

A Perspective on Transportation Regulations for Low Specific Activity (LSA) Material and Surface Contaminated Objects (SCO)

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ABSTRACT

Revisions to domestic regulations for transportation of radioactive materials became effective on April 1, 1996, and have affected the shipment of Low Specific Activity (LSA) Material and Surface Contaminated Objects (SCO). To clarify some technical uncertainties and ensure that licensees properly implement the revised requirements, the U.S. Department of Transportation and the U.S. Nuclear Regulatory Commission are jointly preparing regulatory guidance for LSA and SCO transport.

The guidance will present examples of acceptable methods for demonstrating compliance with the revised rules. Some of the ideas being investigated for inclusion in the pending guidance are discussed in this paper. Under current plans, the guidance will be issued for public comment prior to final issuance in 1997.

INTRODUCTION

The U.S. Department of Transportation (DOT) [1] and the U.S. Nuclear Regulatory Commission (NRC) [2] regulations for transportation of radioactive materials were revised, effective April 1, 1996, for compatibility with those of the International Atomic Energy Agency (i.e., IAEA Safety Series No. 6, 1985 edition) [3]. The revisions have changed the regulatory framework under which low-specific activity (LSA) material and surface contaminated objects (SCOs) are shipped. The great majority, by volume, of low-level radioactive waste (LLW) shipped as a result of NRC licensed activities is shipped as LSA material or SCOs. In addition, radioactive ores and plant maintenance and outage equipment have typically been categorized as LSA material or SCOs.

Under the previous regulations a single broad category, LSA material, encompassed materials that met the specific activity limit and surface contaminated objects. Under the revised rules, the scheme for shipping these materials has been refined: (1) SCOs, formerly a sub-class of LSA, are now defined separately; (2) LSA material and SCO are further divided into the groups LSA-I, LSA-II, LSA-III, and SCO-I, and SCO-II; (3) the LSA material groups in the revised regulations make distinctions between the terms, *essentially uniformly distributed*, and *distributed*

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throughout; (4) LSA specific activity limits have been tied to each nuclide's A_2 quantity, and have increased substantially for most nuclides (the A_2 quantity is the amount of normal form radioactive material which can be transported in a non-accident resistant package - see 49 CFR 173.433); (5) SCO definitions distinguish between fixed and removable contamination on accessible and inaccessible surfaces; (6) NRC certification of the packaging for LSA material and SCOs is no longer required, unless the dose rate from the unshielded material exceeds 10 mSv/hr (1 rem/hr) at 3 meters (9.9 ft); and (7) the industrial packagings (IPs) have been authorized for use with LSA material and SCOs.

Generally the 1996 regulations for LSA material and SCOs are more prescriptive than were the previous regulations. However, DOT and NRC have not observed a major economic or practical impact of the revised rules on the shipment of waste as LSA material or SCOs, in that activities that have taken place in the past have continued to take place in a safe manner.

JOINT NRC-DOT DRAFT GUIDANCE

The revised regulations have generated several questions regarding their proper and consistent implementation. At the request of industry, NRC and DOT will be issuing joint guidance on shipment of LSA material and SCO in the near future. The remainder of this paper describes some of the questions and the corresponding guidance under development.

This paper presents initial thoughts on the content of the joint guidance being considered by NRC and DOT staff. Current plans are to issue the joint guidance, in draft form, for public comment in 1997. As a result of the public comments, peer review, and internal discussions, the content of both the draft and final guidance may be significantly different from that presented in this paper. NRC staff is presenting this paper to enhance public involvement in the early stages of the guidance development.

The questions on the revised regulations can be grouped into four general categories: (1) definitions and classification of materials, (2) compliance with SCO surface contamination limits, and (3) measurements of the dose rate 3 m (9.9 ft) from the unshielded material, and (4) determination of distribution of activity in LSA material.

DEFINITIONS AND CLASSIFICATION OF MATERIALS

Many materials that were previously shipped as LSA material can and should now be shipped using the LSA-I, LSA-II, or LSA-III groups. For example, process wastes (e.g., resins, filter media) and dry active wastes (e.g., absorbent materials, "bags, tags, and rags") should be classified as LSA-II. However, some objects which are not themselves radioactive, but have radioactive materials distributed on their surfaces (e.g., certain equipment used during an utility outage) must now be classified as SCO in accordance with the revised regulations. There may be, however, some practical exceptions to this, which may be addressed in the guidance (e.g., collections of small SCOs such as sample containers could be combined with LSA material and

shipped as LSA material).

