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STORAGE LIFE AND SURVEILLANCE OF THE 9975 SHIPPING PACKAGE

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ABSTRACT

Plutonium oxide bearing materials stabilized and packaged per DOE-STD-3013 are currently stored at the US Department of Energy Savannah River Site (SRS) in the 9975shipping package. Additionally, the 9975 package is used to store plutonium bearing materials in non-3013 containers (e.g. nested screw lid, slip lid and food pack can types of containers). The 9975 package was initially given a 10 year storage life. Field surveillance and laboratory studies of the 9975 non-metallic fiberboard and O-ring materials were used to justify a 15-year storage life as minor detectable degradation occurred. Subsequently, a 20-year and most recently a 40-year storage life was established by using degradation data as input to hypothetical design based accident event evaluations. For storage of non-3013 containers within the 9975 package the storage life is limited to 20 years.

INTRODUCTION

Radioactive materials, such as plutonium bearing oxides, are stored in 9975 shipping packages at the US Department of Energy Savannah River Site near Aiken, South Carolina. Typically, the plutonium bearing materials are stabilized and packaged per DOE-STD-3013 in 3013 containers which are then shipped in 9975 shipping packages to SRS [1]. The plutonium materials are limited to no more than 4.4 kg of plutonium (up to 5.0 kg as plutonium oxide) and no more than 19 Watts heat generation. The 9975 packages are received at SRS and palletized for long term storage. Additionally, the 9975 package is used to store plutonium bearing materials in non-3013 containers (e.g. nested screw lid, slip lid and food pack can types of containers). The plutonium materials in both 3013 and non-3013's are stored in 9975 shipping packages until they are dispositioned by down blending. Surplus plutonium oxide materials are mixed with an inert adulterant at SRS, packaged in authorized waste containers, and transported to the Waste Isolation Pilot Plant (WIPP) for final geologic disposal. Surplus plutonium metal materials are currently re-packaged and shipped offsite to be oxidized for future down blending.

Figure 1 illustrates the 9975 shipping package by showing its two nested containment vessels, lead shielding, and fiberboard overpack within an outer stainless steel 35 gallon drum; the 3013 container is not shown. These 9975 shipping packages are palletized and stacked to store 3013 containers at the Savannah River Site as seen in Figure 2.

The 9975 packages have been used to store plutonium bearing materials for approximately 20 years at SRS with continued storage anticipated for another 15-20 years. This time frame is well beyond the standard 1 year allotment for a certified (i.e. completed annual maintenance) 9975 shipping package used to transport plutonium bearing materials. Since the 9975 packages have exceeded their transportation certification, surveillance and monitoring of the 9975 key components and evaluation of the functional performance of the 9975 shipping packages is necessary to ensure long term storage safety.

SURVEILLANCE PROGRAM

The 9975 storage surveillance program has been ongoing since 2007 and consists of laboratory studies of the non-metallic fiberboard and O-rings materials, field surveillance of in service drums, and destructive examination (DE) of select drums. The laboratory work is ongoing while the field surveillance occurs on select 9975 packages (nominally 10) each year with a single package selected for destructive examination. The results of the field surveillance and laboratory studies are used as inputs to finite element computational modeling of the SRS storage facility hypothetical design based accident analyses (e.g. drop/impact and fire events) in order to verify the functional performance of the 9975 shipping package as a long term storage container.

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The field surveillances performed in KAC include NDE techniques (e.g. visual inspections, leak checks, dimensional, weight and thermal measurements). For 9975s storing non-3013s, visual examination of the PCV is performed.

The 9975 package was initially given a 10 year storage life. Field surveillance and laboratory studies of the primary 9975 non-metallic fiberboard and O-ring materials were used to justify a 15-year storage life as minimal detectable degradation occurred. The 15 year storage life was established prior to the oldest 9975 package reaching 10 years of storage. After 10 years of storage the surveillance program began identifying increased levels of degradation which required more comprehensive analyses to extend the storage life of the container which is the primary focus of this paper.

