Shipment of Small Quantities of Unspecified Radioactive Material in Chalfant Packagings

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Abstract

In the post 6M era, radioactive materials package users are faced with the disciplined operations associated with use of Certified Type B packagings. Many DOE, commercial and academic programs have a requirement to ship and/or store small masses of poorly characterized or unspecified radioactive material. For quantities which are small enough to be fissile exempt and have low radiation levels, the materials could be transported in a package which provides the required containment level. Because their Chalfant type containment vessels meet the highest standard of containment (helium leak-tight), the 9975, 9977, and 9978 are capable of transporting any of these contents. The issues associated with certification of a high-integrity, general purpose package for shipping small quantities of unspecified radioactive material are discussed and certification of the packages for this mission is recommended.

Background

In conduct of DOE, commercial and academic programs, there are many activities which need to ship and/or store greater than Type A quantities of radioactive materials which are not well characterized. In the past, these would have been shipped in 6M specification packagings. With the decertification of the 6M and other specification packages, the users are faced with the more disciplined operations associated with use of Certified Type B packagings. Because of the small amount of radioactive material present, these shipments are typically of low risk to the public, workers, or the environment. However, because of the experimental nature of the work, these contents frequently do not precisely conform to certified content descriptions for currently certified packagings. The essential requirements for safe transport of such materials is that they be properly contained, are subcritical at all times, and do not expose the public, workers, or the environment to radiation dose levels greater than those permitted by the regulations (10 CFR 71) [1]. These requirements would be satisfied if such contents were limited to a fissile exempt amount, were shown by dose rate measurement to meet the regulatory requirements, were placed in a leak tight containment vessel, and were transported in a package certified for large quantities

of similar materials. The 9975, 9977, and 9978 packages meet the requirements for such a package and are presently certified for a wide range of radioactive materials, both fissile and non fissile.

It is worthy of note that the provisions of 10 CFR 71.10 exempt shipments of radioactive materials having a specific activity of less than 10 Bq/gm (0.002μCi/gm) from the provisions of 10 CFR 71. This exemption also applies to small contents of americium or plutonium in special form with an aggregate radioactivity not to exceed 20 Ci.

Contents Definition

The contents allowed under this proposal would be small masses of solid radioactive material. The materials may consist of previously authorized contents but may also contain small concentrations of other actinides, fission products, decay products, and neutron activation products greater than that permitted by the authorized contents, or may consist solely of these materials. Assessment of these constituents may be based on process knowledge.

The contents proposed here would:

- have a total radioactive material mass less than the fissile mass limits given in Table 2, below.
- produce less than 19 w of decay-heat generation,
- have a total mass (RAM and packing materials) of no more than the certified contents weight for the packaging. (For 9975, 40 lb; for 9977, 100lb; for the 9978, 50 lb)
- be contained in a separate convenience container with an attached top,
- include less than 100 gm of plastic or other organic material,
- be solid (metal or oxide),
- contain no liquids,
- not react chemically with the containment vessel or packing, or cause corrosion; and
- not generate significant gas.

Table 1. Example Requirements for Contents Which Do Not Conform to 3013 Standard

Contents	Packaging Configuration			
	3013	**Food-Pack Can**	**Hex-Can**	**Shielded Container**
Example Content	NA	• If ≤ 0.0018 grams ^{232}U. • Maximum 100-g plastic. • Aluminum pellets or foil for packing.	NA	• If > 0.0018 grams and ≤ 0.0101 grams ^{232}U or determined by dose-rate measurements. • The Shielded Container and aluminum convenience can manufactured per listed Addendum drawings are required. • PCV spacers replaced by Shielded-Container honeycomb spacers manufactured per the listed Addendum drawing

All	19 watts maximum radioactive decay heat rate less than 1000 ppm other radionuclides (unless otherwise stated) less than 100 ppm other inorganic impurities with total mass less than 0.1 weight percent (unless otherwise stated) PCV bottom spacer required 44.4 lb maximum content weight (radioactive contents, product cans, spacers, Shielded Container, etc.)

Structural Considerations

The Small Quantity contents are within the authorized contents weight for the 9975, 9977, or 9978. The loadings for all test and service conditions are, consequently, within those for which the package was analyzed and tested. In addition to total mass, there must be no design features which would result in any local loading not addressed in the SARP evaluations.

For highly radioactive materials, for which a small mass produces a significant radiation dose, the material must be contained within a shielding container. The weight of the shielding container is included in the content mass and must be within the certified limit for the package. The Shielded Containers must be evaluated structurally to demonstrate that they are able to maintain functionality for the transportation scenarios for which they are required; for Normal Conditions of Transport and the Hypothetical Accident Conditions. The initial application for a Small Quantity Content will include Shielded Containers for both gamma sources and neutron sources. Additional discussion of the Shielded Containers is provided below in the Shielding section.

