Safety Evaluation Report for the Justification for Shipment of Plutonium Oxide in Large Vented Food-Pack Cans Model 9975 Addendum

S-SARA-G-00013, Revision 6

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Overview

This Safety Evaluation Report (SER) summarizes the results of the Department of Energy (DOE)Packaging Certification Program (PCP) Staff's review of Revision 1 of the Addendum for the Model 9975 Package, *Justification for Shipment of Plutonium Oxide in Large Vented Food-Pack Cans.*[1] The addendum addresses the use of a nested and filtered convenience container configuration for the shipment of plutonium oxide in the 9975 Package, using nitrogen as the inerting gas in the primary containment vessel (PCV). This new content can configuration and approach for inerting the PCV to achieve an oxygen concentration no greater than five percent (i.e., <5%) by volume will be authorized for the Model 9975 Package, supplementing the existing -85 and -96 Safety Analysis Reports for Packaging (SARPs),[2,3] once the Addendum is accepted by the Headquarters Certifying Official and the existing Certificates of Compliance (CoCs)[4,5] are revised, reflecting the additional approved configuration and inerting approach.

Chapter 1: General Information

This SER documents the DOE PCP Staff's review of Revision 1 of the Addendum, S-SARA-G-00013, *Justification for Shipment of Plutonium Oxide in Large Vented Food-Pack Cans,*[1] i.e., the Submittal. The Submittal was prepared for the DOE by Savannah River Packaging Technology, Savannah River National Laboratory, Savannah River Nuclear Solutions, LLC, Savannah River Site, to support the use of large vented food-pack convenience cans in the Model 9975 Package for the transportation of plutonium oxide, and for the use of a new approach for inerting the primary containment vessel with nitrogen gas.

The Submittal is an Addendum to the current SARPs for both the -85 Model 9975 Package,[2] and the -96 Model 9975 Package.[3] This section of the SER covers the review of the General Information provided in Chapter 1 of the Submittal.

The currently approved SARPs require inerting the gas spaces within the product convenience container(s), and within the containment vessels, to achieve no more than five percent (i.e., <5%) oxygen for certain content types. This inerting is performed to reduce the risk of deflagration or detonation of potential flammable gas mixtures that may accumulate within the containment vessels due to radiolysis and/or thermal degradation. When inerting is required, the currently approved SARPs stipulate that the convenience containers be inerted with helium or nitrogen, and that the free volume within the PCV be inerted with carbon dioxide. For contents that require inerting, the SARPs require the use of a cylindrical sleeve between the convenience containers and the inner wall of the PVC to limit the spacing to a size that is less than the minimum cell size that would allow the transition from deflagration to detonation for a stoichometric mixture of hydrogen in air.

The Submittal proposes the use of vented, oversized, site-specific food-pack cans, i.e., "convenience containers," which have an outer diameter that exceeds 4.38-inches, and are inerted with nitrogen such that the gas within the food-pack cans contains no more than five percent oxygen (i.e., <5%) by volume. When using these oversized cans, it is proposed that the primary containment vessel sleeve be omitted, and that the free volume within the PCV also be inerted with nitrogen such that no gas space contains greater than 5% oxygen by volume. Additionally, it is proposed that there be no restriction on the maximum inter-container radial gap for food-pack can configurations, where all gas spaces in the PCV and the food-pack cans are inerted with nitrogen.

Findings

The removal of the current restrictions on the inter-container radial gap essentially reduces the conservatism of a defense-in-depth feature of the package that was based on a potential, worst-case flammable gas mixture; however, the maintenance of a gas atmosphere of no more than five percent (i.e., <5%) oxygen and inerting with nitrogen should still prevent any deflagrations or deflagration-to-detonation transitions.

Although, there was sufficient description and detail to perform the independent technical review on the changes proposed by the Submittal, the Submittal could have been strengthened by the inclusion of a diagram of the proposed new configuration(s) to the same level of detail and quality as shown in Figure 1.5 of both current SARPs.

Based on the technical information provided, however, DOE PCP recommends that new CoCs be issued to allow for: (1) the use of the vented oversized convenience containers for Pu/U oxide contents (i.e., Table 1.2 Content Envelope C.4 in SARPs), and (2) the use of nitrogen gas for inerting, such that the gas atmosphere in both the vented oversized convenience containers and the PCV contains no more than five percent (i.e., <5%) oxygen by volume.

Chapter 2: Structural Evaluation

This section of the SER covers the Structural review.

