

LEAKAGE TESTING OF PACKAGINGS WITH THREE-O-RING CLOSURE SEALS

J. J. Oras (1), R. H. Towell (2), and M. E. Wangler (3)

- (1) Argonne National Laboratory, 9700 S. Cass Ave., Argonne, IL 60439-4825 USA
(2) Eagle Research Group, Inc., 13241 Executive Park Terrace, Germantown, MD 20874 USA
(3) U.S. Department of Energy, Office of Transportation, Emergency Mgmt. & Analytical Services, EM-76, Cloverleaf Bldg., 19901 Germantown Rd., Germantown, MD 20874 USA

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SUMMARY

Both the American National Standard for Radioactive Materials - Leakage Tests on Packages for Shipment (ANSI N14.5) - and the ISO 12807:1996 Safe Transport of Radioactive Materials - Leakage Testing on Packages - provide guidance for leakage rate testing to show that a particular packaging complies with regulatory requirements; both also provide guidance for determining appropriate acceptance criteria. Recent radioactive packaging designs have incorporated three-O-ring closure seals, the middle O-ring being the containment seal. These designs have the potential for false positive results in leakage rate tests. The volume between the containment O-ring and the inner O-ring is used for the helium gas required for the leakage rate tests, in order to reduce both the amount of helium used and the time required to conduct the tests. A leak detector samples the evacuated volume between the outer O-ring and the containment O-ring. False positive results can have two causes: a large leakage in the containment seal or leakage in the inner seal. This paper describes the problem, together with possible solutions and areas that should be addressed in a Safety Analysis Report for Packaging (SARP) before a particular packaging design can be certified for transport. Ultimately, the SARP should provide justification that the requirements for leakage rate testing procedures, including the length of time needed to conduct the tests, will ensure that the containment closure seal is properly tested.

INTRODUCTION

Most Type B packagings used to transport radioactive contents employ a set of two nested O-rings in the closure seal to facilitate the leakage rate testing of the containment boundaries, as recommended in ANSI N14.5 to demonstrate compliance with title 10, part 71 of the Code of Federal Regulations. A small annular volume is created between the outer O-ring and the

containment O-ring being tested. Recent large packagings, such as the TRUPACT II Shipping Package and the RH-TRU 72-B Waste Shipping Package, incorporate three O-rings in their closure seals for the inner containment boundaries. The additional inner O-ring is used either to protect the containment O-ring from grit from the contents which could cause the O-ring to not seal properly during transport, or to limit the amount of helium required to conduct a leakage rate test by defining a volume much smaller than the contents cavity. The concerns caused by the addition of the inner O-ring to the more common set of two nested O-rings will be discussed, together with possible means of addressing these concerns in a SARP. An effort has been made in the DOE certification process to reduce the information requested by the SARP reviewers to that required to show compliance with the applicable regulations and to verify that the contents are safe to ship in the particular packaging. As a result, the cost of certifying the package would be minimized for the applicant. Description of the leakage test procedures, however, is shown to be one area in which the details of the procedures must be presented for evaluation.

DESCRIPTION OF CONCERNS

Figures 1-3 are schematic diagrams for the RH-TRU 72-B Waste Shipping Package of a typical closure and the upper seal test port arrangement, the gas sampling port arrangement, and the backfill port arrangement, respectively. The gas sampling port is used when loading a shipment for ease of lid installation and is used as a sampling port when receiving a shipment. The backfill port is used to backfill the region between the containment O-ring and the inner O-ring with helium. The seal test port is used to pull a vacuum on the annular volume between the containment O-ring and the outer O-ring of the closure seal. The evacuated gas is sampled by a mass spectrometer to determine the leakage rate of helium. Failure of either the inner O-ring of the closure seal (Figure 1) or the inner O-ring of the gas sampling port (Figure 2) would release the helium backfill into the package cavity (where the contents are located), diluting the helium with air.

