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INTERIM SAFE STORAGE OF RADIOACTIVE MATERIALS AT THE SAVANNAH RIVER SITE

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ABSTRACT

Storage of plutonium bearing materials at the US Department of Energy Savannah River Site (SRS) typically are packaged in DOE-STD-3013 welded containers which are stored in 9975 shipping packages. However, some materials are packaged in non-welded metal containers which consist of a can-bag-can configuration. These non-welded containers and the 9975 package provide safe containment of the plutonium bearing materials. Additionally, the materials must be stabilized such that adverse reactions do not occur during storage. Lastly, a surveillance program of these containers provides field and laboratory data with respect to package aging and potential degradation. The packaging, material stabilization, and surveillance requirements are identified in an Interim Safe Storage Criteria (ISSC) Program at SRS. This paper provides a high level overview of the ISSC program. Interim storage is defined as the storage prior to long term plutonium disposition.

INTRODUCTION

Plutonium bearing materials stored at SRS are typically stabilized per DOE-STD-3013 [1], however, not all containers in storage are welded 3013 containers. An example of this is the packaging of plutonium oxide materials resulting from the destructive examination surveillance at SRS of 3013 containers. Plutonium oxide materials may be packaged into a stainless steel filtered slip lid convenience container with the lid secured using polyvinyl chloride tape and bagged out of the processing glove box using a filtered polyethylene bag. The bagged can is next packaged into a screw lid stainless steel container. This can – bag – can configuration is then packaged into a 9975 shipping package. These can-bag-can items must be packaged in accordance to SRS the Interim Safe Storage Criteria (ISSC) Program. Figure 1 presents a typical non-3013 can-bag-can configuration.

Figure 1: Typical Non-3013 Can-Bag-Can Configuration

The ISSC Program is the safety management program for the storage and handling of 9975 shipping packages with non-3013 containers at the Savannah River Site (SRS). Material stored in accordance to the ISSC Program may include radioactive sources, standards, uranium oxides, and plutonium metal and

oxides. Material received in 9975 shipping packages that do not meet the DOE-STD-3013 (e.g. plutonium bearing materials not packaged in welded 3013 containers) standard must be packaged with accordance to the ISSC Program, ensuring the material is safe for handling and storage at SRS.

The ISSC Program ensures there is no credible loss of containment during storage by restricting and quantifying gas generation from radioactive materials, ensuring deflagration and detonation events do not occur, and ensuring potential corrosion or other critical component degradation that threaten radioactive material containment are not credible.

The requirements defined in the SRS ISSC Program are based upon the forerunner to the requirements identified in DOE M 441.1-1, Nuclear Material Packaging Manual [2], which provides detailed packaging requirements for protecting workers from exposure up to 5 rem from stored nuclear materials. A very important aspect of the ISSC Program is that its intent is to provide radioactive material containment and protect workers during normal storage conditions. As such, long term container degradation and adverse nuclear material reactions are of primary concern. The safety of workers during accident conditions (e.g. a fire event) are addressed in nuclear facility safety bases which permit significantly greater radiation dose to workers than the strict 5 rem requirement of ISSC.

This remaining article will present an overview of the ISSC Program and program requirements; highlighting safe handling and storage of material packaged outside the DOE-STD-3013 standard. Other than pyrophoric considerations, plutonium oxides are considered bounding in terms of storage safety considerations.

INTERIM SAFE STORAGE CRITERIA

The ISSC Program is comprised of three sections; material characteristics, packaging criteria, and surveillance.

Material Characteristics

Chemical, radiological, and physical characteristics of the proposed material are evaluated to ensure safe storage and handling is maintained. Material characteristics envelope a wide range of topics: explosion sensitive and/or flammable materials, gas generation, incompatible materials, physical and chemical form, moisture content, pyrophoricity, radioactive decay heat, radiation fields and solution.

