AOS
Alpha-Omega Services, Inc.

April 28, 2021

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk / Mr. Pierre Saverot - STLB
Director, Division of Fuel Management – DFM
Office of Nuclear Material Safety and Safeguards - NMSS
11555 Rockville Pike
One White Flint North
Rockville, MD 20852

SUBJECT: AOS REQUEST TO AMEND CERTIFICATE OF COMPLIANCE 9316

USNRC Reference: EPID L-2021-LLA-0071, Docket No. 71-9316

AOS Reference: FM9006.1-042021-015

Mr. Saverot:

Alpha-Omega Services, Inc. (AOS) would like to request the amendment of Certificate of Compliance No. 9316. Our amendment request includes several minor changes, as described below.

1. Expand the justification of the radiation resistance of elastomeric seals in Section 2.2.3 “Effects of Radiation on Materials”. The revised justification relates specifically to the elastomeric cask lid seals.
2. Revise the pressure evaluation under NCT to include the slight pressure due to backfilling with Helium after leak testing. The new evaluation does not change the Design Pressure and therefore does not change the analyses that evaluate the effects of pressure inside the cask. This change affects pages in Chapters 1, 2, 3 and 4.
3. Revise Chapter 7, “Package Operations” and Chapter 8, “Acceptance Tests and Maintenance Program” to make some clarifications. The changes relate to leak testing and vacuum drying and are associated with our recent Part 71.95 report – being submitted concurrent with this request.

Attached for your review are the revised pages from SAR FM9054 Revision J-1 and the assiocated list of changes.

Best Regards,

Troy Hedger, President
Alpha-Omega Services, Inc.

Attachments:
SAR AOS-FM9054 Rev J-1 (21 pages)
List of Changes to SAR AOS-FM9054 (10 pages)

9156 Rose Street ● P.O. Box 789 ● Bellflower, California, U.S.A 90706
Customer Service (800) 346-7894 ● (562) 804-0604 ● Fax: (562) 804-0610
www.alpha-omegaserv.com

AOS-FM9054
Rev. J-1, April 20, 2021
(Docket No. 71-9316)

Radioactive Material Transport Packaging System

Safety Analysis Report

for Model AOS-025, AOS-050, and AOS-100 Transport Packages

Prepared by
Alpha-Omega Services, Inc.
Bellflower, CA

Revision	Date	Description of Changes
J	January 31, 2021	• Consolidation of Revisions H – H7 (Revision I intentionally skipped) • Subsection 1.2.2 and Section 7.1 – Clarified that the shoring materials are structural • Paragraphs 2.5.3.1.2 through 2.5.3.1.4 – Calculations revised to correct minor errors and typos • Subsection 2.6.7 – Removed stale note created in Revision H-5 • Figures 3-18 through 3-20 – Replaced thermal transient plots for AOS Model-025 fire condition • Figure 4-3 – Changed port cover torque requirement • Chapter 9 – Updated with current requirements, approval letter, and certificate • Updated *ANSI N14.5* references to 2014 edition • Applied miscellaneous corrections (table of changes included with cover page of the submittal)
J-1	April 20, 2021	• Revised Subsection 1.2.2 (added discussion related to cask loading temperature and backfilling pressure) • Revised Subsection 2.2.3 (expanded discussion related effects of radiation), Paragraph 2.6.1.1 (revised initial conditions for NCT pressure calculations), Table 2-31 and Table 2-54 (omitted footnotes b and c, respectively; updated calculated pressures); added new Reference **[2.35]** • Revised Subsection 3.2.2 (update calculated NCT pressures and elaborate on initial conditions and mechanisms that can increase internal cask pressure) • Revised Table 4-6 and Table 4-7 (omitted footnotes b and c, respectively; revised pressure calculations based on updated initial conditions) • Revised Paragraph 7.1.3.1 (revised instructions for wet-loading cask), Figure 7-4 (updated to reflect current equipment), and Paragraph 7.1.3.3 (revised leak testing procedure) • Revised Table 8-1 footnote (clarified test procedure sensitivity), Subsection 8.1.4 (revised fabrication leak testing requirements), Section 8.2 (removed statement regarding pre-shipment leak testing because this belongs in Chapter 7), Subsection 8.2.2 (updated leak testing requirements)

Radioactive contents are limited by the external radiation levels specified in *10 CFR 71.47* and *71.51* **[1.1]**, and *49 CFR 173.441* **[1.3]**. Exclusive-Use mode of shipment is required whenever the radiation dose rates of the package exceed the external radiation standards in *10 CFR 71.47(a)* **[1.1]** for non-exclusive use shipment. For Models AOS-100A and AOS-100A-S, when shipped as exclusive use, the activity limits for each isotope are specified in Table 1-2b.

There are no materials added to the package for the purpose of neutron absorption nor moderation. Radiation shields (that is, liners, axial shielding plates, and/or cavity spacer plates) are required in certain cases, as stipulated in Table 1-2, Table 1-2a, and Table 1-2b.

The construction materials of the AOS Transport Packaging System and their proposed contents are compatible with one another; no chemical nor galvanic reactions are expected to occur, including the generation of combustible gas.

The transport packages shall be loaded under ambient atmospheric pressure and temperature conditions. The cask may have a slight internal pressure due to backfilling with air or an inert gas and internal heating of the enclosed gases can increase the pressure. The cask is normally loaded at room temperature; however, for evaluating the temperature contribution to the pressurization of the cask cavity, the loading temperature will be conservatively assumed to be 50°F. The pressure inside the containment boundary is evaluated in Subsection 4.2.2.

The maximum gross weight of the AOS Transport Packaging System, including contents, is listed in Table 1-1.

The maximum decay heats, listed in Table 1-2, Table 1-2a, and Table 1-2b, are calculated using the constants presented in Chapter 5, "Shielding Evaluation."

The cask's fabrication process excludes any moisture (electrolyte) from being present within the cask. During shipment (jointed unit), the cavity must be dry, regardless of how it was loaded. If the cavity was loaded in water, the cavity must be vacuum-dried. Following this procedure eliminates the presence of the electrolyte, one of the factors for galvanic interaction. Refer to Paragraph 7.1.3.1, "Securing the Cask Lid," for the vacuum drying procedure.

Possible galvanic interaction is eliminated by controlling the potential difference for both permanent and temporary dissimilar metal joints, and by preventing the presence of an electrolyte, during fabrication and shipment.

2.2.3 Effects of Radiation on Materials

The AOS Transport Packaging System's cask component is comprised of the following construction materials:

- 300 series stainless steel (SS300), tungsten alloy or low carbon steel alloy for the cask body, cask lid, and cask lid plug components
- Nickel alloy for the cask lid attachment bolts
- Silver, nickel-chromium alloy, and stainless steel for the cask lid metallic seal
- Silicone material for the O-Rings used in the cask lid elastomeric seal and port cover

Of these materials, the one most affected by radiation is the silicone material. The port cover O-Ring components are not a part of the containment boundary and are used only to seal the port cover to prevent debris from entering the port plug area. Furthermore, these items are visually inspected for damage, deterioration, and wear, and are replaced as needed.

The cask lid elastomeric seal is part of the containment boundary and is exposed to gamma radiation that can cause compression set. The expected maximum dose rate in the cask lid seal region is 1 rad/hr. After one year of continuous use, this would result in a total dose of 1×10^4 rad. However, at a dose of 1×10^6 rads, the radiation effect on elastomers is minor. It is not until the radiation is delivered in doses within the range of 1×10^7 rad that radiation is a concern for O-Ring compounds (Reference **[2.35]**). Therefore, radiation is not a concern because the cask lid elastomeric seals are replaced after every 12 uses or annually, whichever comes first.

The impact limiters are constructed of 300 series stainless steel and polyurethane foam materials. The effect of radiation upon the stainless steel material is minimal. Also, according the manufacturer's data for the polyurethane foam (Reference **[2.13]**), its material does not incur any physical property changes when subjected to a maximum cumulative dose of 2×10^8 rads. Therefore, the impact limiters are not affected by radiation.

