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Using an Adapter to Perform the Chalfant-Style Containment Vessel Periodic Maintenance Leak-Rate Test

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Abstract

Recently the Packaging Technology and Pressurized Systems (PT&PS) organization at the Savannah River National Laboratory was asked to develop an adapter for performing the leak-rate test of a Chalfant-style containment vessel. The PT&PS organization collaborated with designers at the Department of Energy's Pantex Plant to develop the adapter currently in use for performing the leak-rate testing on the containment vessels. This paper will give the history of leak-rate testing of the Chalfant-style containment vessels, discuss the design concept for the adapter, give an overview of the design, and will present results of the testing done using the adapter.

History

Chalfant-style containment vessels (CVs) have been in service in the radioactive materials packaging and transportation industry for over 20 years. Gordon Chalfant designed a vessel with a mating cone design that provides excellent sealing capabilities for vessels packages including those containing contents that have the potential for developing high pressure. The Chalfant-style cone-seal closure has been manufactured in various sizes (Figures 1 and 2). The closure incorporates two Viton GLT-S o-rings, in an inner and outer o-ring configuration, with the outer o-ring serving as the containment boundary[1].

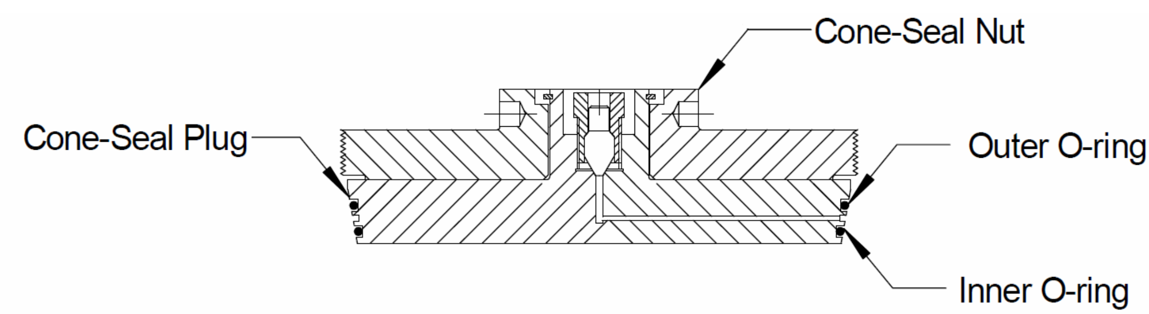

Figure 1 – Cross-Section of the Chalfant-Style Cone-Seal Closure Assembly

The double-o-ring design allows for the package to be leak-tested after assembly by evacuating the annulus between the two o-rings. The leak test may be either a rate of rise test or by a pressure decay test using 150 psig of nitrogen. This pre-shipment leak test assures that the package is assembled properly. However, since the existing safety bases require it, periodically the CV must be recertified to be leak-tight per the ANSI N14.5 requirements. This recertification is done using only the o-ring that is certified as part of the containment boundary for the CV. For all currently certified packages using this style closure, the outer o-ring is the containment boundary. The inner o-ring is removed from the CV for this test so that there is assurance that helium is present in the body of the vessel.