Under the previous regulations, SCOs were a subset of LSA material, although the area allowed for averaging the contamination was greater and the surface contamination limits did not distinguish between fixed and non-fixed (removable) contamination, or accessible and inaccessible surfaces. SCOs are no longer a subset of LSA material, and under the current rules, if the definition is complied with, non-radioactive, contaminated objects can be categorized as SCOs.

Objects that are radioactive (e.g., activated objects) and are also contaminated cannot be classified as SCOs. However, if the activation is less than 70 Bq/g (2 nCi/g), then the object can be classed as SCO because the activation is less than DOT's hazardous materials definition of Class 7 (radioactive) material. If an object is activated to an average level in excess of 70 Bq/g (2 nCi/g), the object itself is classed as radioactive material according to 10 CFR 71.4 and 49 CFR 173.403. Therefore, it may not be classified as an SCO; however, it may be regarded as LSA material insofar as the requirements specified in the LSA definitions are satisfied. Note that 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 definition of contamination was adopted in IAEA Safety Series No 6, 1985 edition, as contamination exceeding 0.4 Bq/cm^2 ($10^{-5} \text{ } \mu\text{Ci/cm}^2$) for beta and gamma emitters and low-toxicity alpha emitters, and 0.04 Bq/cm^2 ($10^{-6} \text{ } \mu\text{Ci/cm}^2$) for all other alpha emitters. A comparable definition was not adopted in the domestic regulatory revisions which became effective April 1, 1996. This lower limit of contamination serves a comparable function to the limit of 70 Bq/g (2 nCi/g) in the definition of radioactive material, in that materials less than these limits are below the scope of the hazardous material regulations.

Since the radioactive material definition of 70 Bq/g (2 nCi/g) is based on an activity per unit mass, it is not readily applicable to SCOs or to whether a slightly contaminated object is subject to regulation or not. Material with surfaces contaminated to levels greater than the above values should not be exempted from hazardous materials regulations in 49 CFR Parts 171-178. Dividing the activity in the contamination by the mass of the object is not appropriate for these materials, because it opens the possibility for a massive object with significant amounts of contamination on its surfaces falling below the regulatory threshold of radioactive material. This situation is not consistent with the intent of the regulatory exemption limit and should be avoided. DOT staff is currently considering addition of the contamination definition to 49 CFR Part 173.

It is NRC staff's understanding that some shippers have had difficulty in implementing the new regulations for categorizing SCOs. For example, health physicists (or other certifying officials) have indicated hesitation in signing the DOT certification statement for SCO shipments, because of concern that the receiver or NRC inspector will find fault and determine there is a DOT violation, despite the shipper's conscientious efforts to meet the intent of the regulation.

Additionally, there have been questions regarding categorization as SCO-I versus SCO-II, since some have questioned whether it is permitted, or conservative, to default to SCO-II. Another question relates to classifying collections of small contaminated objects. Finally, there has been some confusion in defining inaccessible surfaces and fixed contamination.

NRC and DOT staff believe that objects should be classified as SCO when appropriate. SCOs had to be characterized as a subset of LSA under the previous regulations. Presumably, the hesitation to classify objects as SCO is because measurements at the point of origin may be taken using different methods, or locations, as compared to measurements taken at the point of destination. First, there are no requirements to make an SCO determination at the destination point. There are required (10 CFR 20.1906) contamination surveys, upon receipt, of surfaces of packages with DOT radioactive labels. Note that typical packages for SCO (exclusive-use, domestic strong-tight packages) are exempted from DOT labeling requirements by 49 CFR 173.427. In addition, measurements are not the only means of demonstrating compliance with the contamination limits; reasoned arguments, reference to previous shipment, and calculations can also be used if justified.

It is always permitted to classify and ship an object meeting the SCO-II definition as an SCO-II, even if further characterization might demonstrate the object meets the lower contamination limits of SCO-I. SCO-II has equivalent packaging requirements to SCO-I in domestic regulations (49 CFR 173.427). Further, SCO-I is less of a contamination hazard than is SCO-II, therefore categorization of a potential SCO-I as SCO-II is conservative.

