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ABSTRACT

Data obtained from testing shipping package materials have been leveraged to support extending the service life of select shipping packages while in nuclear materials transportation. Increasingly, nuclear material inventories are being transferred to an interim storage location where they will reside for extended periods of time. Use of a shipping package to store nuclear materials in an interim storage location has become more attractive for a variety of reasons. Shipping packages are robust and have a qualified pedigree for their performance in normal operation and accident conditions within the approved shipment period and storing nuclear material within a shipping package results in reduced operations for the storage facility. However, the shipping package materials of construction must maintain a level of integrity as specified by the safety basis of the storage facility through the duration of the storage period, which is typically well beyond the one year transportation window. Test programs have been established to obtain aging data on materials of construction that are the most sensitive/susceptible to aging in certain shipping package designs. The collective data are being used to support extending the service life of shipping packages in both transportation and storage.

INTRODUCTION

The end of the Cold War caused dramatic reductions in the size of the U.S. nuclear arsenal and has resulted in large quantities of excess nuclear materials. The Department of Energy (DOE) is tasked with safely managing these nuclear materials including transportation, interim and/or extended storage, and disposition activities. The use of a shipping package to not only transport but also store nuclear materials has become more common for a variety of reasons. First, shipping packages are robust and have a qualified pedigree for their performance in normal operation and accident conditions. Design and construction of Type B packages are required to abide by three upper tier documents: the DOE Order 460.1C – Packaging and Transportation Safety, the DOT 49 CFR Parts 171-180 – Hazardous Materials Regulations, and 10 CFR part 71 – Packaging and Transportation of Radioactive Material. These upper tier documents provide strict guidance to ensure the safety and integrity of a Type B shipping package and require adherence to a number of other supporting documents, such as a Certificate of Compliance (CoC) and a Safety Analysis Report for Packaging (SARP) which dictate very stringent inspection criteria at the time of fabrication and during the maintenance program for recertification for shipping. As such, Type B shipping packages are very robust for their

specified contents and are constructed of high quality, tightly controlled materials. Additionally, they are designed, fabricated, tested, operated, and maintained under strict standards of quality control. While the accident scenarios for transportation and storage are different, there are considerable similarities between the two and a packaged authorized for shipment has a solid basis for analyses against the storage facility safety requirements.

Second, the interim and/or extended storage of nuclear materials within the shipping package results in reduced operations for the storage facility. Prior to receipt of any shipping/storage package, a rigorous review of the package is performed by the facility engineering personnel to ensure normal storage conditions are adequately captured in the safety documentation for the facility and any facility accident scenarios are mitigated by use of the shipping/storage package. The storage facility conditions are also verified to be compatible with the shipping package environmental requirements. Once the packages are approved for storage, if not before, a surveillance program should be implemented to validate the technical basis for the package analysis and to ensure the materials of construction maintain an acceptable level of integrity throughout the storage period, which is typically well beyond the normal one year transportation window. With all the required analyses and reviews completed, facility operations can then receive a shipping/storage package and transport it to an approved storage location without opening it. This ability to use the shipping package for storage therefore results in reduced operations time during receipt and also eliminates both the labor and material costs of repackaging and the risk of radiation dose to the facility operators.

Consolidation of packaged plutonium-bearing materials in the K-Area Complex (KAC) at the Savannah River Site (SRS) began in 2003. The plutonium materials are packaged using the DOE 3013 Standard which requires two nested, welded stainless steel containers. Within KAC, the welded 3013 containers are stored in DOT Type B 9975 packages. The 9975 shipping/storage package consists of two nested stainless steel containment vessels capped with threaded cone-seal plugs, surrounded by a lead shield and fiberboard overpack, all contained within a 35 gallon stainless steel drum, Figure 1. The 9975 shipping/storage package is part of the approved storage configuration for plutonium materials in KAC. As such, 9975 shipping/storage packages have been continuously exposed to the service environment for a period of time greater than the approved transportation service life. A 9975 Storage Surveillance program was undertaken to verify the integrity of the age-sensitive materials (e.g., containment vessel O-ring seals and fiberboard overpack) over time in the environment they are exposed to in KAC.