2.6.1.1 Summary of Pressures and Temperatures

Table 2-30 presents the maximum temperatures, throughout the transport package, resulting from Normal conditions of transport. The structural analyses are applied to the temperature field generated by the thermal analysis, to determine the thermal stresses.

Table 2-31 presents the pressure corresponding to the maximum temperature for each transport package model. These pressure values are based on air occupying the cavity volume. To calculate these pressures, the initial temperature is conservatively assumed to be 50°F and the initial pressure is assumed to be 4.5 psig, which is the maximum pressure to which the cavity will be backfilled after vacuum drying as per Paragraph 7.1.3.1. These pressures do not exceed the design pressure, which is also listed in Table 2-31. Therefore, the transport package can withstand pressures and temperatures in excess of those encountered in Normal conditions of transport.

Pressure-related Load Cases 201 through 204 are analyzed by the 2D cask model. Pressure is applied to the model's inside cask cavity wall or cask outside surface. The LIBRA LE -4[a] loading function is used to apply pressure loads. This function generates nodal forces in 2D models due to surface tractions along edge nodal lines. The nodal lines are defined by terminal nodes.

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a. *The LIBRA program's LE feature defines several types of edge and surface loadings. The first entry is a negative integer that distinguishes the type of loading. The types of loadings and nodal specifications are listed below, with former record types in parentheses.*

Options Available when Applying the "LE" Command

Type -1 *– General loading on nodes specified by numbering sequence.*

Type -2 *– General loading on arc defined by control points (LE1).*

Type -3 *– Surface pressure on arc defined by control points (LEP).*

Type -4 *– Linearly varying pressure on line specified by end nodes.*

Type -5 *– Linearly varying harmonic pressure on 3D model generated from a 2D model.*

Further Details for Types -4 and -5

Type -4 *– This command generates nodal loads corresponding to linearly varying surface tractions along a line on a 2D model. The line is specified by the two (2) terminal nodes, and loads are applied to all nodes within a specified distance of the line. The linearly varying pressure is specified by the terminal values.*

Type -5 *– This command generates nodal loads corresponding to surface tractions over a 3D model generated from an axisymmetric (2D) model. The tractions may vary linearly along a radial line, and circumferentially as a Fourier harmonic. The loaded nodes are identified by specifying the two (2) terminal nodes on the zero meridian. The linearly varying pressure is specified by the corresponding terminal values on the zero meridian.*

Table 2-30. Temperature Summary of Normal Conditions of Transport – All Models

Package Component	Maximum Temperatures, by Model							
	AOS-025A		AOS-050A		AOS-100A AOS-100A-S		AOS-100B	
	°C	°F	°C	°F	°C	°F	°C	°F
Cask Cavity	125	257	147	296	155	312	156	312
Shielding Material	124	256	142	288	148	298	148	298
Cask Lid Seal Area	124	255	141	286	145	293	145	293
Cask Vent Port	124	255	140	284	143	290	143	290
Cask Drain Port	124	255	141	286	144	291	144	291
Test Port	124	255	141	286	145	293	145	293
Cask Vent Port Pipe Plug	124	255	140	285	143	290	143	290
Cask Drain Port Pipe Plug	124	255	141	286	144	292	144	292
Cask Vent Port Conical Seal	124	255	141	286	145	293	145	293
Cask Drain Port Conical Seal	124	255	142	288	147	296	147	297
Cask Outside Surface	124	256	142	287	146	295	146	295
Impact Limiter, Foam Materials	94	202	117	242	111	231	111	231
Accessible Outside Surface	48	119	45	113	41	106	41	106

Table 2-31. Maximum Cask Cavity Pressure Due to Normal Conditions of Transport – All Models

Model	Temperature		Pressure[a]			Design Pressure	
	°C	°F	kPa	psia		kPa	psia
AOS-025A	125	257	186	27	<	207	30
AOS-050A	147	296	196	28	<	414	60
AOS-100A AOS-100A-S	155	312	200	29	<	1,930	280
AOS-100B	156	312	200	29	<	1,930	280

a. *Pressure calculation is based upon the ideal gas law illustrated in Table 4-6, "Maximum Cask Cavity Pressure Due to Normal Conditions of Transport – All Models," footnote a.*

Table 2-53. Temperature Summary of Fire Condition – All Models

Component	Maximum Temperatures, by Model							
	AOS-025A		AOS-050A		AOS-100A AOS-100A-S		AOS-100B	
	°C	°F	°C	°F	°C	°F	°C	°F
Cask Cavity	136	277	259	499	246	476	241	467
Shielding Material	135	276	262	504	246	475	242	467
Cask Lid Seal Area	134	274	223	434	207	404	204	399
Cask Vent Port	134	274	225	437	208	407	206	403
Cask Drain Port	135	276	227	440	210	410	207	405
Test Port	134	274	223	433	206	402	203	397
Cask Vent Port Pipe Plug	134	274	225	437	209	407	206	402
Cask Drain Port Pipe Plug	135	276	227	441	211	411	208	406
Cask Vent Port Conical Seal	134	274	224	435	207	405	205	400
Cask Drain Port Conical Seal	135	276	224	436	208	407	206	402
Cask Outside Surface	145	294	414	777	463	866	463	866

Table 2-54. Maximum Cask Cavity Pressure Due to Fire Condition – All Models

Model	Temperature[a]		Pressure[b]			Design Pressure	
	°C	°F	kPa	psia		kPa	psia
AOS-025A	136	277	191	28	<	207	30
AOS-050A	259	499	249	36	<	414	60
AOS-100A AOS-100A-S	246	476	243	35	<	1,930	280
AOS-100B	241	467	241	35	<	1,930	280

a. *Temperature listed is the maximum value obtained throughout the Fire event.*

b. *Pressure calculation is based upon the ideal gas law illustrated in Table 4-6, "Maximum Cask Cavity Pressure Due to Normal Conditions of Transport – All Models," footnote a.*

[2.19] General Plastics Manufacturing Company, *Design Guide for Use of LAST-A-FOAM FR-3700 for Crash & Fire Protection of Radioactive Material Shipping Containers*, Tacoma, WA, March, 1998 (revised October, 2003).

[2.20] Communication from ATI Firth Sterling to Alpha-Omega Services, Inc., and GE Energy.

[2.21] Parker O-Ring Division, *Evaluation of Parker Compound S1224-70 to ASTM D2000 7GE705 A19 B37 EA14 EO16 E036 F19 G11 Compound Data Sheet*, Kentucky, June 19, 1996.

[2.22] Fitzroy, Nancy D., Ed., *Heat Transfer Data Book*, General Electric Company, New York, November, 1970 Edition, Section G502.5, p. 7.

[2.23] Touloukian, Y. S., *Thermophysical Properties of Matter, Metallic Elements and Alloys*, 1971.

[2.24] Fischer, L. E. and W. Lai, *NUREG/CR-3854, Fabrication Criteria for Shipping Containers*, Lawrence Livermore Laboratory, Prepared for U.S. Nuclear Regulatory Commission (NRC), Livermore, California, March, 1985.

[2.25] Monroe, R. E, H. H. Woo, and R. G. Sears, *NUREG/CR-3019, Recommended Welding Criteria For Use in the Fabrication of Shipping Containers for Radioactive Materials*, Lawrence Livermore Laboratory, Prepared for U.S. Nuclear Regulatory Commission (NRC), Livermore, California, March, 1984.

[2.26] American Society of Mechanical Engineers, *ASME Boiler and Pressure Vessel Code*, *Section III, Division 1, Subsections NB*, *NF, and NG*, 2004 Ed., No Addendum.

[2.27] ASTM International, *ASTM F1145 - 05(2011)*, *Standard Specification for Turnbuckles, Swaged, Welded, Forged*, Table 3, West Conshohocken, PA, 2011.

[2.28] Shigley, Joseph E., *Mechanical Engineering Design*, Chapter 6, “The Design of Screws, Fasteners, and Connections,” McGraw Hill, Inc., 3rd Edition, 1977.

[2.29] American Society of Mechanical Engineers, *ASME Boiler and Pressure Vessel Code*, *Section VIII, Division 1*, 2004 Ed., No Addendum.