Material considered explosive, shock-sensitive, and/or pyrophoric are not allowed to be stored in accordance to the ISSC Program. Compliance with this criterion may be satisfied by stabilization of material per the criterion outlined in the DOE-STD-3013 standard. An example of this is packaging plutonium oxide after performing the destructive examinations on the 3013 container. As part of the 3013 surveillance program, plutonium oxide is sampled and undergoes a series of analyses. The remaining plutonium oxide is repackaged in a can-bag-can configuration for continued storage, until disposition, at SRS.

Under the ISSC Program, no formation or accumulation of a flammable gas mixture within the plutonium containers or shipping package containment vessels are allowed. The generally accepted lower flammability limits for hydrogen and oxygen are 4 % vol. hydrogen and 5 % vol. oxygen. Hydrogen or oxygen concentrations below these limits ensure the mixture is not flammable. The production of hydrogen and oxygen typically occur due to the adsorbed moisture on the plutonium oxide.

Plutonium oxide materials are known to radiolyze adsorbed moisture, forming hydrogen and in some instances oxygen. To mitigate the formation of a flammable gas mixture, the convenience containers used to package the plutonium oxide are vented, and the containment vessel may be inerted and enclosed with a hydrogen getter/recombiner assembly. These assemblies are materials that either recombine available hydrogen gas with available oxygen gas into water via a precious metal (e.g., platinum and/or palladium) catalyst, or hydrogenate an unsaturated alkene polymer such that hydrogen gas is removed from the containment vessel. This ensures no accumulation of a flammable mixture exists during storage.

Operational handling restrictions are also imposed in order to prevent moisture adsorption on the plutonium oxide (and thus, limiting the available moisture for gas generation via radiolysis). For example, the relative humidity during glove box handling of plutonium oxides containing salt impurities, which may form hydrates (e.g. MgCl), is limited to less than 50%. This ensures the salts do not deliquescence which potentially could cause corrosion problems in the storage container and potentially generate hydrogen and oxygen gases beyond the capability of the getter/recombiner.

Material considered to be stored under the ISSC Program must not react in an adverse manner to cause failure of the containment system. Where can-bag-can configurations are stored within a 9975 shipping package, degradation of the innermost convenience can is not a concern because it is not credited with providing containment, however, degradation of the 9975 containment vessel is not permitted. Examples of potential failure mechanisms include corrosive or oxidative expansion (e.g. metal oxidation). Radioactive materials evaluated in the 9975 Safety Analysis for packages (SARP) are permitted without justification. Additional materials not addressed in the 9975 SARP may be stored provided sufficient evaluation is performed to ensure adverse reactions which may degrade the containment system do not occur.

Adsorbed moisture of the material is also limited. All material stored under the ISSC Program must be evaluated to determine the maximum amount of adsorbed moisture at the time of packaging into the 9975. Individual moisture measurements for specific items are utilized where available, and a bounding evaluation is utilized for groups of materials when measurements are not available.

Radioactive decay heat of each material must be determined and showed to be less than the limit of the storage package. The ISSC Program utilizes the 9975 shipping package and thus imposed a 19 W ISSC limit. Note that additional wattage limitations may exist such to limit degradation of plastics (i.e., plastics within the getter assembly).

The ISSC Program prohibits the storage of free liquids.

Packaging Design Criteria

Packaging criteria under the ISSC Program ensures the selected package for storage (in this paper that package is the 9975) has been evaluated against corrosion, radiolytic and thermal degradation, oxidation expansion, pressurization, incompatible materials and handling.

The 9975 shipping package is the credited containment system for plutonium bearing materials. The 9975 shipping package was selected because of its robustness, transportation certification pedigree, and availability. It is a Type B shipping package that has been qualified for shipping across public roads in accordance with Department of Transportation (DOT) regulations. The 9975 is certified for up to 19 Watts of radioactive materials. The 9975 shipping package has been tested and shown to maintain containment during and after a series of severe transportation accidents. Illustrated in Figure 2 is a cross-sectional view and image of a 9975 shipping package.

