Proceedings of the 17th International Symposium on the Packaging and Transportation of Radioactive Materials
PATRAM 2013
August 18-23, 2013, San Francisco, CA, USA

REGULATORY CHALLENGES RELATED TO SHIELDING SAFETY ANALYSES FOR NON-FISSILE RADIOACTIVE MATERIAL TYPE-B TRANSPORTATION PACKAGES

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ABSTRACT

U.S. Nuclear Regulatory Commission (NRC) regulations and NRC staff review guidance for Type B radioactive material transportation package design require that Certificate of Compliance (CoC) applicants demonstrate that the package design meets the regulatory requirements with dose rate measurements as a final check for each shipment. However, for historic reasons, some legacy Type B non-fissile material transportation packages were reviewed and approved based on pre-shipment dose rate measurements. Since that time, NRC experience, regulations and staff review guidance has evolved significantly. Pre-shipment dose rate measurements are no longer considered adequate for this purpose. The NRC staff faced challenges in performing some reviews for Type B transportation packages. Some of the applications for certificate amendments for new contents do not include shielding evaluations that bound the maximum content specifications and if loaded with the maximum allowed contents, packages would not meet regulatory dose rates. In addition, recent experiences also show that a package without appropriate consideration for dose rates during design approval can lead to operational issues.

To help address these challenges, the NRC has issued a regulatory issue summary (RIS) that clarifies its use of staff review guidance for the review of content specifications and shielding evaluations included in the CoC and safety analysis reports (SARs) for Type B transportation packages. This paper discusses the staff's considerations for sufficient demonstration for compliance with the regulation in its review and approval of the legacy packages as well as new Type B package designs in light of the RIS.

INTRODUCTION

In the spring of 2010, the NRC received an application to amend a CoC for a Type B transportation package under Title 10 CFR Part 71. This package's applicant did not perform a shielding analysis that bounded the allowable content but instead relied upon pre-shipment dose

rate measurement as required by 10 CFR 71.87(j) to determine compliance with regulatory dose rate limits in 10 CFR 71.47 for normal conditions of transport (NCT). Evaluations had been performed to determine compliance with hypothetical accident condition (HAC) regulatory dose rate limits in 10 CFR 71.51(a)(2). However, these evaluations did not bound all possible contents allowed by the CoC. The maximum allowable contents were specified in multiples of A_2[1]. The NRC staff could not perform a review per the guidance in its "Standard Review Plan for Transportation Packages for Radioactive Material" (SRP, NUREG-1609) (Reference 1) because the application did not include a shielding analysis for the package under normal conditions of transport per the requirements of 10 CFR 71.47.

The NRC staff found that there were a few more packages that also had relied to some extent on pre-shipment measurement for complying with regulatory dose rate limits. These packages are typically waste packages intended to ship mixed nuclides and had been originally certified before the NRC issued the SRP. Therefore, the staff found it necessary to issue a RIS as it did not see this to be a change in current review practices documented in the SRP. The NRC staff issued NRC RIS 2013-04, "Content Specification and Shielding Evaluations for Type B Transportation Packages," on April 23, 2013 (Reference 2).

BACKGROUND

In 1996, the NRC amended 10 CFR Part 71 to conform NRC regulations to those of the International Atomic Energy Agency (IAEA) (60 FR 50248). The U.S. Department of Transportation (DOT) correspondingly issued an amendment to Title 49 of the Code of Federal Regulations (49 CFR), "Transportation," which then brought all U.S. regulations into general accord with the IAEA's Safety Series No. 6, "Regulations for the Safe Transport of Radioactive Material," 1985 Edition. As part of this amendment, the definition of low specific activity (LSA) material became more explicit, and a quantity limit of radioactive material for shipment of LSA material was added. The updated regulations required that packages containing LSA material exceeding this limit would be subject to NRC Type B package regulations. Before this update, there was no quantity limit on LSA material within DOT regulations in 49 CFR 173, "Shippers–General Requirements for Shipments and Packagings." This material could be shipped under self-certified package designs as either a Type A package or a "strong, tight, package." The 1996 revision added consistency to NRC and DOT regulations.

[1] A_2, as defined in 10 CFR 71.4, "Definitions," is an activity limit corresponding to the maximum activity of radioactive material for normal form material, other than low specific activity (LSA), and surface contaminated object (SCO) material, permitted in a Type A package. The corresponding value for special form material is A_1. These values are either listed in Table A-1 of 10 CFR Part 71, Appendix A, "Determination of A_1 and A_2," or may be derived in accordance with the procedures prescribed in Appendix A of 10 CFR Part 71.