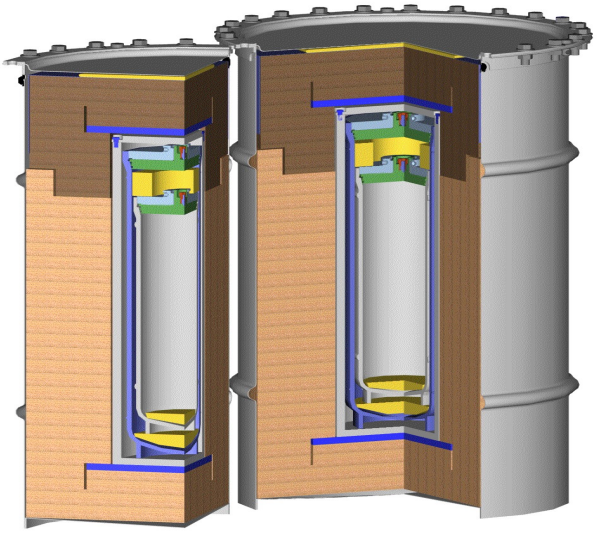

Figure 1: 9975 Shipping Package

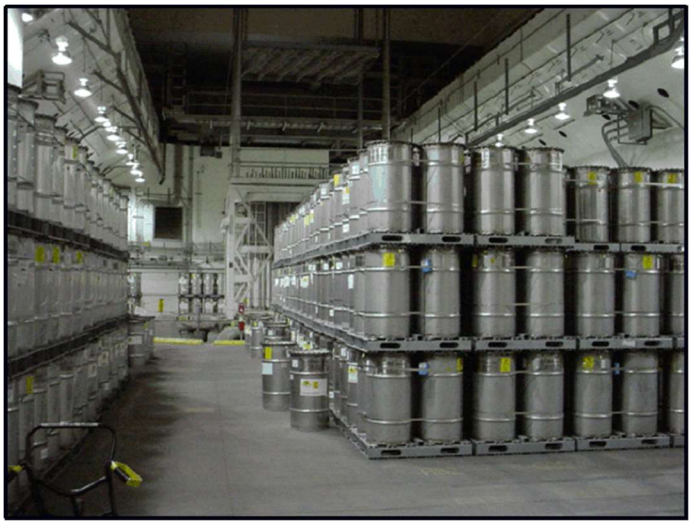

Figure 2: 9975 Shipping Packages At Savannah River Site

LABORATORY STUDIES

The laboratory studies at the Savannah River National Laboratory (SRNL) utilize established facilities to characterize and monitor material properties and performance parameters of key 9975 shipping package components (e.g., O-rings and fiberboard) in a simulated storage environment. The laboratory tests are designed to accelerate material aging (via humidity, temperature, and radiation effects) in order forecast anticipated field conditions. The accelerated aging laboratory tests are designed to evaluate material properties to validate they will perform their intended safety functions.

FIELD SURVEILLANCE

The 9975 field surveillance is performed at the SRS storage facility. Photographs of components depicting aged or abnormal conditions are taken as the packages are opened. The primary containment vessel is leak tested prior to opening. After the radioactive material has been removed from the package and properly staged in the facility, detailed dimensional measurements of fiberboard are taken to investigate shrinkage. Containment vessel O-rings are removed and packaged for shipment to SRNL for further examination.

DESTRUCTIVE EXAMINATION

A limited number of 9975s, nominally one per year, will undergo DE to provide additional assurance that the packages have not degraded such that their safety performance is compromised. The selected package for DE is among the ones which underwent field surveillance and is based on that evaluation. A detailed full examination of the container is performed at SRNL and documented in a technical report.

SURVEILLANCE PROGRAM RESULTS

The SRS surveillance program has identified degradation of 9975 shipping packages used to store both 3013 and non-3013 containers. Emphasis has been placed on fiberboard and O-ring aging. Fiberboard aging is primarily a function of humidity and temperature, and a small fraction of the total package population (typically packaged with higher heat generation items) have seen fiberboard mold growth and dimensional and thermal/structural property changes. Additionally, lead carbonate formation has been observed on older 9975 packages (model 9975-85) which do not have an outer stainless-steel liner between the lead shield and fiberboard subassemblies.

Results from the surveillance program are used to evaluate two design basis accident events hypothesized to occur within the storage facility. The two events address a facility fire and inadvertent impact events. The events are evaluated using computational methods where the aging effects on 9975 package material properties are conservatively applied based on results

from the surveillance program. Additionally, the aging effects of fiberboard mold growth, fiberboard shrinkage and lead carbonate formation are included. Fiberboard shrinkage is most evident in the measurement of the axial gap in the 9975 package which is the distance between the drum lid and the upper fiberboard assembly.