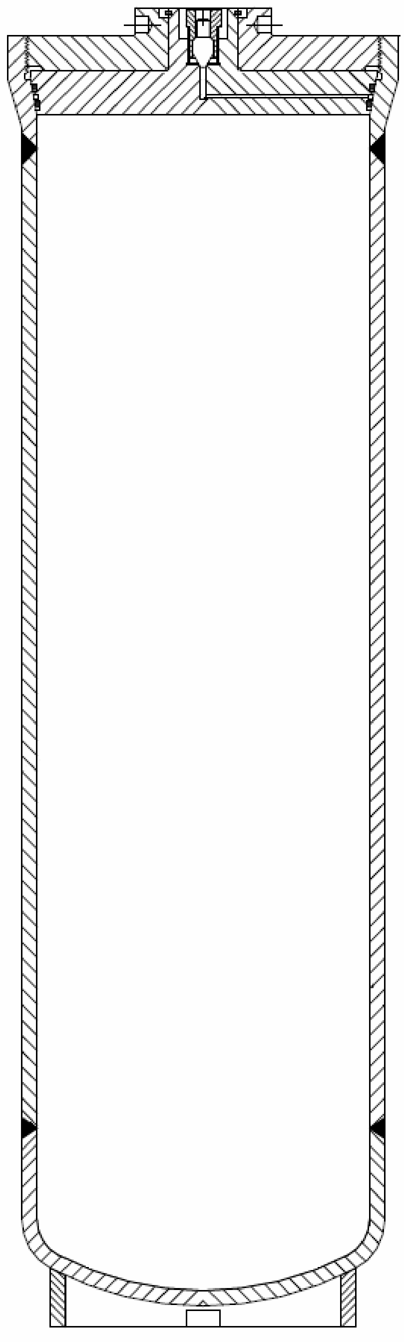

Figure 2 – Containment Vessel with a Chalfant-Style Closure

Radioactive material (RAM) packages used in the United States must be designed, reviewed, and certified to be in compliance with the regulations set forth in Title 10 of the Code of Federal Regulations Part 71 (10 CFR 71)[2]. Typically packages that ship RAM are designed to be leaktight per the ANSI N14.5 standard. This means that these packages, such as these designed with the Chalfant-style closure, will have a leakage rate less than 1 x 10^{-7} ref cm^3 air / sec[3].

Concept for the Adapter

Periodic maintenance testing on many Chalfant-style containment vessels is performed at the Savannah River National Laboratory (SRNL). The SRNL Packaging Technology & Pressurized Systems organization performs tests on the containment vessels for users throughout the DOE complex. Typically, SRNL uses the following steps to perform helium bell jar leak tests (a bell jar is an enclosed volume that can be evacuated in order to perform leak testing)[4]:

1. Install the closure assembly without the inner o-ring
2. Evacuate and backfill the CV with helium
3. Torque the closure assembly
4. Place the containment vessel in a close-fitting bell jar
5. Immediately start the leak test.

These steps must be performed quickly to complete the leak test before helium begins to permeate through the outer o-ring.

Due to rising transportation costs and the need to have the testing performed within a very short timeline (i.e., needing a quick turnaround), other DOE sites have the desire to perform periodic maintenance on the packages. The Pantex Plant in Amarillo, Texas, recently decided to seek authorization to perform the periodic maintenance testing of the H1700 Shipping Package, which incorporates a Chalfant-style closure. The Pantex Plant has bell jars and leak-testing equipment in use for other applications. Although they have high-quality equipment, the large size of their bell jar prevents the use of the SRNL leak test method. Helium permeates through the o-ring before the containment vessel can be loaded into the bell jar and the bell jar evacuated to a vacuum. Thus, Pantex was unable to perform a valid leakage rate test on the H1700 CV using the SRNL method. In order to perform a valid test, the Pantex Plant and SRNL developed an adapter that allows the containment vessel to be evacuated and filled with helium while inside of the bell jar.

Design of the Adapter

The design of the adapter is an insert that incorporates the female threaded closure side of the CV body on the top end and the plug and male threaded portion of the CV closure assembly on the bottom end (see Figures 3 and 4). The adapter also has a fill port with standard fittings for evacuating and backfill purposes. The fill port attaches via a hose on the inside of the bell jar for evacuating the adapter and backfilling with helium. The adapter has two o-rings on the vertical throat between the plug and the nut portion of the adapter. These o-rings provide the necessary sealing between the CV body and the helium detector. The design allows for the evacuation of the bell jar prior to filling the CV with helium. This prevents helium permeation through the o-rings prior to obtaining acceptable leak-test results. Figure 3 shows a detail from the drawing of the adapter and Figure 4 shows an isometric view. Figure 5 is an illustration of the adapter installed in a CV.

The adapter is constructed of both brass and Nitronic-40 steel. The bottom of the adapter that serves as the plug for the CV body is made of brass and the rest of the adapter is machined from a bar of Nitronic-40. The port incorporates standard Swagelok fittings.

