *distributed throughout* and *essentially uniformly distributed.*

4.2.1 What is the intent of the terminology *rubble, other debris, and activated material* in the LSA-I definition?

The definition states that LSA-I consists of, among other things, "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 per gram of material." This part of the LSA-I definition is an area where domestic regulations are not compatible with the international regulations (IAEA, 1990a). This text was included in domestic regulations based on comments received on the proposed rules. A discussion of the changes appears in the statement of considerations for 10 CFR Part 71 (NRC, 1995b).

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The phrasing, "other debris, and activated material in which ... the average specific activity does not exceed 10^{-6} A_2 per gram," is somewhat ambiguous and can be misinterpreted to mean that many materials, including process wastes, could be placed in the LSA-I group. Based on the statement of considerations, LSA-I material should not include day-to-day wastes from plant operations. The LSA-I category is primarily intended for use with wastes from decommissioning activities.

Examples of *rubble, other debris and activated material* are: small fragments of mortar or broken concrete block or bricks; chipped or scabbled concrete vacuumed or swept into storage or handling receptacles; floor sweepings of small size; activated and contaminated vinyl or linoleum flooring or carpeting stripped from laboratories, work areas or other locations; or activated non-masonry building materials (e.g., lumber, glass, metal, and sheetrock) including fasteners (e.g., nails, screws, and rivets).

Examples of material that would not be *rubble, other debris and activated material* are: processed wastes or product streams; sludge; evaporator bottoms; contaminated building materials (lumber, panels, flooring, sheetrock, structural steel or aluminum, etc., that are more appropriately SCOs); and dry-active wastes including absorbent cloths, and protective clothing.

4.2.2 What is the difference between *distributed throughout* and *essentially uniformly distributed*?

Essentially uniformly distributed is intended to be more restrictive than *distributed throughout.* However, using the guidance in Section 4.2.3, this difference only becomes important for LSA material in packages with radioactivity exceeding a quantity of 1 A_2. The terms, *essentially uniformly distributed* and *distributed throughout*, are both intended to disallow categorization of material as LSA in a situation during which a small volume of very high radioactivity is placed within a large quantity of nonradioactive or slightly radioactive material, thereby reducing the average concentration to within specified limits. If, in such a case, the packaging were destroyed during transport and the highly radioactive portion were separated from the nonradioactive or slightly radioactive portion, it could cause substantial radiation exposure, either from direct radiation or through a pathway (e.g., inhalation or ingestion). The IAEA models justifying the less restrictive rules applied to LSA shipments (as compared to other radioactive materials shipments) assume uniform distribution of any LSA material released from the package.

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?

It is permissible to apply qualitative techniques for LSA materials having radioactive materials in quantities less than 1 A_2, and to apply the more quantitative techniques in the IAEA's advisory material (IAEA, 1990c) for LSA materials having radioactive materials in quantities exceeding 1 A_2.

There is no need to quantitatively address the distribution of the nuclides in the LSA material for packages with radioactivity less than 1 A_2 in quantity. In this case, shippers may determine that the activity is adequately distributed within the material based upon a criterion that a large amount of non- or slightly-radioactive material has not been used in the specific activity determination with the radioactive material. If it is known that the material has a highly-stratified or significantly non-uniform distribution, then this criterion cannot be used, and a more rigorous assessment will be required. For example, most LLW packaged for disposal would typically have the radioactivity distributed within the package to an acceptable extent.

When a quantity of material has radioactivity exceeding 1 A_2, and a dose rate less than 10 mSv/hr (1 rem/hr) at 3 m (9.9 ft) from the unshielded surface of the material, a more quantitative determination of the distribution of activity is needed. This determination can be made through reasoned argument, reference, calculation, or measurement. The following, based upon the IAEA's advisory material (IAEA, 1999c), may be used:

- 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.

- For *essentially uniformly distributed,* 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 3.