Containment

The Chalfant containment vessels in the 9975, 9977, and 9978 are high integrity, leaktight, leak testable containment vessels, which have been certified for shipment of Plutonium and other radioactive contents requiring the highest level of containment. Because they have been demonstrated to be leaktight (by the helium leakage-rate testing method) under Normal Conditions of Transport and after Hypothetical Accident Conditions, they meet all containment requirements for all radioactive materials.

Subcriticality

A Nuclear Criticality Safety Evaluation was performed to determine the acceptable mass of material that can be safely transported under the Small Quantity Content amendment. The acceptable contents are:

Table 2. Allowed Contents Envelopes

Material	Mass Limit	
	Type 1	Type 2
Special Actinide Isotopes[a] ^{242m}Am, ^{243}Cm, ^{245}Cm, ^{247}Cm, ^{249}Cf, ^{251}Cf	5 grams	<1000 ppm
All other RAM	5 grams	100 grams
Total RAM	5 grams	100 grams
Light Elements and Impurities	5 grams	50 grams

Total Content	10 grams	150 grams

[a] The characteristics of these special actinides are not as well established as for other, more common fissile isotopes. Accordingly, a larger safety factor is employed for these contents.

Shielding

The radiation level external to the package specified by 10 CFR 71.47 is 2 mSv/hr (200 mrem/hr) or less. Satisfaction of this requirement would be demonstrated by survey of the package as prepared for shipment. A higher level could be accepted for packages shipped by exclusive use shipment. The acceptance criterion for this Small Gram Content proposal is demonstration that the dose level meets these requirements by post load radiation level survey of the content container.

Any packaging component credited with performing a shielding function and necessary to meet the acceptable radiation level must have been authorized as a Content Configuration as part of a certified content for the 9975, 9977, or 9978. Under this proposal, any materials requiring shielding would be shipped in a Shielded Container evaluated and authorized for such use. Initially two such containers are proposed, for gamma shielding and for neutron shielding.

Shielded Container For Gamma Sources

This Shielded Container configuration is shown in Figure 1. The Shielded Container for Gamma Sources is a hollow lead cylinder, with a stainless steel outer shell and a stainless steel liner. The assembly provides top and bottom shielding of comparable thickness to the radial shielding. The internal cavity for this initial Shielded Container is 1.625-inches in diameter and 5.5-inches deep. The shielding thickness is approximately 2.0 inches radially and axially, with rounded corners. Aluminum foam spacers, placed above and below the Shielded Container, restrict axial movement within the PCV and protect the Container during transport and accident scenarios. The total Shielded Container packaging configuration weight is less than the maximum content weight authorized for the packaging.

Shielded Container For Neutron Sources

This Shielded Container for Neutron Sources is conceptually similar to that for Gamma sources, consisting of a hollow cylinder of polyethylene neutron absorbing material. For this Container, the outer shell and inner liner are not needed. The assembly provides top and bottom shielding of comparable thickness to the radial shielding. The internal cavity for this initial Neutron Shielded Container is 1.625 inches in diameter and 8 inches deep. The shielding thickness is 2.1 inches radially, and 6 inches top and bottom. The neutron Shielded Container is sized to fill the containment vessel, so that spacer materials are not needed. As in the case of the Gamma Shielded Container, the total Neutron Shielded Container packaging configuration weight is less than the maximum content weight authorized for the packaging.

Dose Rate Survey

To ensure that the package dose rate satisfies the regulatory limits, items shipped under the Small Quantity authorization shall have their dose rate determined by surveying the surface of the convenience container used for the material. The acceptable dose rate would be the 2 mSv/hr value. For material employing one of the Shielded Containers, the dose rate would be determined on the surface of the

Shielded Container. Establishing acceptable dose rate in this manner ensures that the package surface dose rate will be less that the 2 mSv/hr limit specified for Normal Conditions of Transport in transportation regulations.

Risk Assessment

There are no aspects of the use of the 9975, 9977, or 9978 for transport of small, fissile exempt quantities, as described here, that are beyond the tested safety basis (i.e., the deterministic safety basis) of the 9975, 9977, or 9978. Accordingly, a risk assessment is not required.

Discussion

The functional requirements for radioactive materials packagings are containment of the material, shielding of radiation to protect the public, workers, and the environment, and maintenance of subcriticality for fissile contents. A package whose containment vessel can be leak tested and shown to meet the highest level of containment, helium leaktight, under all conditions, is able to meet the containment requirement for any radioactive material. For fissile materials, the material can be insured to remain sub critical if its mass is limited. Accordingly, if the total mass of radioactive material is limited to a small quantity, the sub-criticality requirement is met. The surface dose rate can be readily monitored for packages, and enables direct confirmation that the shielding requirement is met. Some nuclides are sufficiently active and energetic that even small amounts exceed the dose rate allowed by the regulations. For such cases, the radioactive material can be placed in appropriate shielded containers to meet the dose rate limit imposed by the regulations. Using the dose rate at the Container insures that the package dose rate is acceptable.