[2.30] U.S. Nuclear Regulatory Commission (NRC), *Regulatory Guide 7.11*, “Fracture Toughness Criteria of Base Material for Ferritic Steel Shipping Cask Containment Vessels with a Maximum Wall Thickness of 4 Inches (0.1 m),” 1991.

[2.31] Holman, W.R, and R.T. Langland, *NUREG/CR-1815*, *Recommendations for Protecting Against Failure by Brittle Fracture in Ferritic Steel Shipping Containers Up to Four Inches Thick*, Lawrence Livermore National Laboratory, Prepared for U.S. Nuclear Regulatory Commission (NRC), June 15, 1981.

[2.32] McConnell, J. W. Jr., A. L. Ayers, Jr., and M. J. Tyacke, *NUREG/CR-6407*, *Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety,* Idaho National Engineering Laboratory, Prepared for U.S. Nuclear Regulatory Commission (NRC), Idaho Falls, Idaho, February, 1996.

[2.33] American Society of Mechanical Engineers, *ASME Boiler and Pressure Vessel Code*, *Section III, Division 1,* 2004 Ed., No Addendum.

[2.34] ANSYS, Inc. ANSYS documentation release 15.0, November, 2013.

[2.35] Parker Hannifin Corporation, *Parker O-Ring Handbook, ORD 5700*, 2018.

3.3.2 Maximum Normal Operating Pressure

The maximum operating pressure, based upon steady state temperatures for Normal conditions of transport are 27 psia, 28 psia, and 29 psia for Models AOS-025, AOS-050, and AOS-100, respectively. The calculation is applied by using the Ideal Gas Law, a relationship of temperature and pressure. The volume parameter does not enter into the calculation, because it is constant. Refer to Table 4-6, "Maximum Cask Cavity Pressure Due to Normal Conditions of Transport – All Models," for pressure calculation details.

The AOS Transport Packaging System can be loaded dry or wet; however, if loaded wet, the cask cavity must be vacuum-dried to remove all water or other moisture and then backfilled with dry air or inert gas to a maximum pressure of 4.5 psig in accordance with Paragraph 7.1.3.1. None of the contents undergo alpha decay in any appreciable amount, nor do they contain neutron emitters or boron systems, that could generate helium gas.

3.3.3 Thermal Finite Element Model

The thermal evaluation of the AOS Transport Packaging System is conducted using the thermal analysis modulus of the LIBRA computer program, **MAIN12**. This heat conduction solution determines both steady-state and transient temperature fields. For transient thermal problems, the user can control the integration scheme by specifying the integration parameter. A zero (0) value for this parameter provides an explicit integration scheme; while between zero (0) and one (1) provide implicit schemes. A value of one (1) is used in the evaluation, corresponding to a backward difference integration technique. Temperature-dependent properties are either incorporated into an algorithm or implemented by a user-written subroutine. In this evaluation, the temperature-dependent properties are provided by an algorithm, and are shown in Subsection 3.2.1, "Material Properties."

The thick stainless steel cask outer shell, which comprises the bulk of the cask, defines the outside dimensions of the cask. The cask cavity is defined by the cask cavity shell, which is secured to the cask outer shell. The cask lid plug shell is secured by the cask lid and cask cavity shell. Four-node quadrilateral conduction elements are used to model the cask outer shell, cask cavity shell, and cask lid plug shell. Also, the bottom plate and cask lid are modeled with four-node quadrilateral conduction elements. Figure 3-1 shows the analytical model used in the evaluation of Normal conditions of transport. Refer to Appendix 3.5.4.2 and Appendix 3.5.4.3 for descriptions of the analytical model used in this evaluation.

The side tungsten alloy or carbon steel shielding is encapsulated by the cask outer shell and cask cavity shell. The vertical wall between the shielding and cask outer shell is packed with stainless steel wool on one side, and between the shielding and cask cavity shell, an air gap exists on the other. At the top and bottom horizontal surfaces, existing gaps within the cask cavity shell are filled with stainless steel shim plates. Two-node conduction elements are used in the model for the surface contact resistance and conduction through the stainless steel wool. Other surface interfaces, between cask components, are assembled with zero (0) gap, and are modeled with two-node conduction elements that have pressure surface-contact resistance properties.

The analytical FEA methodology and model are validated by a thermal test, the details of which are provided in Appendix 3.5.7.

Table 4-6. Maximum Cask Cavity Pressure Due to Normal Conditions of Transport – All Models

Model	Temperature (T)		Pressure (P)[a]			Design Pressure	
	°C	°F	kPa	psia		kPa	psia
AOS-025A	125	257	186	27	<	207	30
AOS-050A	147	296	196	28	<	414	60
AOS-100A AOS-100A-S	155	312	200	29	<	1,930	280
AOS-100B	156	312	200	29	<	1,930	280

a. *Pressure calculation is based upon the ideal gas law:*

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \Rightarrow \frac{P_1}{T_1} = \frac{P_2}{T_2}$$

Initial Conditions
Assumed to be an ambient temperature of 50°F and a pressure of 4.5 psig corresponding to the cask cavity being backfilled with helium in accordance with Paragraph 7.1.3.1.
$P_1 = 14.7 + 4.5$ psig $= 19.2$ psia
$T_1 = 50$°F

Final Condition
$P_2 = ?$
$T_2 = 257$°F

$$P_2 = \frac{(257 + 460)}{(50 + 460)} \times 19.2 = 26.99 \text{ psia}$$

Table 4-7. Maximum Cask Cavity Pressure Due to Fire Condition – All Models

Model	Temperature[a]		Pressure[b]			Design Pressure	
	°C	°F	kPa	psia		kPa	psia
AOS-025A	136	277	191	28	<	207	30
AOS-050A	259	499	249	36	<	414	60
AOS-100A AOS-100A-S	246	476	243	35	<	1,930	280
AOS-100B	241	467	241	35	<	1,930	280

a. *Temperature listed is the maximum value obtained throughout the Fire event.*

b. *Pressure calculation is based upon the ideal gas law illustrated in Table 4-6, footnote a.*

4.2.3 Containment Criterion

The AOS Transport Packaging System containments are designed, and verified by Leak test, to meet the "leak-tight" criteria established in Reference **[4.4]**, for the transportation of activated material in *Normal form*.

7.1.3 Preparation for Transport

7.1.3.1 Securing the Cask Lid

To secure the cask lid, in preparation for transport:

Note: *Torque sequence is stamped on top surface of the cask lid, about the bolt location.*

a. Torque the cask lid attachment bolts (refer to Table 7-2), using one of the two conditions listed below.

   1. **If the cask was dry loaded** – Torque the cask lid attachment bolts in a crisscross pattern, with a final pass all the way around, to ensure even seal compression after the elastomeric seal has been visually inspected and installed, –or– a new metallic seal has been installed.

   2. **If the cask was wet loaded** – To torque the cask lid attachment bolts:

      a. Install the cask lid and a minimum of at least five (5) bolts in the cask lid, as the cask breaks the water's surface. Note that this step may be skipped with the approval of Radiation Protection.

      b. Drain the cask over the pool area. After the water has drained from the cask, move the cask to the decontamination pad.

      c. Remove the bolts (previously installed for the transfer) and cask lid.

      d. Dry the sealing surfaces and the bolt threaded holes.

      e. Install the cask lid elastomeric seal after it has been visually inspected, –or– a new cask lid metallic seal onto the cask lid, then re-install the bolts and torque the cask lid attachment bolts in a crisscross pattern, with a final pass all the way around, to ensure even seal compression.

