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Accelerated-Aging of Shipping Package O-Rings for Pu Storage

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INTRODUCTION

The Savannah River Site (SRS) is storing surplus plutonium (Pu) materials in the K-Area Materials Storage (KAMS) facility. The Pu materials are packaged per the DOE 3013 Standard. The nested, welded 300 series stainless steel 3013 containers are transported to KAMS in Type B shipping packages and subsequently stored in the same packages. These type B shipping packages consist of double containment vessels sealed with dual O-rings. The O-ring compound is Parker Seals V0835-75, based on Viton® GLT fluoroelastomer. This work evaluates the performance of the V0835-75 O-rings at accelerated-aging conditions. The results will be used to develop a lifetime prediction model for O-rings in KAMS.

EXPERIMENTAL

Compression stress-relaxation (CSR) tests are being performed on V0835-75 O-rings per ASTM D6147 using Shawbury-Wallace C11 jigs in a Wallace Mark IV relaxometer. A custom insert was designed to impose an O-ring ID stretch of ~18% and a ~20% compression during aging to simulate the package design (Figure 1).

Per ASTM standards, the aging temperatures selected for the CSR tests are 175, 235, 250, 300, 350 ºF. The peak O-ring temperature expected during the storage period is 200 °F. The 350 °F temperature is higher than expected in transport or storage but is less than the "continuous" service rating from the O-ring vendor of 400 ºF, which is nominally based on 1000 hours.

In addition to thermal effects, the effects of radiation on CSR behavior are also being investigated. A set of O-rings was irradiated to a 50-year dose (0.88 Mrad) at 0.44 Mrad/hr prior to thermal aging.

O-rings are lubricated, placed in the inserts, installed into CSR jigs, and then thermally aged appropriately. To address potential effects of ID stretch, some O-rings are being tested in the unstretched condition. Jigs are removed from the oven for periodic sealing force measurement.

RESULTS

CSR forces are plotted as a force decay ratio ($F/(F_o)$) over time (Figure 2), where F_o is the initial force at the aging temperature. Thermocouples are used to monitor temperature loss during measurement. The temperatures of the jigs during CSR testing were ~25 ºF lower than the oven aging temperatures.

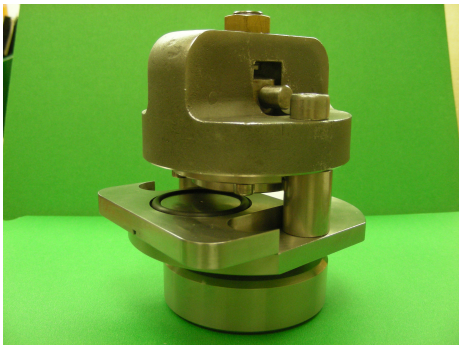

Fig. 1 O-ring stretch insert in Shawbury-Wallace C11 jig.

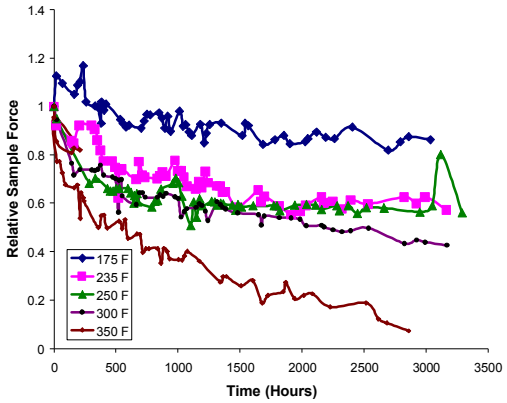

Fig. 2. CSR behavior of irradiated and stretched O-rings aged from 175 to 350 ºF.

From Figure 2, the O-ring aged at 350 ºF has lost approximately 90% of initial sealing force after ~2800 hours. Tests are currently in progress to determine the relationship between CSR and leak rate for this particular design.

Changes in sealing force at 175-250 ºF are less severe. These values could remain steady for an extended time or could suddenly drop once a threshold time is reached. This has been observed in other elastomers such as EPDM, nitrile and butyl rubber due to antioxidant depletion or diffusion-limited oxidation.

CSR behavior of the V0835-75 O-rings will be monitored until target values of relaxation are reached at

all aging temperatures or until valid extrapolations can be made for lifetime model development.