Safety Evaluation Report for Addendum 4 to the Safety Analysis Report for Packaging Model 9977 Justification for Use of the Radio Frequency Identification (RFID) System and Extension of Packaging Periodic Maintenance Interval

Docket No. 11-12-9977

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Summary

Addendum 4 to the Safety Analysis Report for Packaging (SARP)[1,2] Model 9977 and its previously approved addenda provide the changes in the SARP[2] that justify the use of the radio frequency identification (RFID) system and extension of packaging periodic maintenance interval for the 9977 shipping package. The currently authorized contents for Model 9977 are listed in Revision 10, U.S. Department of Energy (DOE) Certificate of Compliance (CoC) USA/9977/B(M)F-96 (DOE), dated May 2, 2011. There are no content or content configuration changes per Addendum 4. Addendum 4 addresses specific evaluations of the currently approved safety basis and justifications for using DOE ARG-US RFID tag for transportation and the extension of the packaging periodic maintenance interval.

The DOE ARG-US RFID system used for the Model 9977 packaging is described in the *Guide to the Radio Frequency Identification Monitoring System* (Models 9975, 9977, and 9978 Packages).[3]

It should be noted that an option to use the RFID system for the Model 9977 packaging has already been approved in Revision 10 DOE CoC, for which Condition (7) states, "If the option is chosen to attach a DOE MK-II RFID tag to the 9977 packaging, the operating procedures must follow the additional steps per Chapter 7 in Addendum [See 5(e)(5)], and the guide to RFID monitoring system [See 5(e)(6)]. The RFID guide contains a copy of the Material/Product Safety Data Sheet for the batteries used in the DOE MK-II RFID tag, which provides guidance on the safe use of the batteries."

It should also be noted that another DOE CoC, USA/9977/B(M)F-96 (DOE S/T-1), Rev. 1, dated October 29, 2010, approved the use of the RFID system for seven (7) Model 9977 packagings in storage and transportation, and it extended the packaging periodic maintenance interval from one (1) year to a maximum of two (2) years. Thus, the focus of the certification review of Addendum 4 was on the basis for extending the packaging periodic maintenance interval to a maximum of five (5) years.

Addendum 4 and the associated documents were submitted for certification review in January 2011. Eleven (11) Q1 questions were issued in 2011. Satisfactory responses to Q1s were incorporated into the SARP Addendum 4, Revision 5, in February 2012.

On the basis of the statements and representations in Addendum 4, Revision 5, to the 9977 SARP and the DOE Packaging Certification Program (PCP) staff's confirmatory evaluation as summarized in this Safety Evaluation Report (SER), DOE PCP finds the design and performance of the 9977 packaging and the use of the RFID system for extension of the periodic maintenance interval acceptable and will provide reasonable assurance that the regulatory requirements of 10 CFR Part 71, 49 CFR Part 173, and DOE Order 460.1C have been met.

DOE PCP has concluded that an additional condition [see 5(d)(10) in Revision 11 of DOE CoC] with six (6) sub-conditions for that additional condition will be added to the Revision 11 CoC as follows:

1. The maximum allowable radioactive decay heat rate for the 9977 package is 19 watts, except for extension of the packaging periodic maintenance interval, in which case the maximum allowable radioactive decay heat rate is limited to 15 watts.