Note: *For shipments of Special Form material, a Maintenance Leak test is not necessary after replacing a cask lid elastomeric seal, provided that a Periodic Leak test has been performed on the cask's containment system within the past 12 months.*

f. Flush the cask cavity with dry air or nitrogen, to displace any remaining water within the cavity.

g. Vacuum-dry the cavity until the cask cavity pressure is 1 torr or less and then isolate the vacuum source. The pressure within the cask cavity must remain at or below 3 torr for at least 30 minutes. Gas discharged from the vacuum pump should be filtered to prevent airborne release of radioactive material that might be present within the gas stream. After completing this operation, fill the cask cavity with dry air, helium, or other inert gas, to 2.5 psig ±2.0 psig.

h. Figure 7-4 illustrates a typical vacuum drying system and its basic components. These components include a vacuum pump, pressure gauge, connectors, and valves.

b. Install the cask drain port plugs, cask vent port plugs, and covers, as applicable. Prior to installation, completely remove all previous thread sealant from the pipe plugs, if not already done. Apply pipe thread sealant on the plug thread areas. If using Loctite Thread Seal Tape No. 39904, wrap the threads with three (3) full turns of tape. Three (3) full turns are necessary to ensure a leak-tight seal of the port plugs.

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Table 7-2. Cask Lid Attachment Bolt Size and Preload Torque – All Models[a]

Model	Function	Bolt Size / ASME and ANSI Standards	Preload Torque	
			N-m	ft-lb
AOS-025	Cask Lid Attachment Bolt	3/8-16 UNC-2A / ASME SB-637, UNS N07718	47	35
AOS-050	Cask Lid Attachment Bolt	1/2-13 UNC-2A / ASME SB-637, UNS N07718	85	62.5
AOS-100	Cask Lid Attachment Bolt	7/8-9 UNC-2A / ASME SB-637, UNS N07718	678	500

a. *Refer to Table 1-5, "AOS Transport Packaging System Certification Drawing List – All Models."*

Figure 7-4 illustrates a typical Leak testing setup (vacuum drying system and its basic components) that can be used for all AOS Radioactive Material Transport Packaging System models (Models AOS-025A, AOS-050A, AOS-100A, AOS-100B, and AOS-100A-S).

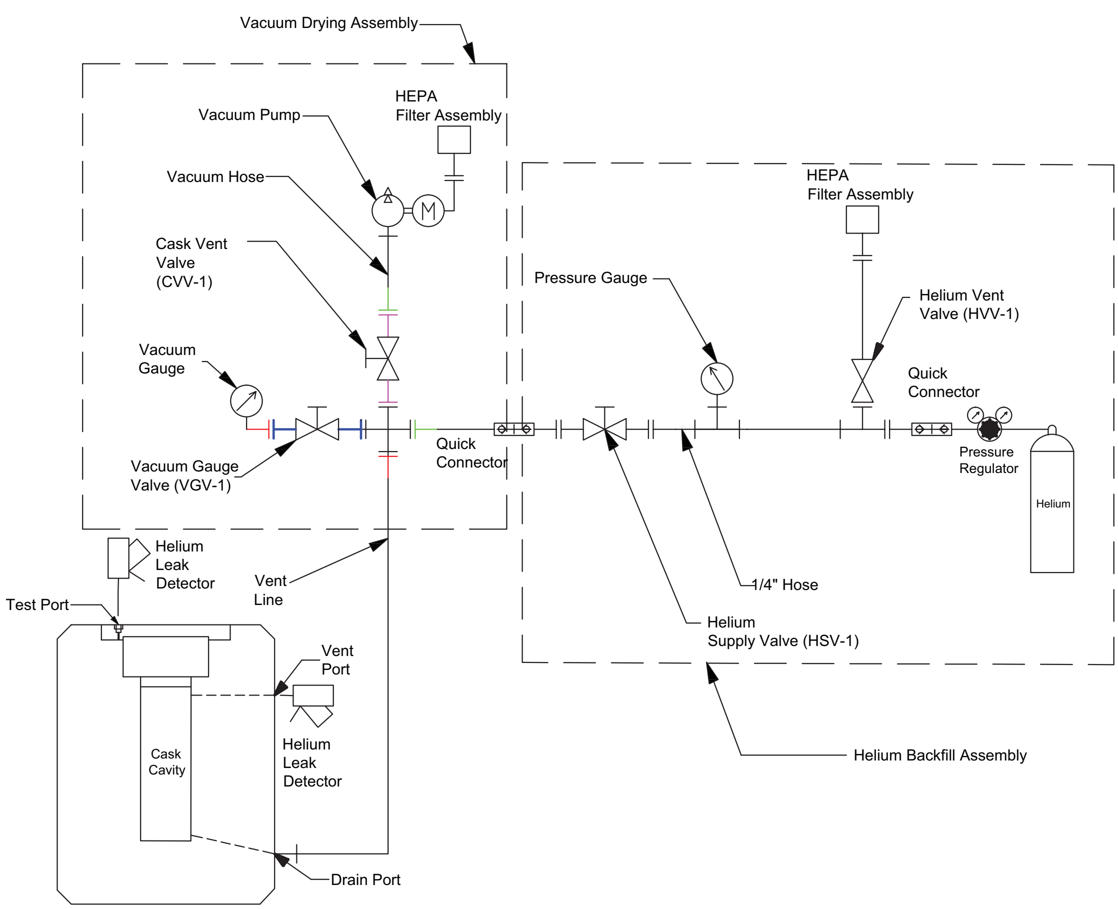

Figure 7-4. Typical Vacuum Drying System Setup and Equipment

7.1.3.2 Removing the Cask from the Loading Area

To remove the cask from the loading area, in preparation for transport:

a. Carefully measure the cask radiation levels, while removing the cask from the storage basin or cell area.

b. Decontaminate the cask to a level consistent with *IAEA TS-R-1, Paragraph 508*, *10 CFR 71.87(i)*, and *49 CFR 173.443* (References **[7.1]**, **[7.2]**, and **[7.3]**, respectively).

7.1.3.3 Pre-Shipment Leak Testing

To verify that the transport package's containment system is properly assembled for shipment, perform one of the following Pre-Shipment Leak tests – Test A1, A2 or B – depending on the content and cask lid seal type. Tests A1 and A2 are minimum requirements for shipments that contain *Special Form* contents. Test B is the minimum test required for shipments that contain *Normal Form* content. However, Test B can be performed in lieu of Tests A1 or A2.

Notes: *A Periodic or Maintenance Leak test performed on a loaded cask in accordance with Subsection 8.2.2 may be acceptable as a Pre-Shipment Leak test, provided that the test meets or exceeds the requirements for Pre-Shipment Leak testing described below.*

When the Model AOS-100A-S is used, both cask lid seals must be leak tested.

Test A1 – Gas Pressure Rise: For *Special Form* Contents (Tests: Cask Lid(s), Vent and Drain Ports)

To perform a pre-shipment verification of the elastomeric lid seal:

a. Perform the test by evacuating the space between the cask lid seal's elastomeric O-Ring seals, –or– the cavities outside the cask vent and drain ports, and then measuring the pressure rise.

Notes: *The cask vent port and cask drain port need to be leak tested only if the ports have been opened since they were last tested.*

The Gas Pressure Rise Leak test is performed using a test manifold, isolation valve, vacuum gauge, and vacuum pump. Use the test apparatus described in the test procedure or equivalent.

b. Connect the test manifold to the test port. Evacuate the test volume to the required level. and then close the isolation valve.

c. Disconnect the vacuum pump and then wait for the prescribed test time. After the test time, the acceptance criterion is a pressure rise that corresponds to no detectable leakage.

Test A2 – Gas Pressure Drop: For *Special Form* Contents (Tests: Cask Lid(s), Vent and Drain Ports)

To perform a pre-shipment verification of the elastomeric lid seal:

a. Perform the test by pressurizing the space between the cask lid seal's elastomeric O-Ring seals, –or– the cavities outside the cask vent and drain ports, and then measuring the pressure drop.

Notes: *The cask vent port and cask drain port need to be leak tested only if the ports have been opened since they were last tested.*

The Gas Pressure Drop Leak test is performed using a test manifold, isolation valve, pressure gauge, and pressure supply. Use the test apparatus described in the test procedure or equivalent.

b. Connect the test manifold to the test port. Evacuate the test volume to the required level. and then close the isolation valve.

c. Disconnect the pressure supply and then wait for the prescribed test time. After the test time, the acceptance criterion is a pressure drop that corresponds to no detectable leakage.