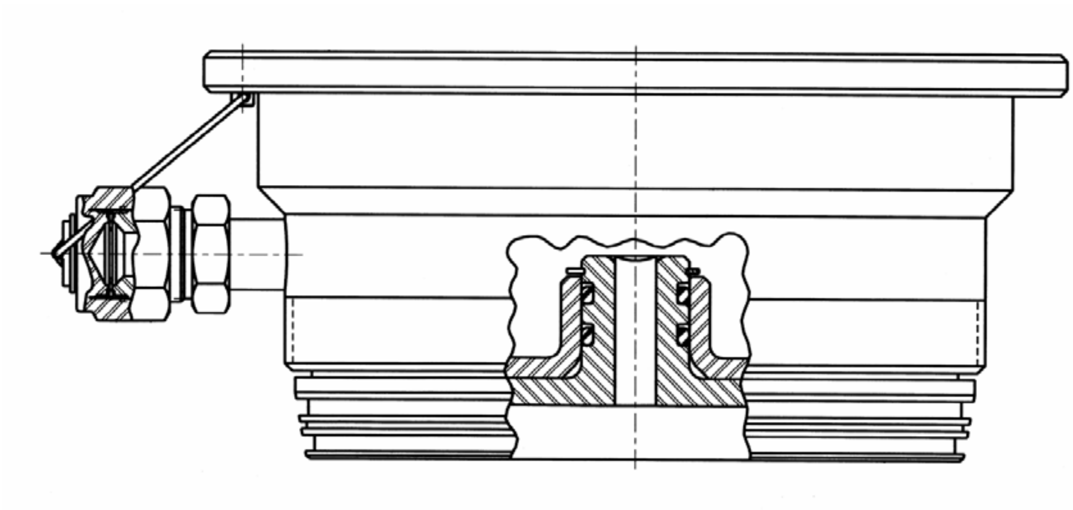

Figure 3 – Detail Drawing of the Adapter

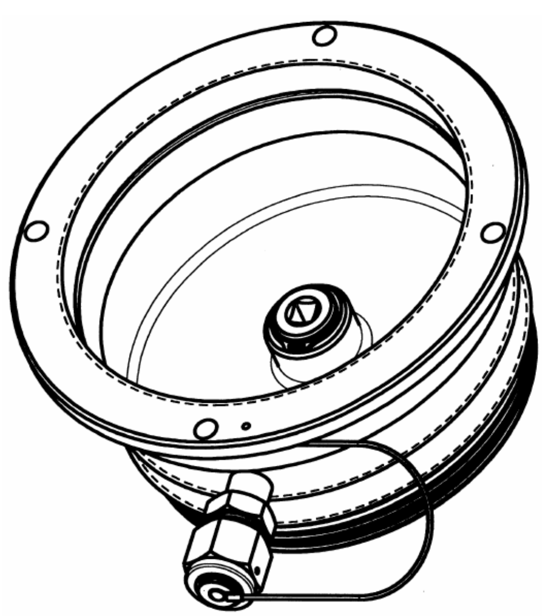

Figure 4 – Isometric Illustration of the Adapter

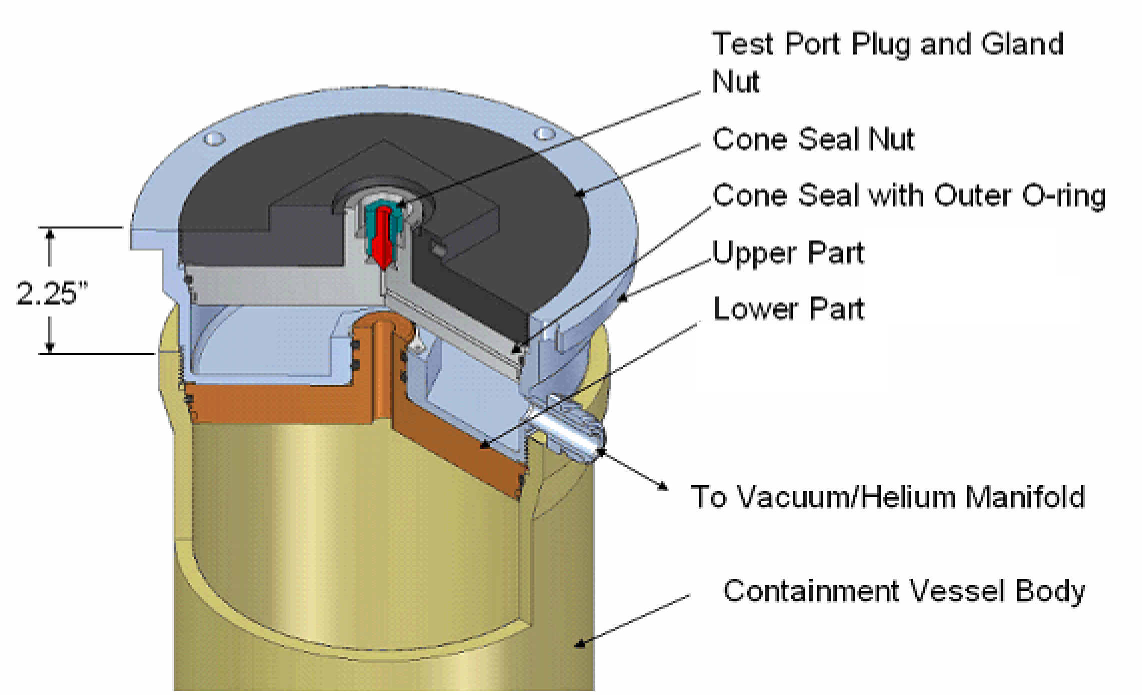

Figure 5 – Adapter Installed onto the CV

Testing the Adapter

The first two adapters were manufactured for the Pantex Plant. In order to qualify the adapter for use in the periodic maintenance/recertification application, the DOE NNSA certifying authority required an ASNT Level III Leak Test Engineer approve the design and verify the ability of the design to perform its function. The Level III Leak Test Engineer at SRNL obtained one of the adapters from Pantex and began testing the adapter in the SRNL High Pressure Laboratory. Figure 6 shows the High Pressure Laboratory apparatuses used in this testing. Figure 7 shows the results of the leakage-rate test obtained during the evaluation of the adapter.