2. The user shall verify the installation of proper O-rings (i.e., GLT vs. GLT-S) and record the date of installation, e.g., 9977/GLT (or GLT-S)/xx/xx/201x, in the memory of the ARG-US RFID tag.
3. During both use (loading, shipment, and unloading) and storage (loaded and empty) of the 9977 packaging, the containment vessel (CV) must remain sealed over the entire approved extended maintenance interval. In the event that operations require the CV to be opened, then the old O-rings shall be replaced with new O-rings, all the requirements for the extended maintenance interval described in the SARP Addendum 4 shall be complied with for the new O-rings, and the sealing time shall be re-initialized to zero.
4. The extension of the packaging periodic maintenance interval is to a maximum of five (5) years for the 9977 packaging using the Viton GLT O-rings; and to a maximum of two (2) years for the 9977 packaging using the Viton GLT-S O-rings as shown in Drawing R-R2-G-00042, Item 8. If the ongoing O-ring fixture long-term leak performance testing shows any GLT and GLT-S O-ring failures at 200^{o}F, notify the Headquarters Certifying Official within 72 hours.
5. The user of this CoC for extension of packaging periodic maintenance interval shall complete the prescribed training to become qualified and to be certified for operation of the RFID temperature monitoring system. The training course will be administered by Argonne National Laboratory on behalf of the Headquarters Certifying Official.
6. When a temperature-sensing DOE ARG-US RFID tag is attached to a 9977 packaging, it shall be verified to be functional in accordance with the Operating Procedures requirements of Addendum 4. If a failure of the RFID tag or the temperature recording system results in a loss of temperature data for a duration ≥72 hours, then the packaging shall have a Nonconformance Report issued against it and be tagged and segregated until the disposition of the Nonconformance Report has been approved by both the 9977 Design Authority and Headquarters Certifying Official.

1. GENERAL INFORMATION

Detailed packaging descriptions, drawings and contents of the 9977 packaging can be found in the SARP.[2] The 9977 packaging is a cylindrical drum-type container ≈36.1 inches in overall height, including the cover and lid, and ≈18.35 inches in overall diameter. The packaging consists of an outer drum assembly and a CV with a nominal inner diameter of six (6) inches.

The closure assembly of the CV consists of a Type 304L SS cone-seal plug, and a threaded cone-seal nut made from Nitronic 60 SS. The double (outer and inner) O-rings fit into the two O-ring grooves, which are machined in the face of the external cone-seal plug to complete the closure assembly. A leak-test port is incorporated into the cone-seal plug to provide a means of verifying proper assembly of the vessel closure. The containment boundary of the CV is formed by the vessel body weldment, the cone-seal plug, the cone-seal port plug, and the outer O-ring.

The contents in of the 9977 package under Addendum 4 are not changed except for the decay heat rate, which is limited to 15 watts.

The DOE ARG-US RFID tag is ≈8 inches long, ≈7 inches tall, ≈1.5 inches thick, and it weighs ≈2 pounds. The RFID tag uses four (4) primary, (nonrechargeable), lithium-ion batteries to power a suite of sensors (e.g., temperature, humidity, shock, seal integrity, etc.);, although only the temperature sensor is of interest for the current application with regard to extending the periodic maintenance interval. The electronics boards and the RF antenna are enclosed in a plastic housing mounted to a metal backplate, with the seal sensor secured by a set of washers. The RFID tag is attached to the 9977 package by using one of the lid bolts. The tag is contoured to the Model 9977 drum curvature at ≈36°.

On the basis of the statements and representations in Addendum 4 to the 9977 SARP and the DOE PCP staff confirmatory evaluations, DOE PCP finds the general information (and drawings) presented in Chapter 1 of the SARP acceptable. DOE PCP has concluded that the following additional condition of approval needs to be added to Revision 11 of the CoC:

"The maximum allowable radioactive decay heat rate is 19 watts, except for extension of the packaging periodic maintenance interval, in which case the maximum allowable radioactive decay heat rate is limited to 15 watts."

Evaluations of the packaging's design and performance with regard to safety and regulatory compliance in structural, thermal, containment, shielding, criticality safety, operating procedures, acceptance tests, maintenance, and quality assurance areas are given in the remaining sections of this SER.

2. STRUCTURAL

2.1 Discussion

The DOE PCP staff reviewed Section 2 of Addendum 4 and Chapter 2 of the 9977 SARP to assess the information justifying the adequacy of the structural design and performance of the packaging for the proposed use of the RFID system and extension of packaging periodic maintenance interval. The review and evaluation focused on the effects of the RFID tag on the weight and structural performance of the package.