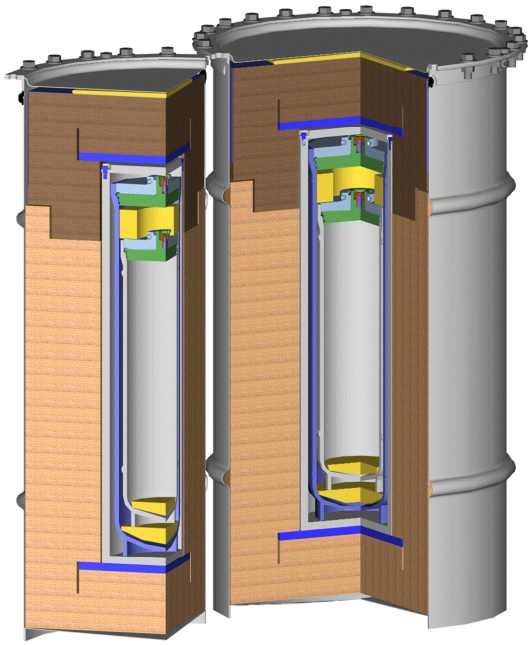

Figure 1. Illustration of 9975 package including drum, fiberboard, lead shielding, and double containment vessels.

APPROACH

A generic approach to materials life management is to understand the baseline properties of the materials of interest and to obtain performance data at aging conditions for comparison. The environmental conditions of the aging tests should bound any conditions that may be experienced with the lifetime of the materials of interest. Bounding conditions may include the highest or lowest temperature and/or humidity, the maximum radiation dose expected, chemical interactions, weight factors, storage configurations, etc. Figure 2 provides a schematic that represents the many considerations needed when defining a program to validate integrity of the materials during the life of the package. Those considerations are further explained in Table 1.

Figure 2. Schematic of general life extension program considerations for a shipping/storage package life extension program

Table 1. Description of life extension program considerations for a shipping/storage package life extension program

Program Considerations	**Description**
Design & Fabrication	Design and fabrication of packages need to consider the materials of construction relative to its application
Baseline Materials Analysis	An understanding of the baseline materials properties is imperative to know whether behavior in service is normal or related to degradation
Aging Studies	Perform materials aging at bounding conditions for package
Degradation Evaluation	Evaluate materials performance throughout aging tests and determination of "end of life" materials properties
Operational Controls	Implement operational controls to ensure materials integrity is maintained
In-Service Inspection – Service History	Inspect selected packages during service and understand the history of the packages
Integrity Analysis	Ensure materials perform as expected to validate integrity of package
Life Prediction	Use aging study data to predict useful life of materials in packages

As part of the 9975 Storage Surveillance Program the O-rings, fiberboard, and lead shielding body were recognized early on as age-sensitive materials in the shipping package. The performance of these materials to specified minimum levels were credited by the KAC facility to ensure a zero release scenario for the 3013 containers. The predominant facility credit is:

- Lead shielding body – gamma shielding;
- Fiberboard - impact resistance, fire resistance, spacing (criticality control) and;
- O-rings – containment of the contents.

The containment O-rings are based on Viton® GLT (now GLT-S) and the fiberboard is Celotex® (Grade 1, Type IV, ASTM specification C-208-95, cane or softwood, 14 to 16 pcf). The O-rings and fiberboard overpack have been studied for lifetime evaluation in KAC storage conditions [1]. O-rings have been subjected to accelerated thermal and radiation aging and evaluated for changes in compression stress-relaxation, compression set, and leakage behavior [2]. Fiberboard was evaluated for changes in dimensions, thermal conductivity, specific heat capacity, and mechanical strength [3]. The lead shield was also inspected and evaluated for thickness changes and slumping within the package [4-5]. Based on all the information from the 9975 Storage Surveillance program, the current approved storage duration for the 9975 shipping/storage package in KAC is 15 years [6], Table 2. It is anticipated that the packages may remain in service as long as the surveillance program shows that the drums are capable of performing their design function.