LSA material is radioactive material thathas a low activity per unit mass (specific activity) throughout the content volume. LSA material includes low-level radioactive waste, which is composed mainly of alpha and beta emitters; therefore, no substantial shielding is needed for such material. Because of the inherent properties of LSA material, it qualifies for less restrictive packaging requirements. However, for some former LSA packages that were converted to Type B packages, and other Type B packages containing material similar to that of LSA, certificate applications did not contain a shielding analysis that estimated maximum external dose rates based on allowable contents during NCT. Instead, pre-shipment dose rate measurements were accepted as a way to demonstrate compliance with NCT dose rates in 10 CFR 71.47, "External Radiation Standards for All Packages," with analysis demonstrating compliance with HAC dose rates in 10 CFR 71.51(a)(2). The NRC staff considered the nature of LSA material in finding reasonable assurance that NCT dose rate limits would not be exceeded. This is in addition to the practicality of limiting specific radionuclide contents with individual activity limits.

Since the maximum quantity allowed in these packages was limited by the pre-shipment dose rate measurements, the NRC staff also previously found it acceptable for these Type B packages containing material similar to that of LSA to have maximum content limits specified only in terms of multiples of A_2. This was done for structural categorization of the package for fabrication and inspection purposes and was not meant to establish content limits that would ensure the package meets dose rate regulations.

DISCUSSION

For Type B packages that were once only used to ship LSA material, or material similar to LSA, applicants are now requesting approval for additional contents. To make positive findings on a package's compliance with the regulations, and therefore approve a revised CoC, the NRC needs sufficient details on content descriptions and a corresponding shielding evaluation that represents or bounds the requested contents.

For each package, the NRC staff will review any certificate amendment applications, including the next certificate renewal application, using the guidance in NUREG-1609. Specifically, the NRC staff will review the specification of contents using Section 1.5.2.3 of that guidance and look for a shielding evaluation corresponding to these contents in accordance with Section 5.5 of the guidance. The RIS provides further discussion on content specifications and package evaluations and is summarized below.

Content Specification

In accordance with 10 CFR 71.33(b), the description of the contents should be complete with

respect to the chemical and physical form of the material, as well as its radioactive content (radionuclides and quantity). Interim
Staff Guidance-20 (SFST-ISG-20) (Reference 3), "Transportation Package Design Changes Authorized Under 10 CFR Part 71 Without Prior NRC Approval," states that the content description must be consistent with the assumptions made about the contents in the package evaluation (e.g., in the containment, shielding, and criticality evaluations). These features must be described in sufficient detail to provide a basis for evaluating the package.

The RIS explained why it may not be sufficient or practical to specify maximum allowable contents for multiple radionuclides only in multiples of A_2 within a CoC. It is appropriate to use A_2 values to provide structural categorization of the package and to limit the leak rate. For example, in 10 CFR 71.51, "Additional Requirements for Type B Packages," leak rate testing sensitivity requirements can be calculated in accordance with ANSI N14.5, "Radioactive Materials–Leakage Tests on Packages for Shipment," in which the A_2 value is specified to evaluate the leakage rate. Also in NUREG-1609, and Regulatory Guide 7.11, "Fracture Toughness Criteria of Base Material for Ferritic Steel Shipping Cask
Containment Vessels with a Maximum Wall Thickness of 4 Inches (0.1 m)," structural categories for fabrication and inspection of packages are specified in terms of A_2. Therefore, the CoCs may have maximum content values specified in multiples of A_2 in addition to ones corresponding to the shielding evaluation (and thermal, criticality, etc.) The contents will then be limited by the least of these values. For example, a package may contain a package limit for shielding for gamma emitting contents but not for alpha or beta emitting contents. In the case that this example package is loaded with gamma emitting contents then it is limited by the shielding evaluation. For alpha and beta emitting contents, the example package may be limited by the value used to calculate leak rates or may be limited by another factor such as the thermal evaluation.

Package Evaluation

In accordance with 10 CFR 71.31(a)(2) and 10 CFR 71.35(a), the package design must include an evaluation that demonstrates the package satisfies the dose rate limits in 10 CFR 71.47 for NCT and 71.51(a)(2) for HAC. SFST-ISG-20 states that the evaluation may be based on a representative loading to allow flexibility in the contents that can be loaded for Type B packages in which exact contents are not known. The applicant should provide information in the application that demonstrates the evaluation is representative or bounding for all allowable contents.

