



**EM Environmental Management**

safety ❖ performance ❖ cleanup ❖ closure

**DOE Packaging Certification Program**

**Safety Evaluation Report to  
Amend Certificate of Compliance Number 9315 for Periodic  
Leakage Rate Test Alternate Frequency**

**Docket No. 16-45-9315**

Prepared by:

James M. Shuler

Date:

7/25/19

James M. Shuler  
Manager, Packaging Certification Program  
Office of Packaging and Transportation

Approved by:

Joanne D. Lorence

Date:

07/24/2019

Joanne D. Lorence  
Headquarters Certifying Official  
Director  
Office of Packaging and Transportation

# SER for Request to Amend Certificate of Compliance Number 9315 for Periodic Leakage Rate Test Alternate Frequency

Docket 16-45-9315

---

This Safety Evaluation Report (SER) documents the U.S. Department of Energy (DOE) Packaging Certification Program (PCP) independent technical review of the application submitted by the National Nuclear Security Administration (NNSA) Office of Material Management and Minimization (NA-23) to amend DOE Certificate of Compliance (CoC) Number 9315 to approve an alternate frequency, from 12 months to 24 months, of the periodic leakage rate test of the Model ES-3100 package containment system with ethylene propylene diene rubber (EPDM) O-rings (seals).

The current edition of the American National Standard *For Radioactive Materials — Leakage Tests on Packages for Shipment*, N14.5-2014 (ANSI N14.5-2014), states in Section 7.5.2, *Frequency*, for the *Periodic Leakage Rate Test* (Section 7.5), “Periodic leakage rate testing shall be performed within 12 months prior to each shipment, unless an alternate frequency is justified and approved by the applicable regulatory authority.” As a result of this change to ANSI N14.5, DOE PCP will review requests to extend the periodic leakage rate test frequency beyond 12 months prior to shipment for DOE certified package designs on a case-by-case basis and will recommend approval by the Headquarters Certifying Official if the applicant provides a sufficient basis of seal performance, e.g., test, a technical basis, and performance evidence, to demonstrate that the proposed alternate frequency is appropriate for the seal and its performance environment.

## Evaluation

By letter <sup>[1]</sup> dated September 8, 2016, as supplemented <sup>[2,3]</sup> June 15, 2018 and July 11, 2019, NA-23 submitted a request to amend DOE CoC 9315 for the Model ES-3100 package to extend the periodic leakage rate test interval of the package containment system with EPDM O-ring seal from 12 months to 24 months. The initial application, Revision 2 of the ES-3100 Safety Analysis Report for Packaging (SARP) <sup>[4]</sup> and supplement in support of this request, was prepared and submitted for NA-23 by Consolidated Nuclear Security, LLC, the Management and Operating Contractor for the Y-12 Plant. The SARP, as supplemented, implemented the changes to the periodic maintenance frequency and also included minor changes in Sections 7.1.1.2 and 8.2.5.6 to add rejection criteria for inspection of the silicone rubber pads (CoC Drawing M2E801580A009, Revision D) during operations and periodic maintenance.

The methods used by the applicant to support this change to the frequency of the periodic leakage rate test and demonstrate compliance with 10 CFR Part 71 are a combination of testing and analysis-by-comparison to similar seal applications and their performance environment. The SARP, as supplemented, relies on *ES-3100 Containment Vessel (CV) O-rings Life Extension Testing*, RP 801580-0022 000 01 <sup>[5]</sup> and its key references (References, page 61) for the technical justification to implement this change; consequently, this SER will focus on PCP staff’s review

and confirmatory evaluation of the RP 801580-0022 000 01, and implementation of the change in the applicable SARP chapters.

The effects of radiation on EPDM O-ring material were previously evaluated in Section 2.2.3 of the SARP. Based on the *Parker O-Ring Handbook* (SARP References Section 2), practically all elastomers suffer no change of their physical properties at a cumulative dose up to  $1 \times 10^6$  rad. Based on the calculated dose rate of 0.5 rad/hr. (SARP Sect. 5.4.4), the maximum cumulative dose for the containment boundary O-ring location would be  $<1 \times 10^4$  rad for an exposure period of 2 years. Since this maximum cumulative dose for the containment boundary O-ring is well below the  $1 \times 10^6$  rad threshold, the applicant provided reasonable assurance there will be no significant degradation of the O-ring material properties due to irradiation.