Aging data obtained from the 9975 Storage Surveillance Program were leveraged to accept the 9977 shipping package as a storage package in the KAC facility. The O-rings are the same material but there are other materials of construction in the 9977 that are being evaluated for

extended storage [7]. The current approved storage duration for the 9977 shipping/storage package in KAC is 5 years [6], Table 2.

Table 2. Examples of Storage Life Extensions

Type	Description	Time	Status	Supporting Information
9975	Storage in KAC	15 Years	Approved	WSRC-SA-2002-00005, Rev. 9, K-Area Complex Documented Safety Analysis
9977	Storage in KAC	5 Years	Approved	WSRC-SA-2002-00005, Rev. 9, K-Area Complex Documented Safety Analysis, working towards 15 years.

Aging data obtained from the 9975 Storage Surveillance Program has also been leveraged to extend shipping packages life cycle for transportation purposes, saving time and money (50-80% reduction in re-certification costs), and decreasing waste. Additionally, extending the life cycle of the shipping packages improves the flexibility with shipping schedules, avoiding untimely delays due to overly conservative maintenance requirements. Benefits to both the storage and shipping package programs can all be implemented and accomplished without compromising the safety of the environment, the public and workers from the stored and/or shipped nuclear materials. Table 3 outlines those packages that have used 9975 aging data for extension of the certification period for transportation.

It is also recognized that many shipping packages are not needed for use as a storage package. However, by identifying those attributes of a testing program that are required to ensure the integrity of a package is maintained throughout the transportation period, a reasonable testing program can be implemented to obtain technically defensible data which supports certification extension for transportation of shipping packages. Or, a package which may be loaded but unshipped for a period longer than expected would have a basis for an evaluation for shipment outside of its authorization basis. Materials testing for the H1616 shipping package are underway in order to extend the maintenance cycle (Table 3).

Table 3. Examples of Transportation Package Life Extensions

Type	Description	Time	Status	Supporting Information
General	ARG-US RFID	TBD	In Review	RFID would establish upper seal temp of 200°F for extending package lifetime
9977	Maintenance Extension	2 years	DOE-EM Certified	SARP Addendum 1, S-SARA-G-00003 Rev. 2, DOE-EM Certified
9977	Maintenance Extension	5 years	DOE-EM Certified	SARP Addendum 4, S-SARA-G-00010 Rev. 5, DOE-EM Certified
9978	Maintenance Extension	5 years	Not DOE-EM Certified	SARP Addendum 1, S-SARA-G-00011 Rev. 4, DOE-EM Certified
H1700	Maintenance Extension	2 years	NNSA Certified	S-SARP-G-00005 Rev. 0
H1616	Maintenance Extension	2-5 years	Not NNSA Certified	Testing in progress

CONCLUSIONS

Use of a shipping package to store nuclear materials in an interim storage location has become attractive for a variety of reasons. Shipping packages are robust and have a qualified pedigree for their performance in normal operation and accident conditions within the approved shipment period and storing nuclear material within these packages results in reduced operations and cost for the storage facility. The 9975 and 9977 shipping packages have been approved for extended storage life in the KAC facility. Data obtained from testing shipping package materials has also been leveraged to support extending the service life of select shipping packages (9977, 9978, and H1700) while in nuclear materials transportation. Additionally, a test program has been implemented to extend the service life of the H1616 shipping package in transportation. A similar approach to extending the life cycle of other shipping packages may also be beneficial for reducing costs, decreasing waste, and increasing shipping flexibility.

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