2.2 Structural Evaluation

The addition of the DOE ARG-US RFID tag (≈2 lb) to the 9977 package (gross weight 350 lb) does not significantly increase the total package weight. The maximum content weight and packaging configuration authorized are essentially the same as those evaluated in the 9977 SARP. The DOE ARG-US RFID tag is attached to the top lid of the 9977 packaging with one of the lid bolts; the tag thus has a minimum impact on the structural performance of the package. Both of the two worst-case loads for the closure bolts identified in Appendix 2.6 of the SARP are associated with the side drop, which will result in a lateral impact on the RFID tag and no direct impact on the bolt and closure reinforcement. For other structural tests, the addition of the RFID tag was determined not to adversely affect the structural performance of the packaging under either normal conditions of transport (NCT) or hypothetical accident conditions (HAC). Therefore, the structural performance of the package, as documented in the 9977 SARP, is valid with an attached DOE ARG-US RFID tag.

2.3 Conclusion

On the basis of the statements and representations in Section 2 of Addendum 4 to the 9977 SARP and the DOE PCP staff confirmatory evaluations, DOE PCP finds the structural design and performance of the 9977 packaging presented in Chapter 2 of the 9977 SARP and Section 2 of Addendum 4 acceptable and will provides reasonable assurance that the regulatory requirements of 10 CFR Part 71 have been met.

3. THERMAL

3.1 Discussion

The DOE PCP staff reviewed Section 3 of Addendum 4 and Chapter 3 of the 9977 SARP to assess the information justifying the adequacy of the thermal design and performance of the package for the proposed use of the RFID system and extension of packaging periodic maintenance interval. The DOE PCP staff also performed confirmatory thermal analysis to evaluate the O-ring temperatures as a function of the content's heat load and ambient temperature conditions.

3.2 Thermal Evaluation

The DOE ARG-US RFID tag is attached to the exterior of the 9977 drum with an air gap between it and the drum surface. This configuration will mitigate the direct thermal effects to the drum and block the solar flux during NCT. Owing to its small size and mass, and to the small amount of heat generated by the four size-A lithium batteries, the RFID tag will not affect the thermal performance of the 9977 package. In addition, this configuration separates the combustion source of the batteries and ABS (acrylonitrile, butadiene, styrene) plastic of the tag from the outer drum by the air gap, so that the combustible mass of the tag will not create any significant combustion source in HAC such as a fire event. The addition ofAdding the RFID tag does not significantly affect the previous thermal analysis or the component temperatures under both either HAC and or NCT. Therefore, the thermal design and performance of the 9977 package, as documented in the 9977 SARP and summarized below, is valid with an attached RFID tag.

The DOE PCP staff also performed confirmatory thermal analysis using the Abaqus finite-element ABAQUS code to evaluate the 9977 O-ring temperatures with varying content heat loads and ambient temperature conditions, to ensure that the maximum O-ring temperature is less than 200ºF, which is a conservative temperature limit for the Viton GLT and GLT-S O-ring

during the extended packaging periodic maintenance interval.

3.2.1 Model Validation

A thermal test was performed on a prototype 9977 package by the applicant. The prototype was subjected to a fixed ambient temperature of 100°F in an environmental chamber and a 19-watt internal heat load for 140 hours. The component temperatures at different locations in the package were recorded by thermocouples. In the Abaqus Abaqus validation, a two-dimensional (2D)-axisymmetric thermal model was developed by employing the same conditions (i.e., heat source, material configuration, initial and boundary conditions) as those used in the thermal test. Heat transfer between the package exterior and the ambient air was modeled as a combination of radiation and natural convection. Heat transfer across the gaps inside the package was modeled as a combination of radiation and conduction by air. The finite-element model produced results that were in reasonable agreement with the test data; the differences between the calculated and the measured temperatures were within –2% to +8%.

