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Low Specific Activity Materials Concepts Are Being Reevaluated

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Abstract

Many types of radioactive low-level waste are classified, packaged, and transported as Low-Specific Activity (LSA) material. The transportation regulations allow LSA materials to be shipped in economical packagings and, under certain conditions, waives compliance with other detailed requirements such as labeling. The fundamental concepts which support the LSA category are being thoroughly reevaluated to determine the defensibility of the provisions. A series of national and international events are leading to the development of new dose models which are likely to fundamentally change the ways these materials are defined. Similar basis changes are likely for the packaging requirements applicable to these materials.

Background

Some radioactive materials categories have been extremely stable since they were introduced into the regulations. For example, excepted quantities (limited quantities) have changed very little from their introduction into the U.S. Department of Transportation (DOT) regulations through docket HM-2. A comparison of the old and existing requirements for excepted quantities shows very little change over the intervening 25 years. This stability is reflected in the international regulations, those of the International Atomic Energy Agency (IAEA), as well.

The regulations applicable to LSA materials, on the other hand, have been constantly changing since their introduction. Much of the problem can be traced to the very nature of these materials, which are often wastes, difficult to characterize, and frequently involve radioactive materials intermingled with nonradioactive materials. Over the years different approaches have been developed to attempt to deal with mixtures of materials and objects which are contaminated externally (both types of materials which need to be transported frequently).

Initially, LSA materials were conceived as "inherently safe" materials that would not be expected to produce unacceptable doses as the result of a transport accident. If the specific activity of a material is sufficiently limited, then an uptake of even a conservative amount would not result in a health-threatening dose. The original LSA model is based on a person working and breathing heavily in an extremely dusty atmosphere for 30 min. Under these conditions (which would require continuous resuspension of the material), a person could be expected to intake 10 mg of material (dust).[1] Consequently, if the specific activity of LSA materials were limited to values which equate 10 mg to a "not unacceptable" dose, the materials would be "inherently safe." In the mid-1960s the reference dose for an accident such as this was selected to be 50 mSv (5 rem). It

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was felt that equating "once in a lifetime" transport accident with the annual allowable occupational dose was a reasonable approach.

This approach and model formed the basis for the IAEA and, subsequently, the HM-2 approaches. Included in the early category was provision for materials which were not uniformly distributed, but which were limited by the allowable amount of surface contamination. Also included were materials which needed to be moved in large amounts and which were of known limited specific activity, such as uranium ores and concentrates. This basic original approach was simple and direct.

During the 1973 revision of the IAEA regulations, it was felt that provisions needed to be made for the expanding variety of materials which "almost" fit into the LSA category. For example, activated materials which were contaminated did not fit into the existing LSA category (which only provided for nonradioactive materials that were contaminated). A new category of materials, Low Level Solid (LLS) was created to address this need. Additions were made for other levels of contamination and criteria such as the homogeneity of the materials began to vary as the categories expanded. Complexity was beginning to creep into the category, but it still appeared safe enough and was making allowances for most of the types of materials which needed to be transported.

When the United States adopted regulations consistent with the 1973 IAEA regulations (HM-169 and the companion changes to 10 CFR Part 71), DOT and the U.S. Nuclear Regulatory Commission (NRC) were aware of problems with the LSA and LLS specifications since these rulemakings were formulated while the IAEA was preparing the 1985 edition of its own regulations. Consequently, the current DOT and NRC regulations are a hybrid of the earlier (1967 and 1973) IAEA regulations. It was felt that it would be better to work out the problems already identified in the international arena and to then amend the U.S. regulations rather than to adopt the LSA and LLS provisions, which were known to be deficient.

During the 1985 IAEA revision, it was recognized that LSA and LLS materials could meet the 10-mg model (which provides protection against internally deposited radionuclides) but could also present significant external radiation hazards. If a LSA material contained gamma-emitting radionuclides at the maximum allowable concentrations (10^{-4} A_2/g), the resulting external dose rate could approach 10 rem/h at 3 m (ref. 2). This clearly did not fit into the "inherently safe" range and limits on radiation levels were introduced. The 1985 IAEA regulations added a restriction that LSA materials shall not exceed 1 rem/h at 3 m (which would give rise to a dose of 3 rem for a 3-h exposure at 3 m). Performance-based packaging (called Industrial Packaging) was also introduced as a way of improving the expected performance during incidents.