Test B – Tracer Gas: For *Normal Form* Contents (Tests: Lid (Cask Lid Seal), Vent and Drain Ports)

To leak test the containment system:

a. The cask lid seal, and vent and drain threaded pipe plugs must be leak-tested in accordance with *ANSI N14.5-2014* **[7.8]**. The acceptance criteria is 1×10^{-7} ref-cm^3/sec air at an upstream pressure of a minimum of 1 atmosphere and downstream pressure of 0.01 atmosphere absolute or less. The test procedure sensitivity must be one-half of the reference air leakage rate (i.e., 5×10^{-8} ref-cm^3/sec of air) or less.

Table 8-1. Acceptance Test Matrix

Test Type	Model		
	AOS-025A	AOS-050A	AOS-100A AOS-100B AOS-100A-S
Acceptance			
Materials			
Metals	✔	✔	✔
Foam[a]	✔	✔	✔
Seal[b]	✔	✔	✔
Welding Rods	✔	✔	✔
Verification			
Design Features			
Foam[c]	✔	✔	✔
Containment during fabrication[d]	✔	✔	✔
Thermal[e]	✔	✔	✔
Mechanical	Analytical procedure benchmarked by a Drop test of a transport package 165%-larger than the Model AOS-100A. Refer to Appendix 2.12.6, "Impact (Free-Drop) Test Report."		
Containment at assembly[f]	✔	✔	✔
Shielding[g]	✔	✔	✔

a. *Formulation tests are conducted upon initial order or formulation change.*

b. *Seal supplier to conduct independent material verification, per its Quality Assurance Program.*

c. *Batch tests are conducted upon each batch required to fulfill each impact limiter. Pour tests are conducted upon each pour of every batch.*

d. *Pressure test at 150% design pressure 10 CFR 71.85(b)* **[8.1]**.

e. *Thermal test is conducted upon the first unit of each model fabricated. Refer to Subsection 8.1.7.*

f. *MSLD Helium test procedure sensitivity of at least* 5×10^{-8} *ref-cm*^{3}*/sec.*

g. *Refer to Subsection 8.1.6.*

8.1.4 Leakage Tests

The containment system, which includes the cask cavity, cask lid, welds, port plug assembly, seals, and penetrations, is leak tested during fabrication in accordance with *ANSI N14.5-2014* **[8.4]**. The acceptance criteria is 1×10^{-7} ref-cm^3/sec of air at an upstream pressure of 1 atmosphere and downstream pressure of 0.01 atmosphere absolute or less. The test procedure sensitivity must be one-half of the reference air leakage rate (i.e., 5×10^{-8} ref-cm^3/sec of air) or less.

Note: *Casks manufactured prior to April 2016 were leak tested in accordance with the 1997 edition of ANSI N14.5.*

8.1.5 Component and Material Tests

8.1.5.1 Valve, Rupture Disks, and Fluid Transport Devices

Not applicable. Component tests of valve, rupture disks, and/or fluid transport devices are not applicable, because these components do not exist in the AOS Transport Packaging System.

8.1.5.2 Materials

Materials and testing requirements are denoted in Table 8-2 through Table 8-7. Materials are selected and tested in accordance with these specifications, following the approved Manufacturing and Fabrication Quality Assurance Plan when packages are manufactured or repaired.

With respect to FR-3700 series foam, Table 8-6 and Table 8-7 list the maximum value limits for acceptance of the foam formulation test results. These values include the +15% variation resulting from the manufacturing process.

8.2 MAINTENANCE PROGRAM

The cask maintenance program is described, in detail, in an Engineering Specification provided to all AOS Transport Packaging System users. This Specification shall implement the requirements established in this chapter. Packaging System operators can develop procedures of their own, to include site-specific requirements, if they remain within the Engineering Specification requirements.

Pre-shipment Inspections are conducted prior to each shipment. These inspections include visual checks of the packaging and any support structure(s) or device(s) required to properly assemble the transport package. They might also include pressurization of the cask cavity, which is part of the Leak test for *Normal Form* content. Additionally, more detailed inspections are conducted annually, or prior to being used after a storage period of more than one (1) year, as detailed in Subsection 8.2.2(b).

8.2.1 Structural and Pressure Tests

The only periodic pressure test performed on the AOS Transport Packaging System is the Leak test detailed in Subsection 8.2.2(b).

8.2.2 Leakage Tests [8.4]

Prior to leak testing, the cask lid seal, sealing surfaces, cask lid attachment bolts, and seal attachment screws must be inspected for damage such as scratches, dents, dirt, and oil residue. Also, the female thread holes for the cask lid attachment bolts and seal attachment screws must be checked. After completing the inspection, and repairing or replacing any damaged components, the seal is installed on the cask lid groove by the four (4) seal attachment screws, as illustrated in Figure 8-2 for the cask lid metallic seal, which also shows the location of the leak-testing hole.

Note: *Elastomeric O-Rings must be visually inspected for cuts, blemishes, debris, and/or permanent local deformation on the sealing surface. Damaged seals must be replaced. Elastomeric O-Rings must be replaced every 12 uses or once per year, whichever comes first.*

a. Pre-shipment Leak Testing

   Pre-shipment leak testing must be performed before each shipment, after the content is loaded and the containment system is assembled. Perform the test as described in Paragraph 7.1.3.3.

b. Periodic Leak Testing

   Periodic leak testing must be performed prior to the transport package's first use, after its third use, annually, and/or prior to the transport package being used after a storage period of more than one (1) year. The cask lid seal, vent and drain threaded pipe plugs, and the port plug conical seal must be leak-tested in accordance with *ANSI N14.5-2014* **[8.4]**. The acceptance criteria is 1×10^{-7} ref-cm^3/sec air at an upstream pressure of 1 atmosphere and downstream pressure of 0.01 atmosphere absolute or less. The test procedure sensitivity must be one-half of the reference air leakage rate (i.e., 5×10^{-8} ref-cm^3/sec of air) or less.

c. Maintenance Leak Testing

Maintenance leak testing is performed to confirm that maintenance, repair, and/or replacement of components has not degraded containment system performance. The portion of the containment system affected by the maintenance, repair and/or component replacement must be leak-tested in accordance with *ANSI N14.5-2014* **[8.4]**. The acceptance criteria is 1×10^{-7} ref-cm^3/sec air at an upstream pressure of 1 atmosphere and downstream pressure of 0.01 atmosphere absolute or less. The test procedure sensitivity must be one-half of the reference air leakage rate (i.e., 5×10^{-8} ref-cm^3/sec of air) or less.

Notes: *For shipments of Special Form material, a Maintenance Leak test is not necessary after replacement of a cask lid elastomeric seal, provided that a Periodic Leak test has been performed on the cask's containment system within the past 12 months and a Pre-Shipment Leak test is performed in accordance with Paragraph 7.1.3.3.*

Periodic and Maintenance Leak testing on casks prior to April 2016 may have been performed in accordance with the 1997 edition of ANSI N14.5.

