TEST PLAN

Nonmetallic Materials Test Plan for Hanford's HLW Transfer System

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TABLE OF CONTENTS

Introduction 1
Scope 1
Materials 1
Experimental Approach 2
In-Service Configuration Aging 2
Coupon Aging 3
Quantification of Material Degradation 3
In-Service Configured Components 3
Coupons 3
Schedule 4
Health & Safety 4
Waste Disposal 5
Works Cited 5

Introduction

Nonmetallic materials are utilized in the waste transfer system at the Hanford tank farms; these include the inner hose of the hose-in-hose transfer lines (HIHTLs), Teflon® gaskets and ethylene propylene diene monomer (EPDM) O-rings. These materials are exposed to simultaneous stressors including β and γ radiation, elevated temperatures, caustic supernatant as well as high pressures during normal use. In 2011, the Defense Nuclear Facilities Safety Board recommended to the U.S. Department of Energy (DOE) to conduct post service examination of HIHTLs and Teflon gaskets to improve the existing technical basis for component service life. Suppliers of the nonmetallic components often provide information regarding the effects of some of the stressors, but information is not provided for simultaneous exposure. An extensive test plan was developed by Sandia National Laboratories to understand the simultaneous effects of the aforementioned stressors (LH Brush, 2013); however, this test plan was never executed. Additional studies conducted by Lieberman provides information on HIHTLs at elevated temperature and pressure but little information is gained regarding the synergistic effects with caustic supernatant (Lieberman, 2004). Florida International University (FIU) has been tasked with supporting this effort by conducting multi stressor testing on typical nonmetallic materials used at the Hanford tank farms. This document provides the test plan for the initial phase of testing which includes exposure of EPDM components to caustic material at various temperatures for varying lengths of exposure time. After the tests have been conducted and the data analyzed, additional testing phases will be conducted that may include the effects of elevated pressure and the use of different materials (Teflon and Tefzel). Additional studies may also be conducted to determine if the synergistic effects of radiation can be evaluated from a theoretical basis.

Scope

This test plan outlines the use of a caustic fluid at various temperatures as a stressor to determine its effect on EPDM materials. The test plan details the performance objectives, the types of tests, the control parameters and the data to be collected and analyzed. Material samples will be aged as coupons as well as in a specific system configuration setup. The effects of aging due to various stressor combinations on each sample will be quantified. This test plan also details the data quality objectives that must be met to ensure the tests provide confirmation of adherence to the performance requirements.

Materials

EPDM was selected for this phase of testing due to its use in multiple applications within the Hanford waste transfer system. The EPDM material tested will consist of EPDM material coupons, EPDM HIHTL inner hoses and EPDM O-rings. Coupons will be used to obtain a fundamental understanding of the relationship of the stressor with the material. Components (inner hoses and O-rings) will be used to determine the effect on the component being evaluated in an environment similar to its operational environment. Since material properties such as thickness and pressure ratings may vary with each supplier, FIU will work with site personnel to identify these properties and test parameters will be adjusted accordingly.

Experimental Approach

All material samples will have their mechanical performance and properties tested as per ASTM standards prior to any exposure. Once the baseline properties have been determined, each material sample will be aged, which will involve exposing each sample to a chemical simulant at ambient (70^{o}F), operating (130^{o}F) and design temperatures (180^{o}F) for a duration of 30, 60 and 180 days. Tests will be conducted on both material coupons as well as in-service configuration assemblies. After aging/conditioning, the mechanical properties of the samples will again be measured as per ASTM standards.

In-Service Configuration Aging

The in-service configuration aging experimental setup will consist of 3 independent pumping loops with three manifold sections on each loop (Figure 1). Each of the 3 loops will be run at a different temperature (70^{o}F, 130^{o}F and 180^{o}F). Each manifold section can hold up to three test samples and be used for a corresponding exposure time of 30, 60 and 180 days. Three samples of the EPDM inner hose and three samples of the O-rings will be placed in a parallel manifold configuration. Isolation valves on each manifold will allow removal of samples without affecting the main loop and the rest of the samples. The temperature of the chemical solution circulating within each loop will be maintained at a preset temperature by an electronically controlled heating system. This configuration requires 9 test samples (for both the inner hose and O-rings) for each of the three test loops, requiring a minimum of 27 test samples of each the inner hose and O-rings. A 25% sodium hydroxide solution will be used as a chemical stressor that will circulate in each of the loops. The chemical stressor will be changed out every 30 days to ensure that the concentration levels remain constant.