3.2.2 Evaluation of O-Ring Temperature

The O-ring temperature of the 9977 package was evaluated by the applicant (N.K. Gupta, *Thermal Evaluation of 9977 Package O-Rings under Varying Thermal Loading and Ambient Temperature Conditions*, M-CLC-A-00339, September 2008). The DOE PCP staff performed a confirmatory analysis, by using the validated thermal model in Abaqus ABAQUS, to verify that the O-ring temperature would not exceed 200°F for a combination of decay heat loads and ambient temperatures shown in Table 3.1 during the extended packaging periodic maintenance interval. For a given decay heat load, there is a corresponding ambient temperature limit above which the calculated O-ring temperature will exceed 200°F. These ambient temperature limits are used as alarm thresholds for the RFID temperature monitoring system so that excessive temperatures will be recorded as a violation event.

Table 3.1 Calculated O-Ring Temperatures with Varying Decay Heat Loads and Ambient Temperatures*

Decay Heat (watts)	Ambient Temperature (°F)	O-Ring Temperature (°F)
19	100	198.51
17	110	197.13
15	125	200.88
13	135	200.42
10	150	199.96
7	160	195.03
5	175	199.72
2	185	194.92

*For conservatism, contents were assumed to be located near the top of the CV and close to the O-rings.

The results of the confirmatory analysis were in agreement with the calculated temperatures reported by the applicant. For the 9977 packages using the RFID system for extension of periodic maintenance interval, the maximum allowable decay heat is 15 watts, which limits the ambient temperature to 125°F (see Table 3.1). As an example, the highest ambient temperature recorded in one potential storage area of the 9977 packages at the Savannah River Site was 95°F

(35°C) during the summer. If content with a 15-watt decay heat load is located at the center of the CV (i.e., the actual configuration of the 9977 package) and the ambient temperature is 95°F, the calculated O-ring temperature is only 153°F. Therefore, the O-ring temperature of the 9977 package during the extended packaging periodic maintenance interval is expected to be lower than 200°F by a substantial margin.

3.3 Conclusion

On the basis of the statements and representations in Section 3 of Addendum 4 to the 9977 SARP and the DOE PCP staff confirmatory evaluations, DOE PCP finds the thermal design and performance of the 9977 packaging presented in Chapter 3 of the 9977 SARP and Section 3 of Addendum 4 acceptable and will provides reasonable assurance that the regulatory requirements of 10 CFR Part 71 have been met.

4. CONTAINMENT

4.1 Discussion

The DOE PCP staff reviewed Section 4 of Addendum 4 and Chapter 4 of the 9977 SARP to assess the information justifying the adequacy of the containment design and performance of the packaging for the proposed use of the RFID system and the extension of packaging periodic maintenance interval. The results of the containment review are discussed described below.

4.2 Containment Evaluation

The ARG-US RFID tag does not change or affect the 9977 packaging content, content configuration, or the CV. The ARG-US RFID tag does not increase the content within the CV or the evaluated maximum temperature or pressure in the CV. Therefore, the packaging containment design and performance as documented in the 9977 SARP is valid with an attached RFID tag.

4.3 Conclusion

On the basis of the statements and representations in Section 4 of Addendum 4 to the 9977 SARP and the DOE PCP staff confirmatory evaluations, DOE PCP finds the containment design and performance of the 9977 packaging presented in Chapter 4 of the 9977 SARP and Section 4 of Addendum 4 acceptable and will provides reasonable assurance that the regulatory requirements of 10 CFR Part 71 have been met. Extension of periodic maintenance interval is addressed in Section 8 of this SER.

5. SHIELDING

5.1 Discussion

The DDOE PCP staff reviewed Section 5 of Addendum 4 and Chapter 5 of the 9977 SARP. The effects of adding a RFID tag on the radiological safety of the 9977 packaging were evaluated, and the results of the shielding review are discussed described below.