NRC and DOT are proposing to define inaccessible surfaces, as surfaces which cannot be readily smeared or wiped, by hand, using standard assessment techniques. The phrasing, "by hand" is not meant to discourage use of as low as is reasonably achievable (ALARA) tools such as telescopic sampling instruments. The phrasing, "standard assessment techniques," is intended to imply practices similar to those used for complying with package contamination limits in 49 CFR 173.433. For example, the bottom, or top, of an object would be accessible, but surfaces which must be reached by probing small openings would be inaccessible. Similarly, non-fixed (removable) contamination would be defined such that it would not be removed using the techniques in practice for the package contamination limits in 49 CFR 173.443 (i.e., applying moderate pressure using an absorbent material).

COMPLIANCE WITH SCO CONTAMINATION LIMITS

As mentioned above, some non-radioactive objects which are not themselves radioactive, but have radioactive materials distributed on their surfaces are now categorized as SCO. However, the regulations do not require measurement of contamination or radiation levels as the only means of compliance; calculations, reference, or reasoned arguments can also be acceptable.

Pre-shipment analyses are required to demonstrate compliance with the applicable SCO definition. The level of detail in these analyses is expected to be proportional to the potential

hazard that the material represents. The potential hazard is based on the quantity (i.e., activity) of Class 7 (radioactive) material to be shipped. Therefore, the first step in any shipment would be to determine the A_2 fraction of Class 7 (radioactive) material in the package, using the methods required by 49 CFR 173.433 (i.e., the "95% sum of fractions" rule).

There have been many questions regarding the consistency of making SCO determinations with 10 CFR Part 20 requirements to maintain occupational exposures as low as is reasonably achievable (ALARA). Note that the identity of the nuclides representing at least 95% of the total A_2 fraction in the package is required to be entered on the shipping papers, pursuant to 49 CFR 173.433 and 49 CFR 172.203. This identification is required for all radioactive materials shipments, is independent of classification as SCO, and was also required (in a slightly different form) under the previous regulations; therefore, this determination of the nuclides is not construed by NRC or DOT to cause additional doses to personnel. That is, methods used in the past for determining the contents can continue to be used under the revised regulations.

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). One concept is that 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. The materials characterized using this reasoned argument would be shipped as "Radioactive - SCO."

The reasoned argument would be based on the non-fixed (removable) contamination, the quantity of activity in the package, and if the package would otherwise meet the LSA-II material specific activity and distribution requirements. The applicability would be limited to shipment of SCO-I or SCO-II made pursuant to 49 CFR 173.427(b)(3), for domestic, exclusive-use transport of SCOs in strong-tight containers (STCs), in quantities less than 1 A_2 .

The basis for allowing this argument is as follows: for domestic exclusive-use shipments of radioactive materials in quantities less than A_2 , the minimum packaging requirements for LSA material and SCO are identical (i.e., strong-tight containers). Further, there are no other requirements (e.g., emergency response requirements) in NRC or DOT regulations which would increase safety if an object were categorized as SCO as opposed to LSA material. Therefore, incurring additional dose to satisfy the conditions in the SCO definition, would not be expected to provide any additional safety for such a shipment, and would not be consistent with ALARA requirements.

The second part of the guidance in this area would be that, for packages containing SCOs with greater than 1 A_2 quantity, a more quantitative analysis is expected than for packages with less than 1 A_2 quantity. The justification of this expectation is that for quantities greater than 1 A_2 , the packaging requirements for LSA material and SCOs may be different, and for quantities of normal form radioactive material exceeding 1 A_2 , the non-LSA Material or SCO would

otherwise require accident-resistant (i.e., Type B) packaging for transport. For these larger quantities, strict, quantitative compliance with the definition of SCO is important, because the special properties of the SCO is what justifies the use of the non-accident resistant package.