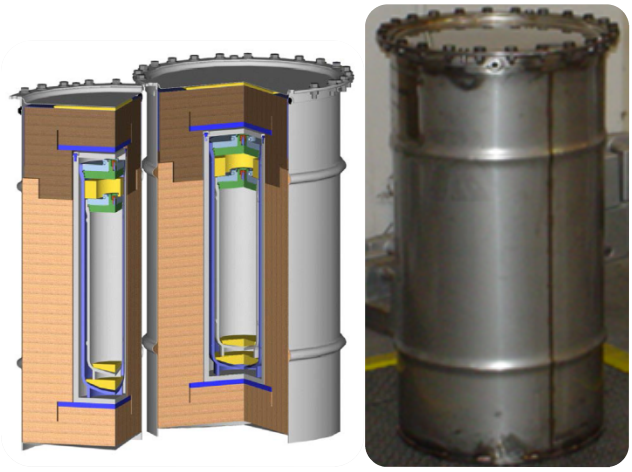

Figure 2: Cross-sectional view of a 9975 shipping package (left) / Image of a 9975 shipping package (right).

Stainless steel is the material of choice for long-term storage of plutonium bearing materials as evidenced by the requirements in DOE-STD-3013 [1]. The 9975 shipping package is a double containment vessel. Both containment vessels are made from stainless steel. Note that two containment boundaries are not required per ISSC.

The shipping package must be resistant to thermal degradation effects. Ongoing evaluations of thermal degradation of the 9975 package during long term storage indicate that non-metallic components, fiberboard overpack and elastomeric O-rings, degrade. For this reason the ISSC currently restricts storage to no more than 15 years. Prior to reaching 15 years of storage, materials must be re-packaged into 9975 packages which have undergone maintenance per the SARP. To date no such re-packaging has occurred as materials have been dispositioned.

Monitoring and Surveillance Requirements

The objective of surveillance is to ensure the nuclear materials storage package continues to meet its objective, which is to protect workers from the hazards of storing radioactive materials. Surveillance activities include laboratory testing of 9975 non-metallic components (fiberboard and O-rings) to aging rates, determine in-field degradation by inspecting 9975 packages currently in use, and destructively examine used 9975 packages. The detailed results of the surveillances are beyond

the scope of this paper, however, a few highlights are worth discussing.

In laboratory testing the O-ring physical properties have been shown to provide for containment well beyond 15 years. The primary mechanism for O-ring degradation is chronic thermal exposure, however, the thermal storage conditions are relatively mild (no insolation and modest average ambient temperature).

Laboratory testing and in-field measurements of fiberboard provide different results. The fiberboard clearly degrades due to long term thermal exposure resulting in lower strength, thermal conductivity, and density. In addition, the fiberboard contains significant quantities of absorbed moisture which tends to migrate during storage from warm to cool locations in the package. As a result the fiberboard at the bottom of the drum tends to compress due to the weight of the lead shield and containment vessels thereby causing a gap between the top of the upper fiberboard and the drum lid. The fiberboard also contains chlorides which provide a mechanism for corrosion at the drum bottom. At most only very small amounts of corrosion have been identified to date. Although the fiberboard degradation observed thus far does not threaten the ISSC required functions, it does need continual monitoring and further evaluation.

CONCLUSIONS

Storage of plutonium bearing materials at SRS is governed by the ISSC Program in order to ensure worker safety. The ISSC Program addresses long term normal condition storage and it is based on a forerunner to the DOE M441.1-1 Program. The objective is to protect workers from a dose of 5 rem due to loss of containment. The ISSC Program does not address accident conditions. Most materials covered by ISSC are packaged in a can-bag-can configuration inside a 9975 shipping package. The 9975 package provides for material containment. Additionally, the materials must be stabilized such that adverse reactions do not occur during storage. Lastly, a surveillance program provides field and laboratory data with respect to 9975 package aging and potential degradation. Interim storage is defined as the storage prior to long term plutonium disposition.

REFERENCES

1. DOE-STD-3013-2012, Stabilization, packaging, and Storage of Plutonium-Bearing Materials, March 2012.

2. DOE M 441-1.1, Nuclear Material Packaging Manual, March, 2008.