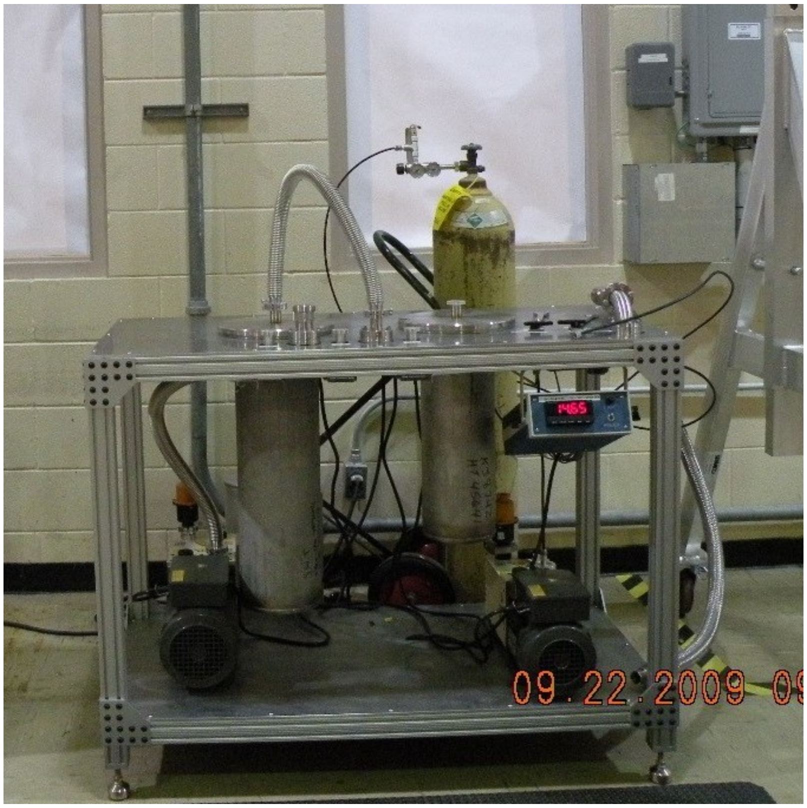

Figure 6 – Leak Test Stand in SRNL

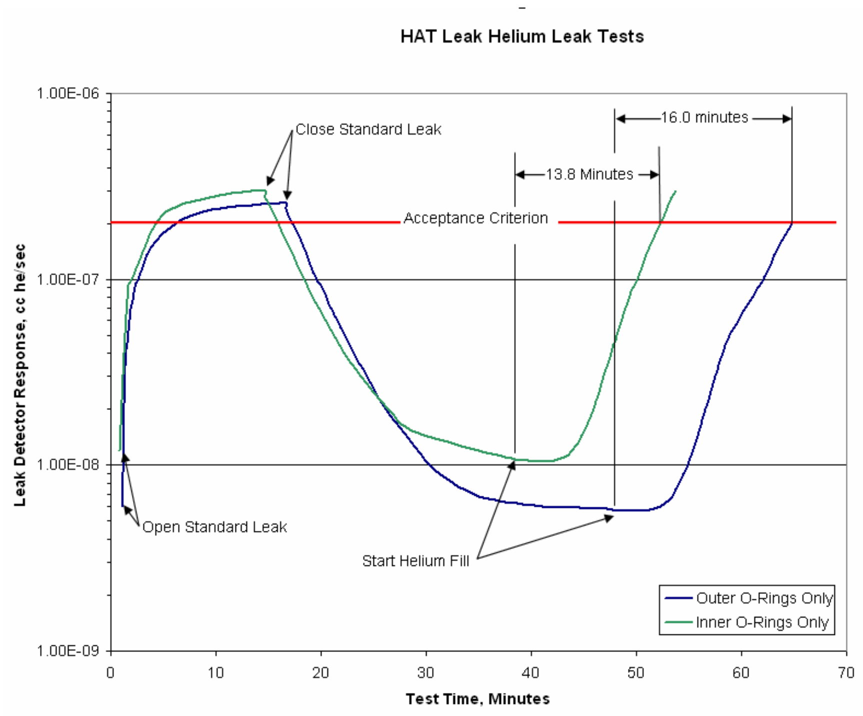

Figure 7 – Leakage-Rate Curves for Adapter Using Both Inner and Outer O-Rings

Summary and Conclusions

The adapter performed very well during testing. SRNL PT&PS personnel visited the Pantex Plant to witness testing of the adapter. The adapter allowed Pantex to evacuate the bell-jar prior to filling the CV with helium and thus prevent permeation through the o-ring prior to obtaining acceptable leak-test results. The SRNL Level III Leak Test Engineer approved the use of the adapter for performing periodic maintenance on the CV within the H1700 shipping package. The Pantex Plant will be using the adapter for this purpose.

To summarize, the advantages of the adapter include:

- The testing of two o-rings simultaneously, thus allowing for two certified o-rings installed into the containment vessel
- Eliminating "false negatives" of a leaking inner o-ring during the pre-shipment test
- Preventing a "rush" necessary to close the CV, evacuate the CV, fill the CV with helium, emplace the CV in the bell jar, evacuate the bell jar, and begin the test all before helium permeates through the o-ring. Rushing can lead to injury or missing key steps in the testing.
- The ability to qualify either the outer or the inner o-ring as the containment boundary.
- The design is adaptable to other size Chalfant-style CVs.

Future Recommendations and Considerations

The adapter is not currently in use for other Chalfant-style containment vessels (e.g., 9975 Secondary and Primary Containment Vessels, 9977 6CV, 9978 5CV). The success of the adapter in performing periodic maintenance should allow for the use of the adapter in performing the periodic maintenance for all Chalfant-style containment