Several theoretical problems still existed with the LSA requirements. Since high-radiation level materials were now limited by dose rate, what geometry was appropriate for materials which were granular or heterogeneous? What degree of homogeneity was required to meet the requirements of "uniformly distributed" and "distributed throughout"? The wording of the IAEA requirements led to varying interpretations by Competent Authorities.

Also during the 1985 revision the LLS category was revised into a new "Surface-Contaminated Objects" (SCO) category. The allowable materials were specified in terms of fixed and nonfixed contamination limits (not specific activity), and the radiation-level limit was imposed as well.

Events didn't stop with the 1985 modifications. During the currently ongoing preparation of the 1996 revision of the IAEA regulations, additional problems have been identified concerning the practicality of the 1985 specifications and the lack of a dose-based model for some of the LSA materials (such as liquids). The issues are sufficiently broad such that a course of action has been developed by the IAEA to prepare comprehensive solutions, and activities will be underway over the next few years to develop improved approaches.

What does this all mean to U.S. shippers? The best answer to that question can be provided by looking at expected regulatory actions. The interaction between the U.S. regulatory bodies (DOT and NRC) and the IAEA will play a significant role in this outcome.

Near-Term Activities

DOT is working on finalizing HM-169A, and NRC is preparing a companion final rule to amend 10 CFR Part 71. The overall thrust of these changes is intended to bring the U.S. regulations into greater consistency with the 1985 IAEA regulations. While the United States was successful in avoiding the LLS problems, other problems, such as how to best categorize materials, limit the external radiation hazard, and specify appropriate packaging, still must be determined.

As proposed in HM-169A and 10 CFR Part 71, external radiation would be controlled by limiting the total amount of radioactivity in a single LSA or SCO package to less than 2 A_1. Since A_1 is a measure of external radiation, it provides a consistent control for all radionuclides, and the factor of 2 recognizes the differences between Type A packages (which are limited to A_1) and the self-shielding which can be expected to be present in LSA and SCO materials. This appears to be a significant departure from the 1985 IAEA regulations, but more recent events will show that the positions may be converging.

Other LSA and SCO specifications in the proposed HM-169A and 10 CFR Part 71 are closely aligned with the 1985 IAEA. Instead of the current approach of specifying a "millicurie per gram" limit based on the A_2 value of the radionuclide [see 49 CFR Part 173.403 (n)], the IAEA approach of a submultiple of the A_2 value has been proposed.

Some of the proposed requirements are being reconsidered in light of more recent thinking, such as the use of multiple packaging performance categories. The 1985 IAEA regulations initiated the category of "industrial packaging" to replace the earlier "strong tight packaging." There are three categories of industrial packagings, IP-1 through IP-3, which range from very minimal to performance requirements nearly identical to Type A packages. At the time of their development, it was felt that the flexibility offered by these graduated requirements would be beneficial. However, shippers are frequently ignoring the middle category (IP-2), especially since the costs are sufficiently close to Type A packagings. The exception appears to be large packagings (intermodal freight containers), where IP-2 requirements can be met and a variety of LSA materials can be transported in them. However, discussions at IAEA technical committees are favoring elimination of the IP packagings. Instead of the IPs a combination of a nonperformance-based packaging (like excepted packagings) would be used for very low-hazard materials, and Type A packaging would be required for all other LSA materials.

While the contents of the final rulemakings are still unknown, it is safe to speculate that while they will be much more consistent with 1985 IAEA, they will contain some major differences also.

Some of the variances (such as minimizing changes until the picture at the IAEA clarifies) may benefit shippers by avoiding unnecessary perturbations in the regulations.