### **Testing Results**

RP 801580-0022 000 01 contains data from air (preshipment) and helium (periodic) leakage rate tests performed by Y-12 on twenty Model ES-3100 packagings removed from storage. Sixteen of these packagings are new and unused and four packagings are used. The sixteen new packagings were in storage at least seven years and the four used packagings were in storage for four years prior to removal for testing. The leakage tests were conducted in ambient conditions. Test results show that all 4 used packagings passed leakage rate tests for both air (leakage rate  $<1.0 \times 10^{-4}$  atm-cc/s) and helium (leak rate  $<1.9 \times 10^{-7}$  cc/s). Three of the sixteen new packagings initially failed both air and helium leak rate tests. The report states:

*After the helium leak test failure, the test flange was removed. The inner CV O-ring and O-ring grooves were carefully examined. No debris, surface, or physical damage could be seen on the O-ring. No debris, moisture, or damage (scratches, nicks) was found in the CV grooves. No corrosion was found. The O-rings and O-ring grooves were wiped clean with alcohol and a lint free cloth. A thin coat of Super-O-Lube was rubbed on the inner O-ring, and it was re-installed in the CV groove. The helium leak test was performed again, and the inner O-ring passed the helium test. The CV was then re-assembled; air leak tested, and passed this test also.*

The test report did not identify the root cause of the initial failure. The SARP includes provisions for retesting a CV when the failure cause is not apparent: Section 7.1.2.1, Step 7 addresses retesting a CV if the preshipment leakage test fails, and Section 8.2.2, Step 5 addresses retesting a CV if the periodic or maintenance leakage test fails. Retesting the three new CVs is consistent with the SARP.

### **Performance Environment**

The Model ES-3100 package is designed to ship radioactive material content with decay heat limit of 5 Watts. The normal service temperature range for the EPDM O-ring used in the containment boundary is  $-40$  to  $150^{\circ}\text{C}$  ( $-40$  to  $302^{\circ}\text{F}$ ). According to the thermal evaluation in SARP Tables 3.14 and 3.15, the maximum predicted temperatures of the containment boundary O-ring under Normal Conditions of Transport (NCT), at Node 6359, in the Tables are  $42.9^{\circ}\text{C}$  ( $109.3^{\circ}\text{F}$ ) and  $91.9^{\circ}\text{C}$  ( $197.36^{\circ}\text{F}$ ), respectively, in shade and with solar insolation in still air at  $37.8^{\circ}\text{C}$  ( $100^{\circ}\text{F}$ ).

### **Analysis by Comparison**

The applicant used aging studies, referenced in RP 801580-0022 000 01, of EPDM O-rings used in similar radioactive material package designs and other applications to perform an analysis-by-comparison with a similar package design to predict the performance of the ES-3100 containment boundary EPDM O-ring beyond 12 months.

The first aging study (Stefek, et., al.) examined the Model H1616: a drum-style package design with a containment boundary seals of EPDM O-rings. The O-rings were aged in H1616-1 CVs at temperatures ranging from  $71.1^{\circ}\text{C}$  ( $160^{\circ}\text{F}$ ) to  $148.9^{\circ}\text{C}$  ( $300^{\circ}\text{F}$ ). The CVs were helium leak tested and re-tested periodically depending on the aging temperature to determine if they continued to meet the ANSI N14.5 leak-tight criterion of a leakage rate less than or equal to  $1 \times 10^{-7}$  ref·cm<sup>3</sup>/s, of air at an upstream pressure of 1 atmosphere (atm) absolute (abs), and a downstream pressure of 0.01 atm abs or less.

The data show that at the O-ring aging temperature of  $71.1^{\circ}\text{C}$  ( $160^{\circ}\text{F}$ ) for up to 3 years, both inner and outer EPDM O-rings of the H1616-1 CV are leak tight in multiple helium leakage rate tests. The data also show that for an O-ring aging temperature of  $112.8^{\circ}\text{C}$  ( $235^{\circ}\text{F}$ ) for up to two years, both inner and outer EPDM O-rings of the H1616-1 CV are leak tight in multiple helium leakage rate tests. The H1616-1 CV test results bound the ES-3100 CV NCT temperatures calculated for the containment boundary O-ring of  $43^{\circ}\text{C}$  ( $109.4^{\circ}\text{F}$ ) in shade, and  $91.9^{\circ}\text{C}$  ( $197.4^{\circ}\text{F}$ ) with solar insolation.