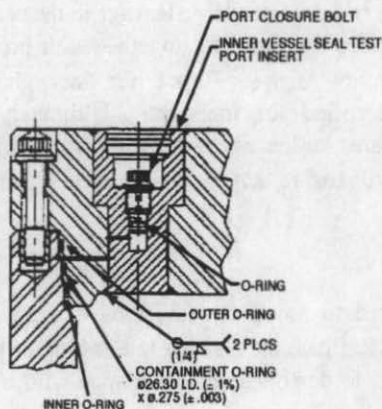


Figure 1. Upper Seal Test Port Arrangement

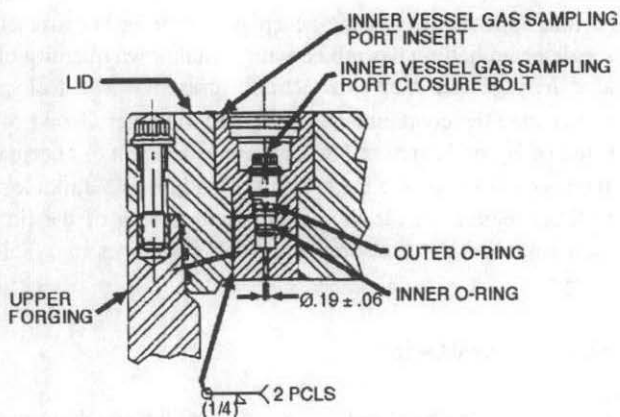


Figure 2. Gas Sampling Port Arrangement

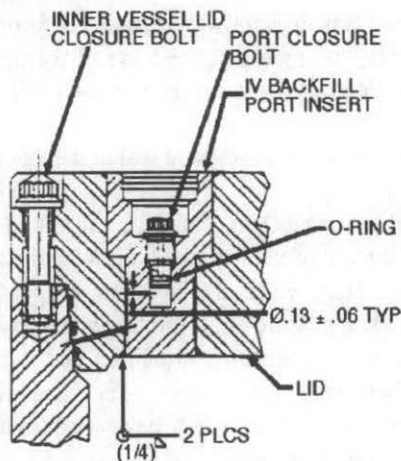


Figure 3. Backfill Port Arrangement

The gas sampling port insert and the backfill port insert are designed for leakage-rate testing of the seal of the containment boundary, specifically the outer O-ring of the gas sampling port and the O-ring of the backfill port, once the port closure bolts are tightened. The outer O-ring of the gas sampling port is the containment seal, while the inner O-ring provides a barrier between the contents cavity and the containment O-ring of the lid closure.

The concern is that the procedures in the SARP for the RH-TRU 72-B Waste Shipping Package do not preclude false positive results of the leakage rate tests of the containment O-ring, i.e., that

the measured leakage rate appears to pass the acceptance criteria because either no helium is detected or because the detected helium has mixed with an unknown quantity of air, resulting in a much smaller indicated leakage rate than was actually present. The leakage test procedures require that the region between the containment O-ring and the inner O-ring of the lid closure be evacuated to either 1 mm of Hg or 52 mm of Hg for the preshipment or acceptance leakage tests, respectively. Then, the procedures require the backfill of helium to 1 atm, closure of the backfill port, and evacuation of the region outside the containment O-ring of the lid closure seal by a roughing pump for the helium leak detector prior to actual leakage testing. False positive results can be caused in two ways:

- A large leakage in the containment O-ring

If there is a large leak in the containment seal, evacuation by the roughing pump could pull the limited amount of helium in the annular volume between the containment and inner O-rings past the containment O-ring before the vacuum required by the helium leak detector is established and the leak detector is functioning. This concern could be eliminated if the source of helium was the entire contents cavity or if the leak detector was operating before the backfill with helium. Filling the entire contents cavity may be impractical because of the time and resulting cost associated with pulling a vacuum on the large cavity volume before backfilling with helium.

- Leakage in either the inner O-ring of the closure seal or the inner O-ring of the gas sampling port

If there is a leak in either the inner O-ring of the closure seal or the inner O-ring of the gas sampling port, the limited amount of helium could mix with the air in the package cavity (where the contents are located). Thus, when the leak detector is pulling a vacuum outside the containment seal, it would see a mixture of air diluted with a small amount of helium, instead of pure helium. The leak detector is sensitive to helium and thus would indicate a leak that is smaller than the actual air/helium mixture leakage. This concern could also be eliminated if the source of helium was unlimited, e.g., if the whole cavity inside containment is filled with helium. Once again, filling the entire contents cavity may be impractical. This concern could also be eliminated if the leakage rate past the inner O-ring was measured and determined to be negligible before the containment O-ring is tested. This could be accomplished by backfilling helium into the annular region between the containment O-ring and the inner O-ring and pulling a vacuum on the contents cavity through the gas sampling port. However, the large contents cavity would have to be evacuated, which may also be time-consuming and therefore costly. The applicant for a packaging certification should justify in the SARP that the inner O-ring will maintain an essentially pure volume of helium tracer in the annular region between the containment O-ring and the inner O-ring/contents cavity during the leakage rate testing of the containment boundary O-ring.

SARP writers frequently indicate, especially for new packaging designs that have not yet been built, that if qualified leaktesters, e.g., Level II or Level III, perform the leakage rate tests, the

tests will somehow always be done correctly. The SARP writers sometimes indicate that qualified leaktesters need a package built before the appropriate leakage testing procedures can be determined. The authors have examined Section V of the ASME Boiler and Pressure Vessel Code, ANSI/ASNT CP-189, the Nondestructive Testing Handbook and the Annual Book of ASTM Standards for the specific training required of Level II or Level III qualified leaktesters and could not find training that would address the specific concerns presented in this paper. As for new packaging designs, the SARP should be written with input from the qualified leaktesters and, if changes must be made after a package is built, a request for an addendum to the certificate of compliance should be submitted to the DOE certifying official. An argument is also frequently presented that evacuation of the annular seal region to 52 mm Hg demonstrates that the seals are functioning properly. However, all this actually shows is that the vacuum pump can evacuate the annular region at a rate greater than the leakage rate through the O-rings forming the annular region. Thus, the length of time required for conducting the leakage rate tests may be important for the particular packaging design. The SARP should provide justification that the requirements for leakage rate testing procedures, including the length of time needed to conduct the tests, are proper to ensure that the containment closure seal is properly tested.

As mentioned earlier, an effort has been made in the DOE certification process to reduce the amount of information requested by the SARP reviewers to that required to show compliance with the applicable regulations and to verify that the contents are safe to ship in the particular packaging. As a result, the cost of certifying the package would be minimized for the applicant. Description of the leakage test procedures, however, has been shown in this paper to be one area in which the details of the procedures must be presented for evaluation.

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