Elevated axial gap was identified as a packaging safety concern during 9975 certification. Elevated axial gap can result in potentially excessive loads on the drum lid during a drop event and/or elevated temperatures in critical package components during a fire event. Per the 9975 SARP this gap should be no more than 1 inch in order for the package to be used to transport radioactive materials. The measured axial gap in stored packages has been found to be directly correlated with the storage duration and heat loading. The greatest axial gap measured to date from the surveillance program is 1.8 inches, which is above the SARP requirement of no more than 1 inch. Further discussion of axial gap effects are discussed in the accident analysis portion of this paper.

FACILITY ACCIDENT ANALYSES

The results from the 9975 Surveillance Program are used as inputs to the hypothesized facility fire and impact event scenarios. The Surveillance Program results are extrapolated out to 40 years to conservatively evaluate the potential storage life within the facility. These results include fiberboard properties (thermal and mechanical), axial gap, lead carbonate formation, fiberboard mold formation, and O-Ring mechanical properties.

THERMAL FIRE ANALYSIS

The thermal fire analysis includes a very bounding 90 minute fire at 1832F. The 9975 package is very conservatively assumed to be fully engulfed. As already discussed, extrapolated aged fiberboard properties, axial gap, lead carbonate, and mold were utilized in the analysis. Additionally, sensitivity studies were performed to better understand the effects of the aged conditions on 9975 performance in a fire. The fire analysis concluded that the aged parameter of most interest is the fiberboard axial gap. Component temperature limits were achieved during the 1832 °F engulfing fire for the lead shielding and PCV O-rings at axial gap values of 3.149 and 3.289 inches, respectively. Therefore, all component temperatures remained below applicable limits, and the 9975 PCV was shown to maintain containment with an axial gap less than 3.0 inches.

STRUCTURAL ANALYSIS

The structural analysis includes a very bounding hypothetical forklift accident where the 9975 package is impacted simultaneously by two forklifts. This event bounds other hypothesized impact events such as a 30 ft. drop and a collapsing structural member within the storage portion of the facility. The aged fiberboard, lead carbonate, and fiberboard axial gap have only modest effects on the package performance during the impact event. The containment vessels provide the primary protection as they adsorb the vast majority of the impact load. Degradation of the containment vessel O-Ring mechanical properties have a significant effect on maintaining containment within the 9975 package. When the package contents are nested welded stainless steel 3013 containers the containment function is maintained as the impact load on the outer 3013 vessels is significantly impeded by the 9975 containment vessels. However, when the 9975 contents consists of non-3013 containers which are generally significantly less robust vented vessels, the containment function is dependent on the 9975 containment vessel O-Rings. Sensitivity studies showed that the O-Ring degradation at 20 years was not sufficient to preclude containment of the contents, whereas above 20 years storage radioactive material containment was assured by the robust outer 3013 vessels

9975 PACKAGE STORAGE LIFE

Based on the accident analyses, the 9975 shipping package with a 3013 container as contents is currently credited with maintaining its safety functions for safety functions for up to 40 years of storage at SRS provided that 1) the 9975 surveillance program continues to monitor 9975 package degradation to ensure the inputs to the accident analyses remain bounding and 2) the 3013 surveillance program completes its assessment to ensure the 3013 container's 50 year storage life is verified. However, 9975 packages with non-3013 contents are credited with maintaining safety functions for 20 years.

CONCLUSIONS

Plutonium oxide bearing materials stabilized and packaged per DOE-STD-3013 are currently stored at the US Department of Energy Savannah River Site in the 9975 shipping package. Additionally, the 9975 package is used to store plutonium bearing materials in non-3013 containers (e.g. nested screw lid, slip lid and food pack can types of containers). The 9975 package was initially given a 10 year storage life. Field surveillance and laboratory studies of the primary 9975 non-metallic fiberboard and O-ring materials were used to justify a 15-year storage life as minimal detectable degradation occurred. Subsequently, a 20-year and most recently a 40-year storage life was established by using degradation data as input to hypothetical design based accident event evaluations. For storage of non-3013 containers within the 9975 package the storage life is limited to 20 years.

REFERENCES

1. DOE-STD-3013-2018, Stabilization, Packaging, and Storage of Plutonium-Bearing Materials, November 2018.