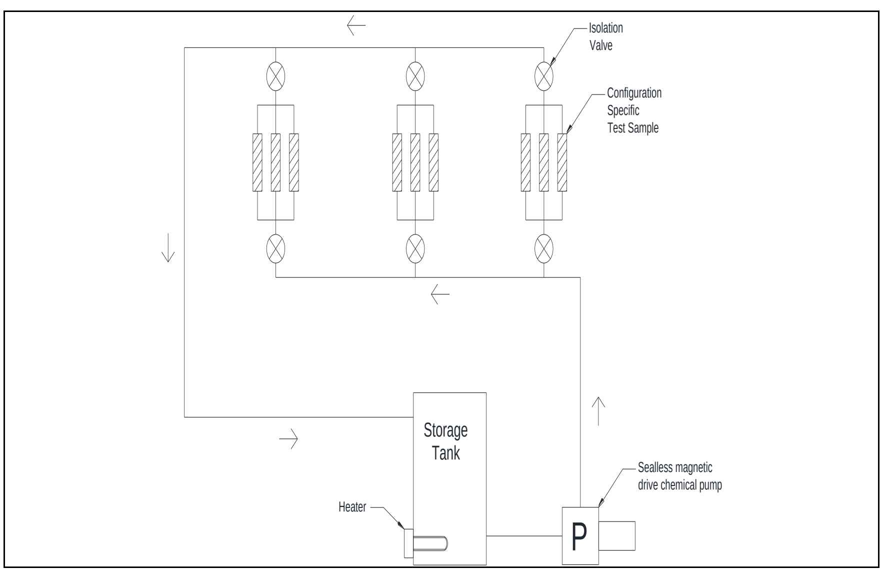

Figure 1. In-service component aging loop.

Coupon Aging

The coupon aging experiment setup will consist of 3 temperature controlled circulating fluid baths. Each bath will be maintained at a different temperature (70°F, 130°F and 180°F). As in the in-service configuration tests, the circulating fluid will be a 25% sodium hydroxide solution. Each bath will have three racks with ten coupons suspended on each rack. Each rack will be submerged in the bath for a duration of 30, 60 or 180 days. In addition, samples will be tested that are not exposed or aged to generate a set of baseline data. Table 1 shows the test coupon aging matrix.

Table 1. Coupon Aging Matrix

Days Exposure	Ambient Temperature (70°F)	Operating Temperature (130°F)	Design Temperature (180°F)	Baseline
0				10 coupon samples
30	10 coupon samples	10 coupon samples	10 coupon samples	
60	10 coupon samples	10 coupon samples	10 coupon samples	
180	10 coupon samples	10 coupon samples	10 coupon samples	

Quantification of Material Degradation

In-Service Configured Components

In order to quantify how each sample was affected by the exposure to the caustic stressor, post-exposure mechanical testing will be conducted. Post-exposure mechanical testing will include hose burst and O-ring leak tests as per ASTM D380-94 and ASTM F237-05, respectively. The tests will be conducted on the 27 aged test samples (9 from each test temperature with 3 at each exposure time). These results will be compared to the baseline mechanical testing results from un-aged samples.

Coupons

Post-exposure mechanical testing of coupons will include material property testing as per ASTM standards. Coupon properties to be evaluated include specific gravity, dimensions, mass, hardness, compression set, and tensile properties (tensile strength, ultimate elongation yield, and tensile stress). These properties will be evaluated using standardized test methods developed by ASTM International. For specific gravity measurements, ASTM D792 will be used, while ASTM D543 will be used for measuring dimensions and mass. For hardness measurements, ASTM D2240 will be used and ASTM D412 – Method A will be used for evaluating tensile properties. Table 2 shows the coupon post exposure test matrix. Each of the sets of 10 coupon samples defined in Table 1 will be used to determine the material property changes described in the 6 tests listed in the table below.

Table 2. Coupon Post Exposure Tests

Test 1	Dimension change (ASTM 543)
Test 2	Specific gravity and mass change (ASTM D792, ASTM 543)
Test 3	Tensile strength (ASTM D412)
Test 4	Compression stress relaxation (ASTM D6147)
Test 5	Ultimate elongation (ASTM D412)
Test 6	Hardness measurements (ASTM 2240)

Schedule

The nonmetallic testing will be comprised of five tasks: aging apparatus design and fabrication, material aging, quantification of material degradation, data analysis and report writing and system decommissioning. Table 3 below lists the tasks and their projected durations.

Table 3. Experimental Tasks and Durations

Task	***Description***	***Duration***
1	Aging apparatus design & fabrication	6 wks.
2	Material aging	6 mos.
3	Quantification of material degradation	4 wks.*
4	Data analysis and report writing	4 wks.
5	System decommissioning	4 wks.

* Quantification of material degradation will be conducted in conjunction with material aging, as the samples complete the aging process.

Health & Safety

All project activities will be performed in accordance with ARC`s Project-Specific Health and Safety Plan (PSHASP) approved by Florida International University's ES&H Coordinator and Project Manager. ARC laboratory procedures will be strictly recognized, and operators will perform all tasks in compliance with OSHA guidelines obeying all the personal protective equipment requirements.

The expected hazards are common to all laboratory environments and include exposure to strong acids or bases, slips on wet flooring, injuries due to broken glass or plastic parts, pinches or punctures while dealing with equipment, and possible back injury while moving heavy objects or equipment. An eye wash chamber and a shower are located near the work areas for quick drenching to minimize the dangers due to chemical exposure. Other health and safety issues are discussed in detail in the PSHASP.

Waste Disposal

The hazardous waste products generated by ARC will be handled and disposed of in accordance with the FIU waste management program. All accumulated toxic or hazardous wastewater products will be stored in specified locations, in labeled receptacles with appropriate spill containers. As such, it will be collected and stored in appropriate containers pending collection by an FIU hazardous waste contractor.

Works Cited

LH Brush, C. O. (2013). *Test Plan for the Irradiation of Nonmetallic Materials.* Albuquerque, New Mexico: Sandia National Laboratories.

Lieberman, P. (2004). *Banded (Band-It) and Swaged Hose-In-Hose (HIHTL) Assembly Service Life Verification Program.* Santa Clarita, California: National Technical Systems.