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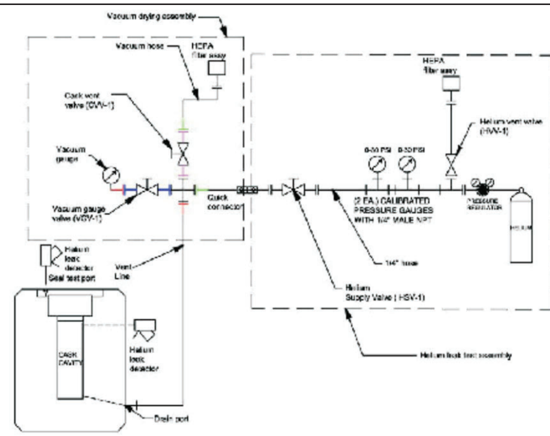
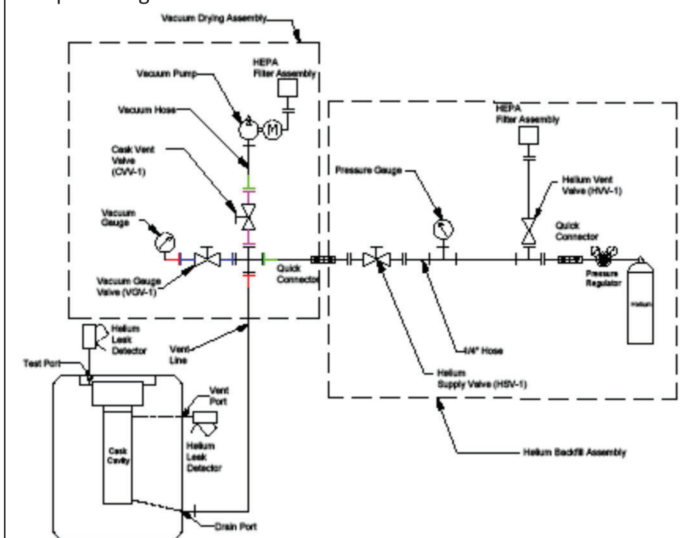
Page	Heading/Item/ Step	Para #/Item/Step	Line #/ Item/Step	What it was (Revision J)	What it is (Revision J-1) *Justification (if needed)*
FrontMatter					
i	–	–	–	Rev. J, January 31, 2021	Rev. J-1, April 20, 2021 (Note: Automatically applied to all footers. Due to software constraints, SAR page footers might/might not include a revision bar indicating this change. Additionally, the revision bar might span both lines of the footer.)
iv	Revision History	J-1	–	–	• Revised Subsection 1.2.2 (added discussion related to cask loading temperature and backfilling pressure) • Revised Subsection 2.2.3 (expanded discussion related effects of radiation), Paragraph 2.6.1.1 (revised initial conditions for NCT pressure calculations), Table 2-31 and Table 2-54 (omitted footnotes b and c, respectively; updated calculated pressures); added new Reference [2.35] • Revised Subsection 3.2.2 (update calculated NCT pressures and elaborate on initial conditions and mechanisms that can increase internal cask pressure) • Revised Table 4-6 and Table 4-7 (omitted footnotes b and c, respectively; revised pressure calculations based on updated initial conditions) • Revised Paragraph 7.1.3.1 (revised instructions for wet-loading cask), Figure 7-4 (updated to reflect current equipment), and Paragraph 7.1.3.3 (revised leak testing procedure) • Revised Table 8-1 footnote (clarified test procedure sensitivity), Subsection 8.1.4 (revised fabrication leak testing requirements), Section 8.2 (removed statement regarding pre-shipment leak testing because this belongs in Chapter 7), Subsection 8.2.2 (updated leak testing requirements)
Chapter 1					
1-13	1.2.2	4	2+	The containment boundary will not normally be pressurized; however, internal heating of the enclosed gases can increase the pressure.	The cask may have a slight internal pressure due to backfilling with air or an inert gas and internal heating of the enclosed gases can increase the pressure. The cask is normally loaded at room temperature; however, for evaluating the temperature contribution to the pressurization of the cask cavity, the loading temperature will be conservatively assumed to be 50°F. The pressure inside the containment boundary is evaluated in Subsection 4.2.2.

Page	Heading/Item/ Step	Para #/Item/Step	Line #/ Item/Step	What it was (Revision J)	What it is (Revision J-1) *Justification (if needed)*
Chapter 2					
2-37	2.2.3	2	All	Of all these materials, the one most affected by radiation is the silicone material. However, these port cover O-Ring components are replaced after each use, thus eliminating the cumulative effect of radiation.	Of these materials, the one most affected by radiation is the silicone material. The port cover O-Ring components are not a part of the containment boundary and are used only to seal the port cover to prevent debris from entering the port plug area. Furthermore, these items are visually inspected for damage, deterioration, and wear, and are replaced as needed.
2-37	2.2.3	3 (new)	–	–	<Added new paragraph.> The cask lid elastomeric seal is part of the containment boundary and is exposed to gamma radiation that can cause compression set. The expected maximum dose rate in the cask lid seal region is 1 rad/hr. After one year of continuous use, this would result in a total dose of 1×10^4 rad. However, at a dose of 1×10^6 rads, the radiation effect on elastomers is minor. It is not until the radiation is delivered in doses within the range of 1×10^7 rad that radiation is a concern for O-Ring compounds (Reference [2.35]). Therefore, radiation is not a concern because the cask lid elastomeric seals are replaced after every 12 uses or annually, whichever comes first.
2-75	2.6.1.1	2	2	This pressure value is based upon air at 100% relative humidity occupying the entire cavity volume.	These pressure values are based on air occupying the cavity volume. To calculate these pressures, the initial temperature is conservatively assumed to be 50°F and the initial pressure is assumed to be 4.5 psig, which is the maximum pressure to which the cavity will be backfilled after vacuum drying as per Paragraph 7.1.3.1.
2-76	Table 2-31	Pressure columns (columns 4-5)	All model rows	AOS-025A: 135 kPa, 20 psia AOS-050A: 142 kPa, 21 psia AOS-100A/100A-S: 145 kPa, 21 psia AOS-100B: 145 kPa, 21 psia	AOS-025A: 186 kPa, 27 psia AOS-050A: 196 kPa, 28 psia AOS-100A/100A-S: 200 kPa, 29 psia AOS-100B: 200 kPa, 29 psia
2-76	Table 2-31	Design Pressure column heading and footnote	–	Design Pressure[b] b. Model AOS-100 transport package – Pressure value is based upon projected operating conditions.	<Omitted footnote b.>
2-148	Table 2-54	Pressure columns (columns 4-5)	All model rows	AOS-025A: 139 kPa, 20 psia AOS-050A: 181 kPa, 26 psia AOS-100A/100A-S: 177 kPa, 26 psia AOS-100B: 175 kPa, 25 psia	AOS-025A: 191 kPa, 28 psia AOS-050A: 249 kPa, 36 psia AOS-100A/100A-S: 243 kPa, 35 psia AOS-100B: 241 kPa, 35 psia
2-148	Table 2-54	Design Pressure column heading and footnote	–	Design Pressure[c] b. Model AOS-100 transport package – Pressure value is based upon projected operating conditions.	<Omitted footnote c.>

Page	Heading/Item/ Step	Para #/Item/Step	Line #/ Item/Step	What it was (Revision J)	What it is (Revision J-1) *Justification (if needed)*
2-986	2.13	[2.35]	–	–	<Added new reference.> Parker Hannifin Corporation, *Parker O-Ring Handbook, ORD 5700*, 2018.
Chapter 3					
3-21	3.3.2	1	2	…20 psia, 21 psia, and 21 psia…	…27 psia, 28 psia, and 29 psia…
3-21	3.3.2	2	All	The AOS Transport Packaging System can be loaded dry or wet; however, if loaded wet, the cask cavity must be vacuum-dried to remove all water or other moisture. Subsequently, only the relative humidity in the loading environment is trapped within the cavity. None of the contents undergo alpha decay in any appreciable amount, neither neutron emitters nor boron systems, that could generate helium gas.	The AOS Transport Packaging System can be loaded dry or wet; however, if loaded wet, the cask cavity must be vacuum-dried to remove all water or other moisture and then backfilled with dry air or inert gas to a maximum pressure of 4.5 psig in accordance with Paragraph 7.1.3.1. None of the contents undergo alpha decay in any appreciable amount, nor do they contain neutron emitters or boron systems, that could generate helium gas.
Chapter 4					
4-30	Table 4-6	Pressure columns (columns 4-5)	All model rows	AOS-025A: 135 kPa, 20 psia AOS-050A: 142 kPa, 21 psia AOS-100A/100A-S: 145 kPa, 21 psia AOS-100B: 145 kPa, 21 psia	AOS-025A: 186 kPa, 27 psia AOS-050A: 196 kPa, 28 psia AOS-100A/100A-S: 200 kPa, 29 psia AOS-100B: 200 kPa, 29 psia
4-30	Table 4-6	Design Pressure column heading and footnote	–	Design Pressure[b] b. Model AOS-100 transport package – Pressure value is based upon projected operating conditions.	<Omitted footnote b.>
4-30	Table 4-6	Footnote a	Initial and Final Condition-related text	**Initial Condition** P_1 = 14.7 psia T_1 = 78°F **Final Condition** P_2 = ? T_2 = 257°F $P_2 = \frac{(257 + 460)}{(78 + 460)} * 14.7 = 19.59$ psia	**Initial Conditions** Assumed to be an ambient temperature of 50°F and a pressure of 4.5 psig corresponding to the cask cavity being backfilled with helium in accordance with Paragraph 7.1.3.1. P_1 = 14.7 + 4.5 psig = 19.2 psia T_1 = 50°F **Final Condition** P_2 = ? T_2 = 257°F $P_2 = \frac{(257 + 460)}{(50 + 460)} \times 19.2 = 26.99$ psia
4-30	Table 4-7	Pressure columns (columns 4-5)	All model rows	AOS-025A: 139 kPa, 20 psia AOS-050A: 181 kPa, 26 psia AOS-100A/100A-S: 177 kPa, 26 psia AOS-100B: 175 kPa, 25 psia	AOS-025A: 191 kPa, 28 psia AOS-050A: 249 kPa, 36 psia AOS-100A/100A-S: 243 kPa, 35 psia AOS-100B: 241 kPa, 35 psia