For small (i.e., smaller than 0.2 m^3 (7.5 ft^3), or a 55 gal. drum) LSA material packages, the IAEA Safety Series No. 37 method described above should not be applied.

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).
- Encapsulated wastes should not be averaged over the weight of the solidified mass for determination of the material's average specific activity (as is allowed for LLW classification).
- Sealed sources cannot be considered LSA material unless the source itself meets the LSA definition (specific activity limit and distribution); although the TP allows averaging the sealed source activity over the entire waste form for LLW classification, this practice is not acceptable for LSA material determinations for transport.

4.2.5 What is a *combustible solid* with respect to the conveyance activity limit for LSA material of Table 9?

The meaning of *combustible solid* only becomes important for LSA-II and LSA-III material when the quantity on a conveyance exceeds 100 A_2 quantities [i.e., the conveyance activity limit in Table 9 of 49 CFR 173.427 (DOT, 1996)]. LSA-II and LSA-III noncombustible solids do not have a conveyance activity limit.

The National Fire Protection Association (NFPA) has published a standard which provides a guide on quantifying combustible hazards of materials, which can be used for characterizing combustibility of LSA material (NFPA, 1990). Based upon this standard, combustible LSA solids may be defined as follows:

> *Combustible solid* LSA materials are LSA-II and LSA-III materials in solid form which, under conditions encountered in transport, may cause or contribute to fire or are capable of sustaining combustion on their own or in a fire. The solid is combustible if the material has a flammability hazard ranking of 1 or 2 according to the test method in NFPA 704 (NFPA, 1990). Solid materials which have a flammability hazard ranking of 0 (zero) according to NFPA 704 are noncombustible.

In assessing combustibility of a mixture of materials, the amount of material which is combustible will determine whether the entire mixture is combustible (i.e., capable of causing or contributing to fire or are capable of sustaining combustion on their own or in a fire). It is permissible, for conveyance quantities greater than 100 A_2, to have a small amount of combustible solid intermixed with noncombustible solids. If combustible solids do not exceed one percent, by mass, of the total material, the mixture shall be deemed to be noncombustible.

Examples of combustible solid materials are: insulating materials; building materials [polyvinyl chloride (PVC), plastic, wood, etc.]; filtering materials (charcoal, fiberglass, etc.); ion-exchange resins; cleaners; paints; personal protective equipment (PPE) such as clothing, booties, and cartridges; or other materials that would be assigned a flammability hazard ranking of 1 or 2 using NFPA 704 (NFPA, 1990). Examples of non-combustible solids are: cement building materials, metal components, or other materials assigned a flammability hazard ranking of 0 ("zero") using the definitions in NFPA 704.

4.2.6 What was the misprint in NRC's and DOT's September 28, 1995 *Federal Register* final rules (60 FR 50292 and 60 FR 50248) regarding the terms *distributed throughout* and *essentially uniformly distributed*?

Two misprints appear in both the NRC Final Rule *Federal Register* notice (NRC, 1995b) and the DOT notice (DOT, 1995), regarding the definitions of LSA-II solids and LSA-III objects that are not solidified in a binder. The use of the phrase "*essentially uniformly distributed*" in Item (2)(ii) of the LSA-II definition, is incorrect, and has been replaced with the term "*distributed throughout.*" The phrase "*essentially uniformly distributed throughout*" in item (3)(I) of the LSA-III definition is incorrect, and has been replaced with the term "*distributed throughout*". The use of the phrase "*essentially uniformly distributed"* in the LSA-I definition, and in the definition for LSA-III materials solidified in a binding agent, is correct as it appears in the regulations. The 1995 bound Title 49 Code of Federal Regulations (CFR) volume, and the 1996 bound Title 10 CFR, also contain the errors from the original *Federal Register* notice. NRC and DOT have since issued corrections notices (61 FR 28723 and 61 FR 20747) which clarify these and other misprints in the original notices.