Intermediate-Term Activities

The differences between the U.S. positions and the IAEA approaches are being addressed during the preparation of the 1996 IAEA revision. These and other problems have been sufficient to lead the IAEA to already convene three consultants services meetings (CSMs) and a Technical Committee (October 1993) and to schedule a Seminar (February 1994) on the topic. The CSMs have prepared recommendations that will be addressed by the Technical Committee and include:

- moving LSA and SCO materials into the "mainstream" of regulatory philosophy where the materials characteristics and their expected packaging performance is factored into the dose models used to derive package contents limits;
- prescribing materials characteristics suitable for excepted packaging, Type A-like packaging, and Type B-like packaging; and
- limiting internal radiation hazards with reference to the A_2 values and external radiation hazards through a combination of dose-rate limit (for fixed-geometry contents) and reference to the A_1 values (for variable-geometry contents).

The three CSMs did not completely agree with each other, and their mixed recommendations will be considered by the Technical Committee scheduled for October. However, because the recommendations of the last CSM are more consistent with the approaches included in the U.S. rulemaking actions and provide for more conservative dose modeling, this should improve the chances of their adoption by the Technical Committee.

The IAEA recognizes that it is imperative that the LSA and SCO categories, which are developed must provide for reasonable accommodation of the materials needing to be transported. Some of the information typically missing from consideration is a full understanding of the materials (particularly wastes) that are transported in these categories. In order to correct this definition, the IAEA has scheduled a seminar in Vienna, Austria, during the February-1994 time frame to allow for interaction between shippers, carriers, and Competent Authorities. Although the deadline for submitted papers has passed, shippers are particularly encouraged to participate, especially if they can provide information on the nature of the materials they need to transport. Given the close relationship between the IAEA and U.S. regulations, U.S. shippers should be sure to participate to make their views and needs known. The results of the Technical Committee and seminar will be provided to the next IAEA Revision Panel (October 1994) which is scheduled to develop further the 1996 revision of Safety Series No. 6.

Long-Term Activities

Some of the more fundamental problems with the LSA and SCO categories are not going to the solved during the 1996 revision process. Significant progress is expected in resolving the practical problems with the current specifications, but defensible dose-based models will not be available to provide a long-lasting solution. The IAEA CSMs have been unanimous in recommending that a "Q-system analog" be developed which would provide a comprehensive set of pathway models like that which is used for determining the A-values. Since the potential pathways for LSA materials can be quite different from Type A packages, a material-specific model is needed. Several

initiatives are underway to develop an analog, but the results are not expected in time for inclusion in the 1996 revision (which concludes its technical work in early 1995).

What To Expect

U.S. shippers should be prepared for the fluctuations ahead. While the preferable solution would be to stabilize the LSA and SCO regulations as soon as possible so that expensive packagings have a long and useful life, that is unlikely to occur. The HM-169A and 10 CFR Part 71 changes are expected to be finalized by spring 1994. This will set the U.S. requirements (which will vary from the IAEA) for some time, probably for 6-8 years. Meanwhile, work will continue to develop a longer lasting basis (the LSA Q-system analog) for the IAEA regulations, and this effort could be expected to be finalized around 1997.

If the U.S. regulatory agencies agree that the Q-system analog is defensible and the resulting requirements are significant improvements, these changes could be introduced through rulemaking. The availability of the improved model should coincide with the time that DOT and NRC will need to consider rulemaking to provide consistency with the 1996 IAEA regulations. The net result could be a rulemaking which is mostly based on the 1996 IAEA but which also "leap frogs" the LSA and SCO requirements. This hybrid approach would minimize the number of significant changes that shippers would have to accommodate.

Since fundamental changes are being considered, shippers need to ensure that they provide input on the nature and quantities of materials which are being transported. Technical approaches to modeling the potential doses and risks from these materials need to be developed, and shippers may be able to contribute to this effort as well. Several specific opportunities are coming in the near future, and U.S. participation in the IAEA regulations development process allows nearly continuous participation. Participation should be coordinated through the Radioactive Materials Branch, Research and Special Programs Administration, U.S. Department of Transportation, Washington, DC 20590.

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