A second study (Kömmling, et., al.) evaluated the influence of aging on the sealability of EPDM O-rings aged at four different test temperatures:  $75^{\circ}\text{C}$  ( $167^{\circ}\text{F}$ ),  $100^{\circ}\text{C}$  ( $212^{\circ}\text{F}$ ),  $125^{\circ}\text{C}$  ( $257^{\circ}\text{F}$ ), and  $150^{\circ}\text{C}$  ( $302^{\circ}\text{F}$ ) up to 1.5 years. The data show considerable degradation effects as demonstrated by hardness, compression stress relief (CSR) and compression set (CS). The leakage rate stays relatively constant, or even decreases, until shrinkage combined with the loss of resilience of the aged seal leads to leakage. Based on extrapolation of the testing data to  $60^{\circ}\text{C}$

## SER for Request to Amend Certificate of Compliance Number 9315 for Periodic Leakage Rate Test Alternate Frequency

Docket 16-45-9315

---

(140°F), the CS (which represents the recovery behavior of a seal after release from compression) would reach 50% in approximately 17 years. This result (17 years) is much longer than the request to revise the periodic leakage test interval on EPDM O-rings of ES-3100 from 12 months to 24 months.

Based on PCP staff's review of the application and confirmatory evaluation, the applicant provided reasonable assurance that the proposed alternate frequency is appropriate for the containment boundary seal in its performance environment and that extending the periodic leakage rate test frequency from 12 to 24 months does not affect the performance of the package or require a change to the packaging design or analysis results reported in the SARP, as supplemented.

Based on the statements and representations in the application, as supplemented, and PCP staff's confirmatory evaluation, this change to extend the periodic leakage rate test frequency from 12 to 24 months is acceptable and will provide reasonable assurance that the regulatory requirements of 10 CFR Part 71 have been met.

### **Conditions of Approval**

The 9315 certificate revision was changed from Revision 15 to Revision 16, with the following changes:

- Section 5(d)(12), Revised as follows: In addition to the requirements of Subparts G and H of 10 CFR Part 71, and except as specified in Section 5(d) of this certificate, each package must be fabricated, acceptance tested, operated, and maintained in accordance with the Operating Procedures requirements of Chapter 7, Acceptance Tests and Maintenance requirements of Chapter 8, and packaging-specific Quality Assurance requirements of Chapter 9 of the SARP, Revision 2, as supplemented.
- Section 5(d)(13), Revised as follows: Revision 15 of the certificate may be used until July 31, 2020. For export or import use of this package under a Department of Transportation Competent Authority Certification (CAC), previous revisions of this certificate may continue to be used until their expiration date, unless otherwise specified in the CAC.
- Section 5(d)(14), Revised as follows: This certificate (Revision 16) extends the periodic leakage rate test interval of the containment boundary from 12 months to 24 months.
- Section 5(e), Added (7) *Safety Analysis Report for Packaging, Y-12 National Security Complex, Model ES-3100 Package with Bulk HEU Contents*, SP-PKG-801940-A001, Revision 2, Page Change 2, July 11, 2019.
- Section 5(e), Added (8) *ES-3100 Containment Vessel (CV) O-rings Life Extension Testing*, RP-801580-0022 000 01, July 11, 2019.

## Conclusion

Based on the statements and representations in the application, as supplemented, and PCP staff's confirmatory evaluation, this change to extend the periodic leakage rate test frequency from 12 to 24 months is acceptable and will provide reasonable assurance that the regulatory requirements of 10 CFR Part 71 have been met, subject to the conditions above.

## References

- [1] *Request for Amendment to ES-3100 Certification of Compliance (CoC) USA/9315/B(U)F-96 (DOE), Revision 10, Docket No. 16-45-9315*, Letter from W. E. Kilmartin to James M. Shuler, September 8, 2016.
- [2] *Response to QIs for ES-3100 HEU 9315 SARP Amendment O-ring Life Extension, Docket 16-45-9315*, Letter from W. E. Kilmartin to James M. Shuler, June 15, 2018.
- [3] Safety Analysis Report for Packaging, Y-12 National Security Complex, Model ES-3100 Package with Bulk HEU Contents, SP-PKG-801940-A001, Revision 2, Page Change 2, Consolidated Nuclear Security, LLC, July 11, 2019.
- [4] *Safety Analysis Report for Packaging, Y-12 National Security Complex, Model ES-3100 Package with Bulk HEU Contents, SP-PKG-801940-A001 Revision 2, Consolidated Nuclear Security, LLC, September 8, 2016.*
- [5] *ES-3100 Containment Vessel (CV) O-rings Life Extension Testing, RP-801580-0022 000 01, Consolidated Nuclear Security, LLC, July 11, 2019.*