Page	Heading/Item/ Step	Para #/Item/Step	Line #/ Item/Step	What it was (Revision J)	What it is (Revision J-1) *Justification (if needed)*
4-30	Table 4-7	Design Pressure column heading and footnote	–	Design Pressure[c] b. Model AOS-100 transport package – Pressure value is based upon projected operating conditions.	<Omitted footnote c.>
Chapters 5 and 6 – No changes					
Chapter 7					
7-10	7.1.3.1	a.2 a.2.a	All	2. If the cask was wet loaded – To torque the cask lid attachment bolts, if the cask was wet loaded: a. Install a minimum of at least five (5) bolts in the cask lid, as the cask breaks the water's surface.	2. If the cask was wet loaded – To torque the cask lid attachment bolts: a. Install the cask lid and a minimum of at least five (5) bolts in the cask lid, as the cask breaks the water's surface. Note that this step may be skipped with the approval of Radiation Protection.
7-10	7.1.3.1	e	Notes (new)	–	Note: For shipments of Special Form material, a Maintenance Leak test is not necessary after replacing a cask lid elastomeric seal, provided that a Periodic Leak test has been performed on the cask's containment system within the past 12 months.
7-10a 7-10b (new)	7.1.3.1	–	–	–	<Moved step f and remaining content from page 7-10 to page 7-10a. Page 7-10b is "blank".>
7-10a (new)	7.1.3.1	g	All	Vacuum-dry the cavity until the cask cavity pressure is 1 torr or less. The vacuum source must be isolated after the pressure is 1 torr or less. The pressure within the cask cavity must remain at or below 1 torr, for at least 30 minutes. Gas discharged from the vacuum pump should be filtered, to prevent airborne release of radioactive material that might be present within the gas stream. After completing this operation, fill the cask cavity with helium, to 2 psig ±0.5 psig.	Vacuum-dry the cavity until the cask cavity pressure is 1 torr or less and then isolate the vacuum source. The pressure within the cask cavity must remain at or below 3 torr for at least 30 minutes. Gas discharged from the vacuum pump should be filtered to prevent airborne release of radioactive material that might be present within the gas stream. After completing this operation, fill the cask cavity with dry air, helium, or other inert gas, to 2.5 psig ±2.0 psig.

Page	Heading/Item/ Step	Para #/Item/Step	Line #/ Item/Step	What it was (Revision J)	What it is (Revision J-1) *Justification (if needed)*
7-10a (new)	7.1.3.1	h	All	Figure 7-4 illustrates a typical vacuum drying system and its basic components. These components include an ultrafine vacuum pump, vacuum pressure gauge, cryogenic water trap, vacuum connectors, and valves. If the vacuum pump used in this procedure is equipped with a “gas ballast” device, turn off the device during the cask cavity vacuum drying operation. The gas ballast device is used to dry any moisture that might be trapped within the vacuum pump oil. If it is necessary to remove water vapor from the pump oil during the vacuum drying operation, isolate the system. Turn on the gas ballast device until the water vapor is removed from the oil, turn off the gas ballast, then place the system back online.	Figure 7-4 illustrates a typical vacuum drying system and its basic components. These components include a vacuum pump, pressure gauge, connectors, and valves.
7-11	Figure 7-4	–	–		<Replaced figure.> 

Page	Heading/Item/ Step	Para #/Item/Step	Line #/ Item/Step	What it was (Revision J)	What it is (Revision J-1) *Justification (if needed)*
7-12	7.1.3.3	1 and Note	All	To verify that the containment system of the transport package is properly assembled for shipment, perform one of the following Pre-Shipment Leak tests – Test A1, A2 or B – depending on the cask lid seal type. Note: When the Model AOS-100A-S is used, both cask lid seals must be leak tested.	To verify that the transport package's containment system is properly assembled for shipment, perform one of the following Pre-Shipment Leak tests – Test A1, A2 or B – depending on the content and cask lid seal type. Tests A1 and A2 are minimum requirements for shipments that contain Special Form contents. Test B is the minimum test required for shipments that contain Normal Form content. However, Test B can be performed in lieu of Tests A1 or A2. Notes: A Periodic or Maintenance Leak test performed on a loaded cask in accordance with Subsection 8.2.2 may be acceptable as a Pre-Shipment Leak test, provided that the test meets or exceeds the requirements for Pre-Shipment Leak testing described below. When the Model AOS-100A-S is used, both cask lid seals must be leak tested.
7-12	7.1.3.3	Test A1	Heading	Test A1 – Gas Pressure Rise: When Using Elastomeric Cask Lid Seals for Special Form Contents (Tests: Cask Lid(s), Vent and Drain Ports)	Test A1 – Gas Pressure Rise: For Special Form Contents (Tests: Cask Lid(s), Vent and Drain Ports)
7-12	7.1.3.3	Test A1	Notes	Note: The cask vent port and cask drain port need to be leak tested only if the ports have been opened since they were last tested. Note: The gas pressure rise leak test is performed using a test manifold, isolation valve, vacuum gauge, and vacuum pump. Use only the test apparatus described in the test procedure.	Notes: The cask vent port and cask drain port need to be leak tested only if the ports have been opened since they were last tested. The Gas Pressure Rise Leak test is performed using a test manifold, isolation valve, vacuum gauge, and vacuum pump. Use the test apparatus described in the test procedure or equivalent.
7-12	7.1.3.3	Test A1	Step c	Disconnect the vacuum pump and then wait for the prescribed hold time. After the hold time, the acceptance criterion is a pressure rise that is less than or equal to 0.1 psig.	Disconnect the vacuum pump and then wait for the prescribed test time. After the test time, the acceptance criterion is a pressure rise that corresponds to no detectable leakage.
7-13	7.1.3.3	Test A2	Heading	Test A2 – Gas Pressure Drop: When Using Elastomeric Cask Lid Seals for Special Form Contents (Tests: Cask Lid(s), Vent and Drain Ports)	Test A2 – Gas Pressure Drop: For Special Form Contents (Tests: Cask Lid(s), Vent and Drain Ports)
7-13	7.1.3.3	Test A2	Notes	Note: The cask vent port and cask drain port need to be leak tested only if the ports have been opened since they were last tested. Note: The gas pressure drop leak test is performed using a test manifold, isolation valve, pressure gauge, and pump. Use only the test apparatus described in the test procedure.	Notes: The cask vent port and cask drain port need to be leak tested only if the ports have been opened since they were last tested. The Gas Pressure Drop Leak test is performed using a test manifold, isolation valve, pressure gauge, and pressure supply. Use the test apparatus described in the test procedure or equivalent.