5.2 Shielding Evaluation

The ARG-US RFID tag is attached to the exterior of the package drum as described in Addendum 4. The use of the ARG-US RFID tag on the 9977 package does not change or affect the contents, the content configuration, or the shielding function of the package. Therefore, the shielding performance of the package as documented in the 9977 SARP is valid with an attached

RFID tag.

5.3 Conclusion

On the basis of the statements and representations in Section 5 of Addendum 4 to the 9977 SARP and the DOE PCP staff confirmatory evaluations, DOE PCP finds the shielding design and performance of the 9977 package presented in Chapter 5 of the 9977 SARP and Section 5 of Addendum 4 acceptable and will provides reasonable assurance that the regulatory requirements of 10 CFR Part 71 have been met.

6. CRITICALITY

6.1 Discussion

The DOE PCP staff reviewed Section 6 of Addendum 4 and Chapter 6 of the 9977 SARP. The effects of adding a RFID tag on the criticality safety of the 9977 packaging were evaluated, and the results of the criticality review are discussed described below.

6.2 Criticality Evaluation

The ARG-US RFID tag (ABS plastic and stainless steel) in the interstitial space of the package array increases the isolation of and reduces the interaction among the array of packages. The effect on k_{eff} for NCT and HAC is small, since the ARG-US RFID tags occupy only a very small portion of the interstitial space. Therefore, the criticality performance of the package as documented in the 9977 SARP is valid with an attached RFID tag.

6.3 Conclusion

On the basis of the statements and representations in Section 6 of Addendum 4 to the 9977 SARP and the DOE PCP staff's confirmatory evaluations, DOE PCP finds the criticality design and performance presented in Chapter 6 of the 9977 SARP and Section 6 of Addendum 4 acceptable and will provides reasonable assurance that the regulatory requirements of 10 CFR Part 71 have been met.

7. PACKAGE OPERATIONS

7.1 Discussion

The DOE PCP staff reviewed Section 7 of Addendum 4 and Chapter 7 of the 9977 SARP. The results of the package operations review are discussed described below.

7.2 Package Operations Evaluation

For a package with an extension of the periodic maintenance interval, a specific ARG-US RFID tag (with a unique serial number) is installed after a new CV seal is installed and tested. Since this specific RFID tag is assigned to monitor a specific 9977 package, the tag and package shall remain together for the entire maintenance period through the use of a label on the tag (see Figure A.8.2, Addendum 4) that records the RFID tag/package serial number, the date the RFID tag is attached, the maximum allowable ambient temperature, and the maintenance expiration date. If the ambient temperature limit is exceeded at any time, action shall be taken by placing a "Do Not Operate" tag on the package and segregating it from the working inventory. A "Nonconformance Report" per SARP Section 9.15 shall be issued per SARP Section 9.8 and transmitted, along with the RFID data, to the Packaging Design Authority (Savannah River National Laboratory) and Argonne National Laboratory for disposition.

DOE PCP has concluded that an additional condition of approval needs to be added to Revision 11 of the CoC :

"When a temperature-sensing ARG-US RFID tag is attached to a 9977 packaging, it the tag shall be verified to be functional in accordance with the Operating Procedures requirements of Addendum 4. If a failure of the RFID tag or the temperature recording system results in a loss of temperature data for a duration ≥72 hours, then the packaging shall have a Nonconformance Report issued against it and be tagged and segregated until the disposition of the Nonconformance Report has been approved both by the 9977 Design Authority and Headquarters Certifying Official."

7.3 Conclusion

On the basis of the statements and representations in Section 7 of Addendum 4 to the 9977 SARP and the DOE PCP staff confirmatory evaluations, DOE PCP finds the operating procedure requirements presented in Chapter 7 of the SARP and Section 7 of Addendum 4 acceptable, and will provides reasonable assurance that the regulatory requirements of 10 CFR Part 71 have been met.

8. ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

8.1 Discussion

The DOE PCP staff reviewed Section 8 of Addendum 4 and Chapter 8 of the 9977 SARP, including the reference documents supporting the extension of packaging periodic maintenance interval. The normal maintenance procedures described in Chapter 8 of the SARP remain unchanged. Section 8 of Addendum 4 addresses the use of the RFID system for extending the packaging periodic maintenance interval from one (1) year to as long as five (5) years. Chapter 7 states, *"Periodic maintenance beyond 1 year is determined by the package contents (decay heat rate) and the ambient temperature of the package during use (loading, shipment, and unloading) and storage (loaded and empty).*"

Long-term sealing capabilities of Viton GLT and GLT-S O-rings are investigated by using Model 9975 primary containment vessel (PCV, 5-inch diameter) O-ring fixtures.[4,5] Seventy (70) tests using mock-ups of 9975 PCVs with GLT O-rings were assembled and heated to temperatures ranging from 200 to 450^{o}F. They were leak-tested periodically at room temperature to determine if they met the leaktightness criterion defined in ANSI N14.5-97. Fourteen (14) additional tests were initiated in 2008 in which GLT-S O-rings were aged at temperatures ranging from 200 to 400^{o}F.

Consideration was given to extending the periodic maintenance interval for the 9977 package beyond one (1) year, under the constraints that (a) the 9977 CV (6-inch diameter) remains unopened during its use and storage, and (b) the O-rings in the CV are kept at or below 200°F. Two issues were key to this consideration: (1) the applicability of 5-inch diameter O-ring sealing test data to 6-inch O-ring seals, the evaluation of which is summarized in Section 8.2 of this SER, and; (2) the long-term sealing capability of both the GLT and GLT-S O-rings that are used in the CV, the evaluation of which is summarized in Section 8.3 of this SER. Additional documents were included to aid in the evaluation of the long-term sealing capability of GLT and GLT-S O-rings.

Table A.8.1 of Addendum 4 (reproduced below as Table 8.1) lists the maximum allowable ambient temperatures as a function of the content's decay heat rate that must be maintained to limit O-ring temperatures at or below 200°F. This table applies to both use and storage. Addendum 4 specifies that ambient temperature conditions must be monitored continuously and certified by the user as being within the limits specified in Table 8.1. The necessary continuous monitoring of the ambient and package temperatures will be accomplished through the use of the ARG-US RFID system.

Table 8.1 Maximum Ambient Temperatures for Content Heat Load*

Content Decay Heat Rate (Watts)	Maximum Ambient Temperature (°F)
0	150
≤ 5	150
≤ 10	150
≤ 15	125

* For extending the Maintenance Period up to 5 years.

8.2 Applicability of 5-inch Diameter O-ring Sealing Test Data to 6-inch O-ring Seals

The 9977 CV has a nominal 6-inch-diameter O-ring, whereas the O-rings used in support of the extended maintenance interval were tested in nominal 5-inch-diameter test fixtures. The DOE PCP staff evaluated the applicability of 5-inch O-ring sealing data to 6-inch O-ring seals by considering the differences between 5-inch-diameter and 6-inch-diameter O-rings in (1) circumferential length and (2) O-ring groove filling.

The circumferential sealing length for a 6-inch-diameter O-ring is about 20% longer than that for a 5-inch-diameter O-ring. There was sufficient margin in the test data[5] showing that any higher leakage rate from the larger 6-inch-diameter O-ring would still be within the required ANSI 14.5 leaktightness limit. In addition, a 6-inch-diameter O-ring would be stretched less than a 5-inch-diameter O-ring and would thus fill the gland to a greater degree. The margins for the ANSI N14.5 leaktightness limit of 10^{-7} std cc He/sec, established with test data, are 250% for GLT and 459% for GLT-S, on average.