Findings

Chapter 2 of the Submittal notes that neither the food-pack convenience containers nor the PCV sleeve are credited structural components of the 9975 shipping package. The use of the oversized vented food-pack convenience containers and the removal of the PCV sleeve do not change the bounding gas volume assumptions in the current SARPs. Additionally, the maintenance of a gas atmosphere within the PCV and the convenience containers that has no more than five volume percent (i.e., <5%) oxygen precludes the possibility of a deflagration, and the transition from deflagration to detonation, and the possible resulting detonation loads. The change of inerting gas from carbon dioxide, i.e., CO_2, to nitrogen, i.e., N_2, does not change these conclusions.

The DOE PCP Staff is in general agreement with these statements and representations.

Conditions of Approval

DOE PCP has concluded that no additional Structurally-related conditions of approval need to be added to the existing CoCs for the approval of this request.

Chapter 3: Thermal Evaluation

This section of the SER covers the Thermal review.

Findings

When using the large vented food-pack cans without the PCV sleeve for the shipment of plutonium dioxide, the gas atmosphere in both the vented food-pack cans and the PCV are inerted with nitrogen so that, at the time of closure, no space in the cans or PCV has more than five percent (i.e., <5%) oxygen by volume. The previously completed thermal analysis, performed with carbon dioxide as the inerting gas in the PCV, bounds the temperature

distributions obtained when using nitrogen as the inerting gas, since the thermal conductivity of nitrogen is greater than that of carbon dioxide.

The DOE PCP Staff concurs with the statements in the Submittal concerning the significant increase in detonation cell size when the diluting gas for a mixture of five volume percent hydrogen with stoichometric oxygen is changed from helium to nitrogen. As a result of this increase in detonation cell size when using nitrogen as the diluting gas, it is appropriate to eliminate the inter-container maximum gap limit (i.e, gap between the convenience cans).

The change from carbon dioxide to nitrogen for the inerting gas for the PCV, however, would result is a reduction of the detonation cell size for a given hydrogen-oxygen mixture. When using the 406x700 convenience can in the PCV without the aluminum spacer sleeve, the maximum gap (the distance between the outer can wall and the inner PCV wall) is approximately 0.625-inches. The currently-approved SARPs specify use of the aluminum spacer sleeve and carbon dioxide inerting when using the 404x1700 convenience cans, which results in a maximum estimated gap of 0.15-inches. Therefore, the requests in the submittal for (1) using the 406-sized cans without the aluminum spacer sleeve, along with (2) using nitrogen for inerting PCV, essentially reduces the conservatism of a defense-in-depth safety feature. As a result of these observations, it is recommended that omitting the aluminum spacer sleeve and inerting the PCV with nitrogen only be done when using the oversized 406-sized convenience containers.

Conditions of Approval

DOE PCP has concluded that no additional Thermally-related conditions of approval need to be added to the existing CoCs for the approval of this request.

Chapter 4: Containment

This section of the SER covers the Containment review.

Findings

The changes proposed in the Submittal do not increase the impact loading on the containment vessel, the temperatures that must be sustained, or the pressure that must be contained. Therefore, the package containment leaktight performance, as documented in the existing Model 9975 SARPs, is still valid.

Conditions of Approval

DOE PCP has concluded that no additional Containment-related conditions of approval need to be added to the existing CoCs for the approval of this request.

Chapter 5: Shielding Evaluation

This section of the SER covers the Shielding review.

Findings

Based on the review of the statements and representations in the Submittal, and independent review by the DOE PCP Staff, DOE PCP has concluded that the proposed use of large vented food-pack cans "convenience containers," the omission of the PCV sleeve, and the use of nitrogen as the inerting gas in the convenience containers and the PCV has no significant effect on the previously performed bounding shielding determinations.

Conditions of Approval

DOE PCP has concluded that no additional Shielding -related conditions of approval need to be added to the existing CoCs for the approval of this request.

Chapter 6: Criticality Evaluation

This section of the SER covers the Criticality review.

Findings

Based on the review of the statements and representations in the Submittal, and independent review by the DOE PCP Staff, DOE PCP has concluded that the proposed use of large vented food-pack cans "convenience containers," the omission of the PCV sleeve, and the use of nitrogen as the inerting gas in the convenience containers and the PCV has no significant effect on the previously performed bounding criticality determinations.

Conditions of Approval

DOE PCP has concluded that no additional Criticality -related conditions of approval need to be added to the existing CoCs for the approval of this request.

Chapter 7: Package Operations

This section of the SER covers the Package Operations review.

Findings

The Submittal proposes using nitrogen as the inerting gas for both the large vented convenience containers and for the PCV. The Submittal also requires that all free volume in both of these enclosures is to be inerted with nitrogen, such that there is no more than five percent (i.e., <5%) oxygen by volume. The Submittal then goes on to indicate that Step 5 in Section 7.2.2 of the SARPs should be implemented for inerting.