Conclusions

The approach proposed here for shipment of small quantities of radioactive material satisfies the functional requirements for packaging of radioactive materials. That is, containment, subcriticality and shielding of contents are assured.
The approach is applicable to all radioactive materials, regardless of the detailed radiological analysis.
The approach provides an economical, user friendly means of shipping the small amounts of poorly characterized or unspecified radioactive materials frequently encountered in research programs.
The approach is applicable to all radioactive materials.

Disclaimer

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References

1. United States Code of Federal Regulations, Title 10, Part 71, 2004.
2. American National Standards Institute, Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors, ANSI/ANS-8.1.

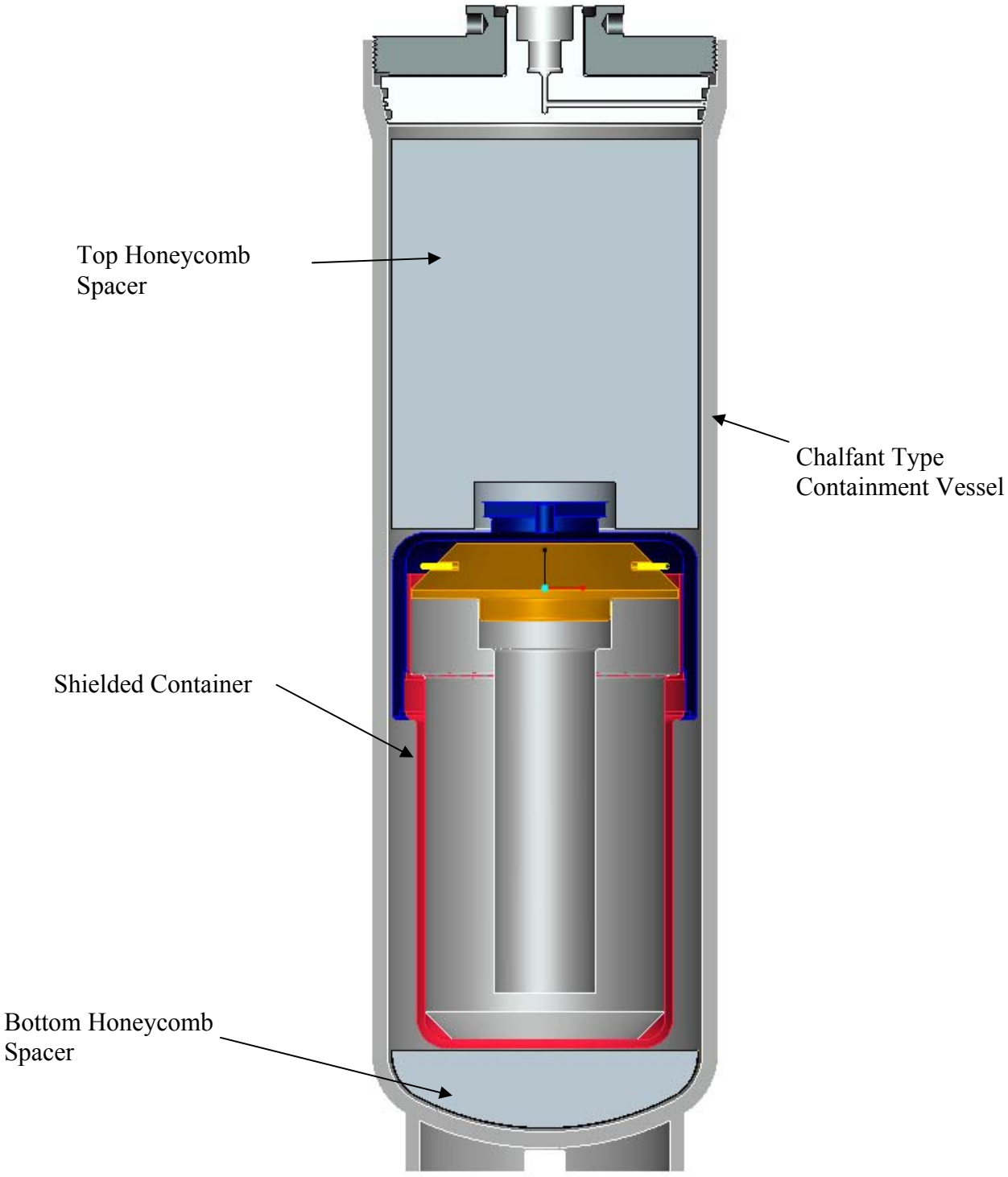

Figure 1. A Shielded Container Configuration