vessels. Additionally, the 9977 Shipping Package, on which the 9978 and H1700 Shipping Packages are based, utilized a modified CV in the regulatory testing phase. This modified CV was tested and qualified as leaktight with the inner o-ring as the containment boundary as opposed to the outer o-ring. Due to review questions during the certification of the 9977, the 9977 reverted back to using the outer o-ring as the containment boundary and using helium bell jar leak tests for acceptance testing and for periodic maintenance in order to certify that the CV meets the leak-tight requirements of ANSI N14.5. One of the concerns of the Technical Review Team was how to test the CV with the inner o-ring installed and ensuring that helium was getting into the vessel. A technique was developed for installing helium into the CV, however due to the concerns of the Technical Review Team it was not employed in the certification. This new adapter, on the other hand, allows for the CV to have helium installed into the vessel. With the use of the adapter for certifying the container during the periodic maintenance period, the Chalfant-style CVs can use the inner o-ring as the containment boundary. The use of the inner o-ring will eliminate one of the two post-loading tests performed on the CV, will save time, increase ALARA, and simplifies the containment boundary.

References

1. Abramczyk, G., Model H1700 B(M)F-96 Safety Analysis Report for Packaging, S-SARP-G-00005, Revision 0, May 2010.

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3. *American National Standard for Radioactive Material - Leakage Tests on Packages for Shipment*, ANSI N14.5, American National Standards Institute, Inc., 1997.

4. Trapp, D. J. and Crow, G. L., Analysis of the ANL Leak Test Method for 6CVS Containment Vessels, SRNL-STI-2010-00672.