On the basis of the above evaluation, the DOE PCP staff concluded that the results for the 5-inch-diameter CV test fixtures[5] are applicable to the 6-inch-diameter CV of the 9977 package.

8.3 Long-term Sealing Capabilities of GLT and GLT-S O-rings

Baseline characterization work indicates that the GLT-S compound is comparable to GLT, with some minor variations.[6] The baseline tensile properties are slightly different, although they all meet Aerospace Material Specifications (AMS). The hardness (IRHD/M-scale) of GLT-S O-rings is slightly higher than that of GLT O-rings. The short-term compression stress-relaxation (CSR) behavior of the GLT-S O-rings at elevated temperature is improved over that of the GLT O-rings. Composition analysis indicates that the polymer structures of GLT and GLT-S are very similar, with some variations in additives. Glass transition temperature (T_g) values for GLT-S, as determined by dynamic mechanical analysis, are lower than those for GLT. The effects of gamma radiation doses to 50 Mrad on both compounds are similar.[6]

The DOE PCP staff evaluated the behavior of both types of O-ring materials by considering (1) seal failure data at higher temperatures and extrapolating those data to lower temperatures by

using the Arrhenius relationship, and (2) long-term seal integrity data at lower temperatures, where no leak failures have been detected to date.

Evaluation of Seal Lifetime for GLT O-rings

For GLT O-rings, applying conservative assumptions to the life-prediction analysis by using the Arrhenius life-temperature model resulted in a predicted lifetime of ten (10) years at 200°F.[6] However, a previous Sandia study[7] indicated that high-temperature data cannot be extrapolated with confidence to define the seal lifetime at lower temperatures.

By comparison, long-term leak performance data on 21 test fixtures aged at 200°F showed no failures for test periods ranging from 41 to 60 months, with an average of 54 months.[5] For all of these tests, the measured leakage rate for each test fixture at the maximum test time and room temperature was less than 10^{-7} std cc He/s.

On the basis of the above testing results for GLT O-rings, DOE PCP concluded that there is sufficient evidence to support an extended packaging periodic maintenance interval for use and storage of the 9977 package from 12 months to 6054 months at this time.

Evaluation of Seal Lifetime for GLT-S O-rings

For GLT-S O-rings, eight (8) test fixtures were aged between 350 and 400°F; all of them failed at times between 50 and 358 days. By applying conservative assumptions to the life-prediction analysis using the Arrhenius life-temperature model, the DOE PCP staff obtained a calculated lifetime of 7.84 years at 200°F. However, a previous Sandia study[7] indicated that high-temperature data cannot be extrapolated with confidence to define the seal lifetime at lower temperatures.

By comparison, long-term leak performance data on six (6) test fixtures aged at 200 to 300°F showed no failures for test periods ranging from 22 to 26 months.[5] For all of these tests, the measured leakage rate for each fixture at the maximum test time and room temperature was less than 10^{-7} std cc He/s.

On the basis of the testing results of the GLT-S O-ring tests, DOE PCP concluded that there is sufficient evidence to support an extended packaging periodic maintenance interval for use and storage of the 9977 package from 12 months to 242 months at this time.

8.4 Conclusion

On the basis of the statements and representations in Section 8 of Addendum 4 to the 9977 SARP and the DOE PCP staff confirmatory evaluations as documented in this SER, DOE PCP finds the acceptance tests and maintenance program presented in Chapter 8 of the SARP and Section 8 of Addendum 4 acceptable, except for the requested periodic maintenance interval of 60 months for both GLT and GLT-S O-ring seals.