Although not specifically clarified in the Operating Procedures section of the Submittal, the reviewers interpret Chapter 7 of the Submittal to stipulate that the void space between the oversized vented convenience containers and the PCV will be inerted with nitrogen according to the procedure referenced by Step 5 Section 7.2.2 in the SARPs (i.e., appendix 7.2), and that the void spaces within the oversized vented convenience containers will be inerted by other means, such as packaging within a nitrogen inerted glove box.

It is therefore recommended that, if there are to be ongoing shipments using the oversized vented convenience containers with the PCV inerted with nitrogen gas, a new procedure for inerting the PCV with nitrogen be written and added to the package safety basis. If, as per the Submittal, "CO_2" is simply replaced with "N_2" in the Appendix 7.2 procedure, most of the statements in the resulting procedure *will not* be consistent with the goal of achieving 95% nitrogen by volume after inerting. Additionally, Appendix 7.2 indicates that changes to the procedure, which includes changing the inerting gas, should be supported with validation tests, and that it is required by Section 9.17 of the SARPs that these validation tests be maintained on file.

The procedure for inerting the PCV was originally developed, and experimentally validated, by Savannah River National Laboratory to be a satisfactory method for inerting the PCV with CO_2 to achieve a gas atmosphere within the PCV with no more than five percent (i.e., <5%) oxygen

by volume. Initially, the reviewers had some concern with the procedure being appropriate for inerting with nitrogen, since nitrogen is not heavier than air, as is the case for carbon dioxide. However, after performing calculations on inerting the PCV with nitrogen, following the steps in Appendix 7.2, with the assumptions of a continuously stirred tank where the gas mixture within the annulus between the PCV and the convenience containers was assumed to be homogeneous, the reviewers confirmed that a level of less than five percent (i.e., <5%) oxygen by volume should be achievable by a dilution time significantly less than half of the complete dilution period stipulated in the procedure.

Conditions of Approval

DOE PCP has concluded that no additional Packaging Operations -related conditions of approval need to be added to the existing CoCs for the approval of this request.

Chapter 8: Acceptance Tests and Maintenance Program

This section of the SER covers the Acceptance Tests and Maintenance review.

Findings

Based on the review of the statements and representations in the Submittal, and independent review by the DOE PCP Staff, DOE PCP has concluded that the proposed use of large vented food-pack cans "convenience containers," the omission of the PCV sleeve, and the use of nitrogen as the inerting gas in the convenience containers and the PCV do not necessitate any changes to the existing Acceptance Tests and Maintenance Program for the Model 9975 Packagings, as described in the -85 and the -96 SARPs

Conditions of Approval

DOE PCP has concluded that no additional Acceptance Tests- or Maintenance Program-related conditions of approval need to be added to the existing CoCs for the approval of this request.

Chapter 9: Quality Assurance

This section of the SER covers the Quality Assurance review.

Findings

It is recommended that, if there are to be ongoing shipments using the oversized vented convenience containers with the PCV inerted with nitrogen gas, a new procedure for inerting the PCV with nitrogen be written and added to the package safety basis. This new procedure should be supported with validation tests that are maintained on file, as required by Section 9.17 of the SARPs.

Based on the review of the statements and representations in the Submittal, and independent review by the DOE PCP Staff, DOE PCP Staff has concluded that the proposed use of large vented food-pack cans "convenience containers," the omission of the PCV sleeve, and the use of nitrogen as the inerting gas in the convenience containers and the PCV does not necessitate a change to the Quality Assurance Program for the Model 9975 as described in the -85 and the -96 SARPs.

Conditions of Approval

DOE PCP has concluded that no additional Quality Assurance-related conditions of approval need to be added to the existing CoCs for the approval of this request.

References

[1] Safety Analysis Report for Packaging — Model 9975, Addendum, Revision 1, S-SARA-G-00013, *Justification for Shipment of Plutonium Oxide in Large Vented Food-Pack Cans*, May 2011.

[2] *Safety Analysis Report for Packaging — Model 9975-85*, WSRC-SA-2002-00008, Revision 0, December 2003.

[3] *Safety Analysis Report for Packaging — Model 9975-96*, S-SARP-G-00003, Revision 0, January 2008.

[4] USA/9975/B(M)F-85 (DOE), *United States Department of Energy Certificate of Compliance for Radioactive Materials Packages, Model 9975*, Revision 25, United States Department of Energy, Washington, DC, expires March 31, 2012.

[5] USA/9975/B(M)F-96 (DOE), *United States Department of Energy Certificate of Compliance for Radioactive Materials Packages, Model 9975*, Revision 4, United States Department of Energy, Washington, DC, expires June 30, 2013.