UNSHIELDED DOSE RATE LIMIT AT 3 METERS

Certification of packaging for LSA material and SCOs is now required only when the dose rate at 3 m (9.9 ft) from the unshielded LSA material or SCO exceeds 10 mSv/hr (1 rem/hr). In excess of this, a Type B (accident resistant) package is required, except that previously approved NRC Type A-LSA packages are authorized until April 1999. Under the previous regulations, NRC certification of LSA material was obtained if the package contents exceeded an A_2 quantity, and then the LSA package was required to meet the Type A (non-accident) standards. Generally, there was no specific upper limit to the activity of LSA material which could be placed in a Type A package (a practical limit existed due to vehicle dose rates). The effect of the new regulations is to explicitly limit the contents allowed in non-accident resistant packages for LSA material and SCO, which is several multiples (e.g., typically about 4 A_2 quantities) of the limit (one A_2 value) for other radioactive material.

NRC and DOT staff believe that in the great majority of candidate LSA/SCO shipments, the dose rate will be much lower than the limit. Therefore, shippers would be expected to be able to use simple, reasoned arguments for meeting the requirement. NRC and DOT staff also assume that the 3 m (9.9 ft) unshielded dose rate will not be an issue for SCOs, other than very large objects (e.g., discarded steam generators), because the surface contamination on objects should not present practical cases in which dose rates could reach such values.

NRC and DOT are considering that the 10 mSv/hr (1 rem/hr) at 3 meter (9.9 ft) dose rate from the unshielded LSA material and SCO, would only be a relevant concern when the package contents exceed a total of 2 A_1 quantities. Analyses during development of the rulemaking demonstrated that it is unlikely that a package of LSA material with 2 A_1 quantities or less would approach the 10 mSv/hr (1 rem/hr) dose rate limit at 3 m (9.9 ft) from the unshielded LSA material or SCO. NRC and DOT staff believe that this guidance could generically address the great fraction of LSA material and SCO shipments.

If the package contents exceed a total of 2 A_1 quantities, it is anticipated that licensees will base the dose rate determination on measured dose rates from the package surfaces; and prior knowledge about the package contents through routine sampling (e.g., for process wastes), or through specific sampling of the contents (e.g., for activated hardware/components). A back-calculation can then be performed which effectively removes *all* packaging, including liners, from the contents. It is expected that licensees may develop or purchase systematic procedures or programs which relate measured dose rates, frequently used package types, and waste stream information, to the unshielded dose rate at 3 m (9.9 ft). Adherence to ALARA practices is still stressed for these determinations. It is recognized that back calculations from measurements, for example, may mask "hot spots" within the LLW. Means for dealing with this technically

difficult issue are being investigated.

The regulations, at 10 CFR 71.52, allow that previously-certified NRC packages for LSA materials may continue to be used for LSA and SCO shipments until April 1, 1999. NRC certified packages for LSA materials are listed in the "Directory of Certificates of Compliance for Radioactive Materials Packages," NUREG-0383 [4]. The authorized contents specified on these certificates are based on the LSA definitions from the previous rules. NRC has revised all certificates for these packages to: (1) show an expiration date of April 1, 1999; and (2) to limit the specific activity allowed to correspond to that of the old rules (i.e., basically 0.1 $\mu\text{Ci/g}$ for nuclides with an $A_2 \leq 0.05$ Ci; 5 $\mu\text{Ci/g}$ if $0.05 < A_2 \leq 1$ Ci; or 0.3 mCi/g for nuclides with an A_2 greater than 1 Ci). Licensees must have a copy, and ship in compliance with, the revised Certificate of Compliance.

DISTRIBUTION OF ACTIVITY IN LSA MATERIAL

The groups, LSA-I, LSA-II, LSA-III, and SCO-I, and SCO-II, are based on the origin of the material, the concentration, distribution, and surface density of the radioactivity. Generally, the group determines the industrial packaging (IP) requirements for non-domestic shipments. For domestic shipments in excess of one A_2 value but less than 10 mSv/hr (1 rem/hr) at 3 meters (9.9 ft) unshielded, shippers may opt to use the appropriate IP in lieu of the more rigorous DOT Spec. 7A Type A package. The practical experience has been that the IPs are not widely available, and shippers tend to use DOT Specification-7A Type A packages.

The LSA material definitions in the revised regulations employ two terms describing the distribution of radioactivity in LSA material, *essentially uniformly distributed* and *distributed throughout*. *Essentially uniformly distributed* is intended to be more restrictive than *distributed throughout*. Note that misprints of these terms appeared in the DOT and NRC final rule Federal Register notices (60 FR 50309 and 60 FR 50265) and the most recent bound Code of Federal Regulations (CFR) volumes, which may have confused this issue. 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.