Page	Heading/Item/ Step	Para #/Item/Step	Line #/ Item/Step	What it was (Revision J)	What it is (Revision J-1) *Justification (if needed)*
7-13	7.1.3.3	Test A2	Step c	Disconnect the pressure supply and then wait for the prescribed test time. After the hold time, the acceptance criterion is a pressure rise that is less than or equal to 0.1 psig.	Disconnect the pressure supply and then wait for the prescribed test time. After the test time, the acceptance criterion is a pressure drop that corresponds to no detectable leakage.
7-13	7.1.3.3	Test B	Heading	Test B – Tracer Gas When Using Metallic Cask Lid Seal for Normal or Special Form Contents (Tests: Lid (Cask Lid Seal), Vent and Drain Ports)	Test B – Tracer Gas: For Normal Form Contents (Tests: Lid (Cask Lid Seal), Vent and Drain Ports)
7-13	7.1.3.3	Test B	All steps and Note	a. Perform a leak test of the cask lid seal, drain threaded pipe plugs, and vent threaded pipe plugs, with a thermal conductivity sensing instrument or mass spectrometer device with a sensitivity of at least 1.0×10^{-8} ref-cm^3/sec. b. Set up the test instrument in accordance with written procedures and the instrument manufacturer's guidance. Note: Leak Test criteria for leak rates must meet the requirement of Reference [7.8]. c. Evacuate the cask cavity and then backfill the cask cavity with helium to a pressure of at least one (1) atmosphere. d. With the instrument selected in step a calibrated with a calibration standard within the range of 1.0×10^{-8} to 5.0×10^{-7} ref-cm^3/sec, check the following for indications of leakage: • Package containment with the test instrument, through the test port • Volume between the double "C" cross-sections • Around the threaded joint area of the drain and vent threaded pipe plugs e. If leakage greater than 1×10^{-7}ref-cm^3/sec, corrected for the nature of the tracer gas and temperature condition at the time of the test, is detected, repair or replace the damaged component(s), and then re-test for indications of leakage.	a. The cask lid seal, and vent and drain threaded pipe plugs must be leak-tested in accordance with ANSI N14.5-2014 [7.8]. The acceptance criteria is 1×10^{-7} ref-cm^3/sec air at an upstream pressure of a minimum of 1 atmosphere and downstream pressure of 0.01 atmosphere absolute or less. The test procedure sensitivity must be one-half of the reference air leakage rate (i.e., 5×10^{-8} ref-cm^3/sec of air) or less.
Chapter 8					
8-2	Table 8-1	Footnote f	1	MSLD He Test at least 2.00E-09 Std atm cm^3/sec sensitivity.	MSLD Helium test procedure sensitivity of at least 5×10^{-8} ref-cm^3/sec.

Page	Heading/Item/ Step	Para #/Item/Step	Line #/ Item/Step	What it was (Revision J)	What it is (Revision J-1) ***Justification (if needed)***
8-4	8.1.4	1-2	All	The AOS Transport Packaging System cask's entire containment boundary is leak-tested per Subsection 8.2.2(b), before its first use, and after its third use. The Periodic Leak test is to be performed in accordance with Subsection 8.2.2(b), every 12 months thereafter. The Leak test procedure shall meet the ANSI N14.5-2014 [8.4] standard. The test uses a mass spectrometer leak detector (MSLD) in an evacuated envelope, with back pressurization technique. This technique consists of creating a 1-atm pressure differential across the boundary, and evacuating outside surfaces of the boundary, at critical locations (such as penetrations and seal joints) with the MSLD. The evacuated gases are passed through the instrument's spectrum portion to detect, quantitatively, the presence of gas, typically helium, used in the pressurization of the containment boundary. The criteria that is required to be met to establish the containment boundary's leak-tightness is 10^{-7} atm cm^3/sec or less, based upon dry air at 25°C (32°F) and for a pressure differential of 1 atm. The MSLD instrument must be sensitive to at least a 10^{-9} atm cm^3/sec reading. Critical locations within the AOS Transport Packaging System are the cask lid seal joint, cask drain port, and cask vent port. These locations are tested by connecting the test probe to the test port that is located between the seal's two (2) seal rings (in the case of the seal joint) and port cover areas, and then determining the leak rate. If the leak-tightness criterion, per Reference [8.4], is not met, the containment boundary is checked, damaged components1 (such as a seal or pipe plug) are replaced, and the unit is re-tested.	The containment system, which includes the cask cavity, cask lid, welds, port plug assembly, seals, and penetrations, is leak tested during fabrication in accordance with ANSI N14.5-2014 [8.4]. The acceptance criteria is 1×10^{-7} ref-cm^3/sec of air at an upstream pressure of 1 atmosphere and downstream pressure of 0.01 atmosphere absolute or less. The test procedure sensitivity must be one-half of the reference air leakage rate (i.e., 5×10^{-8} ref-cm^3/sec of air) or less. Note: Casks manufactured prior to April 2016 were leak tested in accordance with the 1997 edition of ANSI N14.5.
8-17	8.2	2	5-6	…as detailed in Subsection 8.2.2(b). Pre-shipment Leak tests are conducted only when shipping Normal Form material.	…as detailed in Subsection 8.2.2(b).

Page	Heading/Item/ Step	Para #/Item/Step	Line #/ Item/Step	What it was (Revision J)	What it is (Revision J-1) *Justification (if needed)*
8-17	8.2.2	b	2	Periodic leak testing must be performed annually, or prior to the transport package being used, after a storage period of more than one (1) year, or prior to returning to service after repairs (such as weld repair) and/or replacing containment components. The cask lid seal, vent and drain threaded pipe plugs, and the port plug conical seal must be leak-checked with a helium MSLD. This instrument has a sensitivity of $< 1 \times 10^{-9}$ ref-cm^3/sec (helium). Conduct this test by pressurizing the cask cavity to one (1) atm pressure differential across the boundary to be tested (verified with a double pressure gauge), then use the MSLD to test all components of the containment boundary for leaks. If leakage greater than 2×10^{-7} ref-cm^3/sec helium at standard conditions is detected, repair or replace the damaged component(s), then re-test for leakage, to the same criteria as previously tested.	Periodic leak testing must be performed prior to the transport package's first use, after its third use, annually, and/or prior to the transport package being used after a storage period of more than one (1) year. The cask lid seal, vent and drain threaded pipe plugs, and the port plug conical seal must be leak-tested in accordance with ANSI N14.5-2014 [8.4]. The acceptance criteria is 1×10^{-7} ref-cm^3/sec air at an upstream pressure of 1 atmosphere and downstream pressure of 0.01 atmosphere absolute or less. The test procedure sensitivity must be one-half of the reference air leakage rate (i.e., 5×10^{-8} ref-cm^3/sec of air) or less.
8-17a (new)	8.2.2	c	–	–	c. Maintenance Leak Testing Maintenance leak testing is performed to confirm that maintenance, repair, and/or replacement of components has not degraded containment system performance. The portion of the containment system affected by the maintenance, repair and/or component replacement must be leak-tested in accordance with ANSI N14.5-2014 [8.4]. The acceptance criteria is 1×10^{-7} ref-cm^3/sec air at an upstream pressure of 1 atmosphere and downstream pressure of 0.01 atmosphere absolute or less. The test procedure sensitivity must be one-half of the reference air leakage rate (i.e., 5×10^{-8} ref-cm^3/sec of air) or less.

Page	Heading/Item/ Step	Para #/Item/Step	Line #/ Item/Step	What it was (Revision J)	What it is (Revision J-1) ***Justification (if needed)***
8-17 > 8-17a (new)	8.2.2	Note	All	Note: For shipments of Special Form material, a Periodic Leak Test is not necessary after replacement of an elastomeric cask lid seal, provided that a Periodic Leak Test has been performed on the cask's containment system within the past 12 months.	<Moved Note from page 8-17, and then rewrote as two notes.> Notes: For shipments of Special Form material, a Maintenance Leak test is not necessary after replacement of a cask lid elastomeric seal, provided that a Periodic Leak test has been performed on the cask's containment system within the past 12 months and a Pre-Shipment Leak test is performed in accordance with Paragraph 7.1.3.3. Periodic and Maintenance Leak testing on casks prior to April 2016 may have been performed in accordance with the 1997 edition of ANSI N14.5.
8-17b (new)	8.2.2	–	–	–	<New "blank" page to accommodate page 8-17 content shift.>