As stated in Section 7 of Addendum 4 of the 9977 SARP, the periodic maintenance interval encompasses when the package is being used (i.e., when it is being loaded, shipped, and unloaded) and when it is being stored, either loaded with contents or empty. During both use and storage, as defined in Addendum 4, the CV must remain sealed over the entire approved extended maintenance interval. In the event that operations require the CV to be opened, then the old O-rings shall be replaced with new O-rings, all the requirements for the extended maintenance interval described in the SARP Addendum 4 shall be complied with for the new O-rings, and the sealing time shall be re-initialized to zero. In addition, the DOE PCP staff

evaluations of the GLT and GLT-S O-rings supports a periodic maintenance interval of 54 60 months for GLT O-rings and 242 months for GLT-S O-rings at this time. This will provides reasonable assurance that the regulatory requirements of 10 CFR Part 71 have been met.

In order to ensure the provision that the CV remains sealed over the entire approved extended maintenance interval and to ensure the proper use of the two types of O-rings, DOE PCP has concluded that three (3) additional conditions of approval need to be added to Revision 11 of the CoC, as follows:

"The user shall verify the installation of proper O-rings (i.e., GLT vs. GLT-S) and record the date of installation, e.g., 9977/GLT (or GLT-S)/xx/xx/201x, in the memory of the ARG-US RFID tag."

"During both use (loading, shipment, and unloading) and storage (loaded and empty) of the 9977 packaging, the CV must remain sealed over the entire approved extended maintenance interval. In the event that operations require the CV to be opened, then the old O-rings shall be replaced with new O-rings, all the requirements for the extended maintenance interval described in the SARP Addendum 4 shall be complied with for the new O-rings, and the sealing time shall be re-initialized to zero."

"The extension of the packaging periodic maintenance interval is to a maximum of five (5) years for the 9977 packaging using the Viton GLT O-rings; and to a maximum of two (2) years for the 9977 packaging using the Viton GLT-S O-rings as shown in Drawing R-R2-G-00042, Item 8. If the ongoing O-ring fixture long-term leak performance testing shows any GLT and GLT-S O-ring failures at 200^{o}F, notify the Headquarters Certifying Official within 72 hours."

9. QUALITY ASSURANCE

9.1 Discussion

The DOE PCP staff reviewed the requirements for the quality assurance (QA) program in Addendum 4 and Chapter 9 of the 9977 SARP. The results of the QA review are discussed described below.

9.2 Quality Assurance (QA) Evaluation

The ARG-US RFID tag is classified as a non-"Q" Item not related to safety, which does not require formal QA controls. The QA criteria applicable to the ARG-US RFID tag are those identified for other non-safety components. Therefore, the QA program as documented in the 9977 SARP and Addendum 4 is valid with an attached RFID tag.

DOE PCP concluded that an additional condition of approval needs to be added to the CoC pursuant to the approval of the Addendum 4 request:

"The user of this CoC for extension of the packaging periodic maintenance interval shall complete the prescribed training to become qualified and be certified for operation of the RFID temperature monitoring system. The training course will be administered by Argonne National Laboratory on behalf of the Headquarters Certifying Official."

9.3 Conclusion

On the basis of the statements and representations in Addendum 4 to the 9977 SARP and the DOE PCP staff confirmatory evaluations, DOE PCP finds that the QA requirements identified in Chapter 9 of the SARP and Addendum 4 adequately control the operational aspects of loading and shipping of the 9977 package with the ARG-US RFID tag. The information provided in Addendum 4 is acceptable and will provides reasonable assurance that the regulatory requirements in 10 CFR 71, Subpart H, have been met.

References

1. *Justification for Use of the Radio Frequency Identification (RFID) System and Extension of Packaging Periodic Maintenance Interval,* Safety Analysis Report for Packaging Model 9977, Addendum 4, S-SARA-G-00010, Revision 5, February 2012, Savannah River National Laboratory.

2. *Safety Analysis Report for Packaging Model 9977 Type B(M)F-96,* S-SARP-G-00001, Revision 2, August 2007, Savannah River National Laboratory.

3. *Guide to the RFID Monitoring System (Models 9975, 9977, and 9978 Packages),* ANL/DIS-09-5, December 3, 2009, Argonne National Laboratory and its Supplements.

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