The terms *essentially uniformly distributed*, and *distributed throughout*, are both intended to disallow LSA classification for a material with very high radioactivity (such as a leaking sealed source) in one location and a large quantity of non-radioactive material surrounding it, thereby reducing the average concentration to within specified limits. If, in such a case, the packaging were destroyed during transport, and the high activity portion were separated from the non-radioactive portion, it could cause substantial radiation exposure, either from direct radiation or through a pathway (e.g., inhalation). 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.

The proposed approach is to apply qualitative techniques for LSA materials in less than 1 A_2

quantity. However, for LSA materials exceeding 1 A₂ quantity, but less than 10 mSv/hr (1 rem/hr) at 3 meters (9.9 ft) from the unshielded surface, more quantitative techniques of demonstrating compliance with this requirement would be expected. For LSA material exceeding the 3 m (9.9 ft) dose rate limit, the distribution of activity is not viewed as a practical issue, since NRC approved accident resistant (i.e., Type B) packaging will be required for these materials. NRC and DOT staff propose to recommend use of the quantitative guidance in IAEA Safety Series No 37, 1985 edition, as amended 1990 [5], for LSA materials exceeding an A₂ quantity.

For LSA material less than 1 A₂ quantity, NRC and DOT are proposing to allow shippers to assume that the activity is reasonably distributed within the material such that a large amount of non- or slightly-radioactive material has not been considered with the radioactive material presenting the hazard. For example, collections of dry activated low-level radioactive waste (LLW) could meet this assumption. Thus, there would be no need to quantitatively address the distribution of the nuclides in the LSA material for packages with less than 1 A₂ quantity.

For LSA material exceeding one A₂ quantity, but less than 10 mSv/hr (1 rem/hr) at 3 m (9.9 ft) from the unshielded material, a more quantitative determination of the distribution of activity would be expected. This determination can be made through reasoned argument, reference, calculation, or measurement. In this case, NRC and DOT may recommend use of the advisory material in IAEA Safety Series No 37, 1985 edition, as amended 1990 [5]. In this IAEA document, a method for assessing the average activity is described, involving dividing the volume occupied by the material into equal portions, and then assessing and comparing the activity in each of these portions. Five portions would be used for a volume between 0.2 and 1 m³, and, and 10 portions should be used for greater volumes. For *distributed throughout*, activity differences between portions should not vary by more than a factor of 10. For *essentially uniformly distributed*, only 10 or more portions should be used, each with a maximum volume of 0.1 m³, and the activity differences between portions should not vary by more than a factor of 3. For smaller (i.e., than 0.2 m³) LSA materials, these methods should not be applied.

CONCLUSION

In addition to the guidance discussed above, NRC and DOT staff would prefer to clarify several other minor LSA material and SCO regulations in the guidance. Briefly, a sample of additional issues that NRC and DOT staff plan to address in the joint guidance includes: rules for mixing LSA material and SCOs in a single package; impact of the revised regulations on shipment of large components, such as discarded hardware (e.g., steam generators) and outage equipment; and substitution of leach testing for disposal (10 CFR Part 61) for the LSA-III leach testing requirement.

This paper presents NRC and DOT staff's initial thoughts on the answers to questions that have been asked on the revised regulations. Current plans are to issue joint guidance, in draft form, for public comment in 1997. We encourage interested industry and members of the public to

provide feedback, especially on the practicality of what is presented. We would appreciate additional "real world" problems, questions, examples, and experiences in implementing the revised regulations.

Although DOT and NRC have not observed a major economic or practical impact of the revised rules on the shipment of waste as LSA material or SCOs, in that activities that have taken place in the past have continued to take place in a safe manner, significant questions regarding certain materials have arisen. We hope that with your assistance, as well as other interested parties, we will be able to provide effective guidance to address those questions.

REFERENCES

- [1] U.S. Department of Transportation, "Hazardous Materials Transportation Regulations; Compatibility with Regulations of the International Atomic Energy Agency; Notice of Final Rule Making," 60 FR 50292; September 28, 1995.
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