The NRC staff typically will not accept pre-shipment measurements as an appropriate 10 CFR 71.35(a) evaluation method for determining compliance with NCT dose rates in 10 CFR 71.47. The pre-shipment dose rate measurements fulfill the requirements in 10 CFR 71.87(j). Pre-

shipment measurements only indicate that a particular shipment can be transported because it meets the NCT dose rate limits. This ensures that the package was loaded properly with correct contents and the package's shielding is functional.

In addition, a package that relies completely on pre-shipment dose measurements to determine if a package meets its regulatory dose rate limits may not address the possibility of contents shifting or settling during transport, which could potentially result in an increase in package radiation levels. Moreover, measurement procedures, instrument accuracy, efficiency, and calibration can vary widely. Calculating the estimated dose rates provides reasonable assurance against natural uncertainties associated with measurements, especially for packages with small margins to the limit. The pre-shipment measurements can only serve as a confirmation that the certified design meets the regulatory requirements.

Pre-shipment measurements are, however, appropriate to verify an evaluation. The level of rigor in the measurement procedures should depend on the level at which they are relied upon to verify the evaluation (i.e., the level of uncertainty). The NRC staff is considering the use of pre-shipment measurement when compensating for evaluation uncertainties on a case by case basis.

In some evaluations submitted to the NRC for review, the staff found that there were areas of uncertainty in these evaluations but found the overall evaluation acceptable due to the fact that dose rates on loaded packages could be measured. The NRC staff may request, in response to a certificate application, that more comprehensive measurement requirements be added to the operating procedures or the CoC, if they are not present already.

The RIS contains information about some package evaluations that the NRC staff had accepted as examples of evaluation methods the NRC staff has seen and the circumstances under which the NRC staff found them acceptable.

Results

Since the drafting of the RIS began, the NRC staff has had several applications for Type B packages, either new package or amendment that were affected by the information in the RIS. The NRC staff has found that with the clarified guidance, reviews can be performed but that there were still some unique challenges in each and every package review. Some of the NRC staff's experience with these packages thus far is summarized below.

The NRC staff has found that there are fewer questions when evaluating applications with well-defined content descriptions. For example, if a package is only intended to ship certain kinds of process wastes, or certain nuclides, for example Co-60, with a given geometry, the staff finds that when applying for a CoC with only these contents and geometries, then the evaluation

parameters are better defined and makes a more efficient review. It follows that when package applications request a very broad scope in contents that the analysis has to be very detailed as it has to cover all possible geometries, energies and emission rates.

When contents are more accurately represented within an analysis, NRC staff is also able to approve increased contents versus an application that has a representative or bounding evaluation. For example, the most bounding geometry for a shielding analysis is that of a point source because it does not take into account any self-shielding from the source material. However since all contents would have some self-shielding properties, this may be overly conservative in some cases.

The NRC staff is aware that there are packages used to ship many varied contents and simplification is not possible. However, the NRC staff maintains that if at all possible, applicants should specify contents as well as evaluations as narrowly as possible.

Many of the packages seek approval for a maximum quantity of material that will not exceed any regulatory limits. In the case that this is limited by shielding, applicants sometimes design backwards from the dose rate limits. The NRC staff has found that designing up to the regulatory limits with no margin often results in a more difficult and lengthy review. This is because there is no room for error and all uncertainties must be adequately addressed. This is very difficult as all computational codes used to evaluate dose rates have uncertainties associated with them. These uncertainties are not always well defined. In addition, the measurement instrumentation that could be used to benchmark such codes also has uncertainties associated with it that are not well defined. The NRC staff has had fewer questions on applications that contain some margin to the limits. The amount of margin should correspond to the amount of uncertainty within the method.

CONCLUSION

The NRC staff faced challenges in performing some reviews for Type B transportation packages. To help address these challenges, the NRC issued a RIS that clarifies its review guidance, specifically in the areas of specifying the contents and the shielding evaluations that support these contents. This clarification has resulted in improved applications to the extent that the NRC staff is able make positive findings on the package's compliance with the regulations.

REFERENCES

1. NUREG-1609, "Standard Review Plan for Transportation Packages for Radioactive Material," March 1999.

2. NRC Regulatory Issue Summary 2013-04, "Content Specification and Shielding Evaluations for Type B Transportation Packages," April 23, 2013 (ADAMS Accession No. ML13036A135, http://pbadupws.nrc.gov/docs/ML1303/ML13036A135.pdf)

3. Spent Fuel Project Office Interim Staff Guidance – 20, "Transportation Package Design Changes Authorized Under 10 CFR Part 71 Without Prior NRC Approval." (http://www.nrc.gov/reading-rm/doc-collections/isg/isg-20.pdf)