Appendix 2.12.3, Excerpted from Safety Analysis Report for the Century Champion Type B Package Immersion Test

Introduction

The Century Industries Versa-Pac Shipping Container is an evolutionary package design based on the design and testing of the Century Industries Champion Type B package. Due to the similarity in both package designs, tests involving the Century Industries Champion, although not directly applicable, can be used to support the safety basis of the Versa-Pac design as supplemented by further analysis and tests. Tests involving the Champion package that are applicable to the design of the Versa-Pac include drop tests, thermal and immersion tests. The design similarities are further presented with attachment of the test results for the Champion package.

Design Comparison

Both packages share the same basic structural components in that they have an inner and outer liner of sheet metal that is surrounded by vertical and horizontal stiffeners. Both package designs use the same ceramic fiber blanket insulation between the inner and outer liners and also surrounding the radial portion of the containment boundary. Both designs have approximately the same polyurethane foam in their respective bottom and top portions of the container. Both designs are based on an inner structure that slides into an outer drum. Therefore, both package designs should have a similar thermal response including thermal stresses. However, the temperature profiles may be different as further discussed.

The package designs differ in the type of insulation that surrounds the inner containment area. The Champion surrounds the containment area with polyurethane foam that is poured in place while the Versa-Pac utilizes ceramic fiber blanket insulation within the same area.

The Champion utilizes a leak testable inner vessel as the primary containment with a secondary blind cap flange on top of the main sealing flange while the Versa-Pac uses only a ½" blind flange with a high temperature fibrous sleeve at the containment boundary.

Immersion Test

Figure 2.5.3-1 shows the Century Champion Package rigging post-thermal test. Figure 2.5.3-2 displays the package being loaded into the pressure chamber. Figure 2.5.3-3 displays the package during the immersion testing.

Summary of Results

Pages 15 and 16 of the Champion Safety Analysis Report are provided as pages 5 and 6 to Appendix 2.5.3. The test results indicate that immersion testing of a damaged prototype package to a pressure of 23.0 ± 1.0 psig during a 15-minute produce no additional damage.

Figure 2.5.3-1 Champion Package on Test Stand – View from Thermocouple Shielding Tube

Figure 2.5.3-2 Champion Package during Immersion Testing Phase

Figure 2.5.3-3 Champion Package during Immersion Test

Following extinguishment, temperature data was recorded during the cool down period. During the cool down, the test article was protected from precipitation and wind effects to eliminate enhanced cooling of the test article.

Table 3. Pool Fire Test Observations.

TIME (Min:Sec)	OBSERVATIONS
0:00	Test started. Flames fully developed across pool surface.
1:00	CI-1 shipping container engulfed by flames. Light southeast wind blowing flames northwest. Shipping container mostly engulfed by flames.
17:00	Plug melted and off-gassing from side of container at plug location.
30:00	Decision was made to extend time of exposure.
32:30	Additional 310 gallons of diesel started. Ended with 1260 gallons of diesel fuel.
38:00	Off-gassing burning from crease on bottom of container and off-gassing not burning from plug location.
44:15	Fuel beginning to burn out.
46:30	Residual burning continues on container.
47:00	Off-gassing at TC outlet port and at crease. Both continue to burn.
48:00	No visible flames in pool.
55:00	Temperature monitoring of shipping container continuing (5-10 min stop between burn and cool-down period).

Time-temperature profiles and test condition graphs taken during the pool fire exposure and cool down period are shown in Figures 10 through 15. The average flame temperature recorded by the TCs used to measure the pool fire was 1350°F and the average wind speed during the test was 3.1 mph. During the 44-min fire exposure, TC Nos. 5 and 8 attained maximum temperatures of 450°F and 303°F, respectively. TC Nos. 5 and 8 were located on the lower portion of the inner vessel. As a result of the crush tests, a tear developed at the base of the 55-gal drum. It is SwRI's opinion that the tear provided ventilation, allowing the foam to decompose and burn, causing the elevated temperatures recorded by TC Nos. 5 and 8. Tabular data for the test conditions TC measurements appear in Appendix E.

9.4 Hydrostatic Immersion Test

On January 29, 2004, the CI-1 shipping container was transported back to SwRI's main campus facility and delivered to the Test and Evaluation Section of the Department of Structural Engineering. The weight of the container as received from the off-site test facility was 386 lbs. The reduction of weight of 4 lb was due to the consumption of the insulation during the fire exposure.

The port where the TCs exited the shipping container was sealed using J.B. Weld quick drying sealant. The shipping container was moved in to position inside of the hydrostatic chamber and sealed. Water was introduced and the pressure monitored. The pressure was raised until 23 psig was attained and the test begun. The pressure of 23 ± 1 psig was maintained for 15 min before the test was terminated.

The reinforced outer drum lid was removed and the foam plug was found to be in good condition with a minimal amount of charring (approximately 1/4 to 1/2 inch). The plug was removed and inside the secondary cover and gasket were found to be in excellent condition.

9.5 Final Helium Leakage Test

Following completion of the pool fire exposure and the immersion tests on January 29, 2004, the final helium leakage test was performed. The leakage rate was measured after 1, 3, and 5 min and the rates recorded were found to be acceptable (see Table 4 below). After obtaining the leak rates, the calibration leak source was used to verify that the leak detector was working accurately.

Table 4. Final Leakage Test Results. CI-1 Shipping Container.

Time (min:sec)	REQUIREMENT (std cc/sec)	MEASUREMENT (std cc/sec)	PASS/FAIL
1:00	1.0×10^{-7}	2.2×10^{-8}	Pass
3:00	1.0×10^{-7}	2.2×10^{-8}	Pass
5:00	1.0×10^{-7}	2.4×10^{-8}	Pass

9.6 Post-Test Inspection

All bolts on the inner vessel were found to still have the original torque value from the pre-test condition. After all tests were concluded the inner vessel blind flange and steel shot were removed. The inner vessel was inspected for any damage and none was noted. The inner vessel was also inspected to determine if there was any shift in the position of the vertical tube and no movement or shift was found. Data log sheets appear in Appendix F.

10.0 SUMMARY OF TEST RESULTS

The objective of this program was to conduct physical and fire performance evaluation tests of Century Industries' CI-1 shipping container for Nuclear Fuel Services in accordance with the Hypothetical Accident Conditions specified in Title 10 CFR Part 71.73 to verify the performance capabilities under the specified condition. The CI-1 shipping container was subjected to the