

7 PACKAGE OPERATIONS

The information within this chapter provides the operations used to load the AOS Transport Packaging System and prepare it for transport. These operations describe the fundamental steps needed to ensure the requirements of this SAR. The transport packages should be operated using detailed written procedures that are based upon, and consistent with, the operations described in this chapter. During actual operation, these procedures can be supplemented with engineering personnel, training classes, and/or site-specific procedures, as applicable.

Figure 7-1 and Figure 7-2 provide isometric views of Models AOS-025A and AOS-050A, respectively. Figure 7-3 provides an isometric view of Models AOS-100A and AOS-100B. Figure 7-3a provides an isometric view of Model AOS-100A-S.

Note: *Unless indicated otherwise, all information related to the Model AOS-100A is also applicable to Models AOS-100B and AOS-100A-S.*

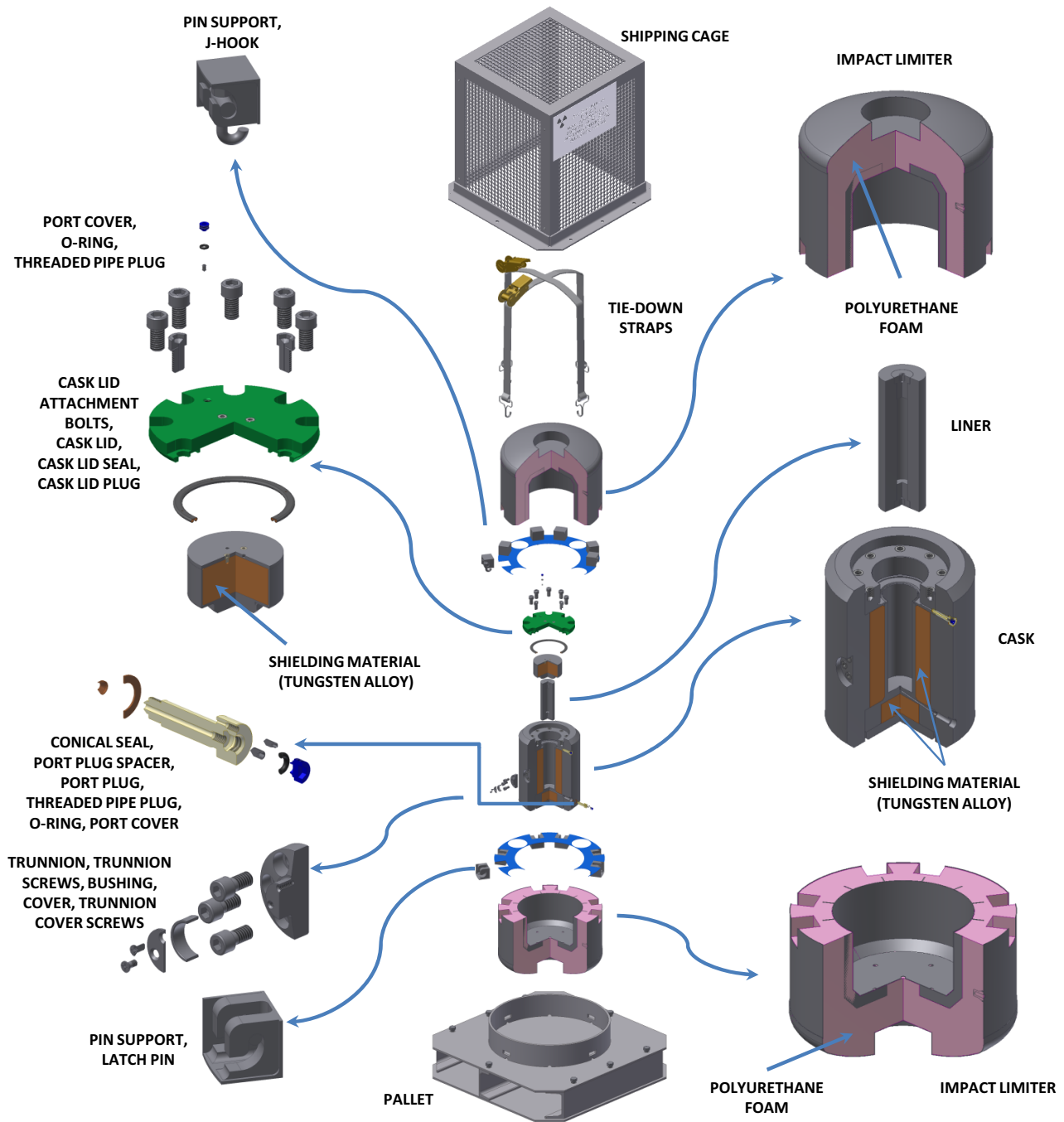


Figure 7-1. Isometric View – Model AOS-025A

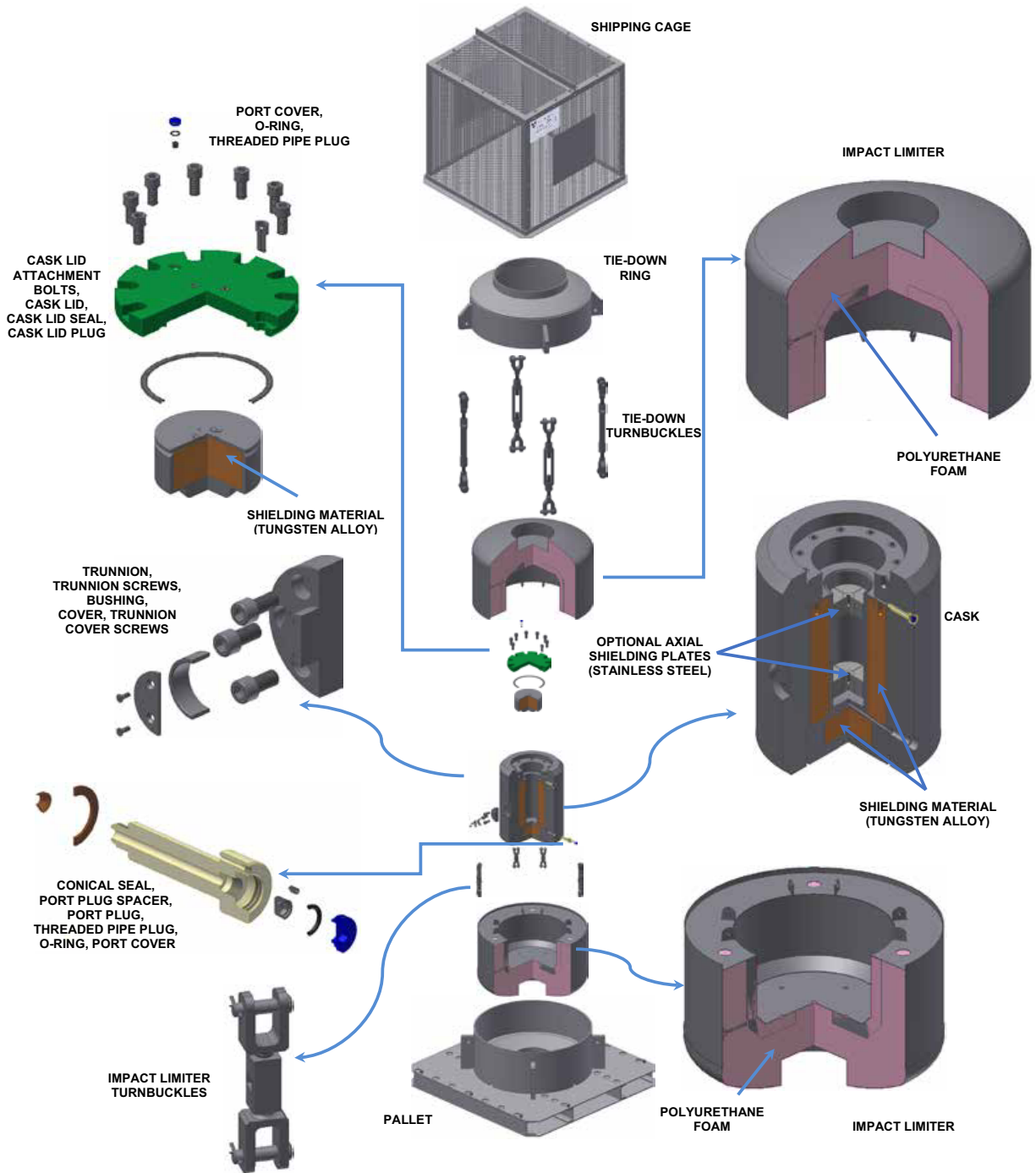


Figure 7-2. Isometric View – Model AOS-050A

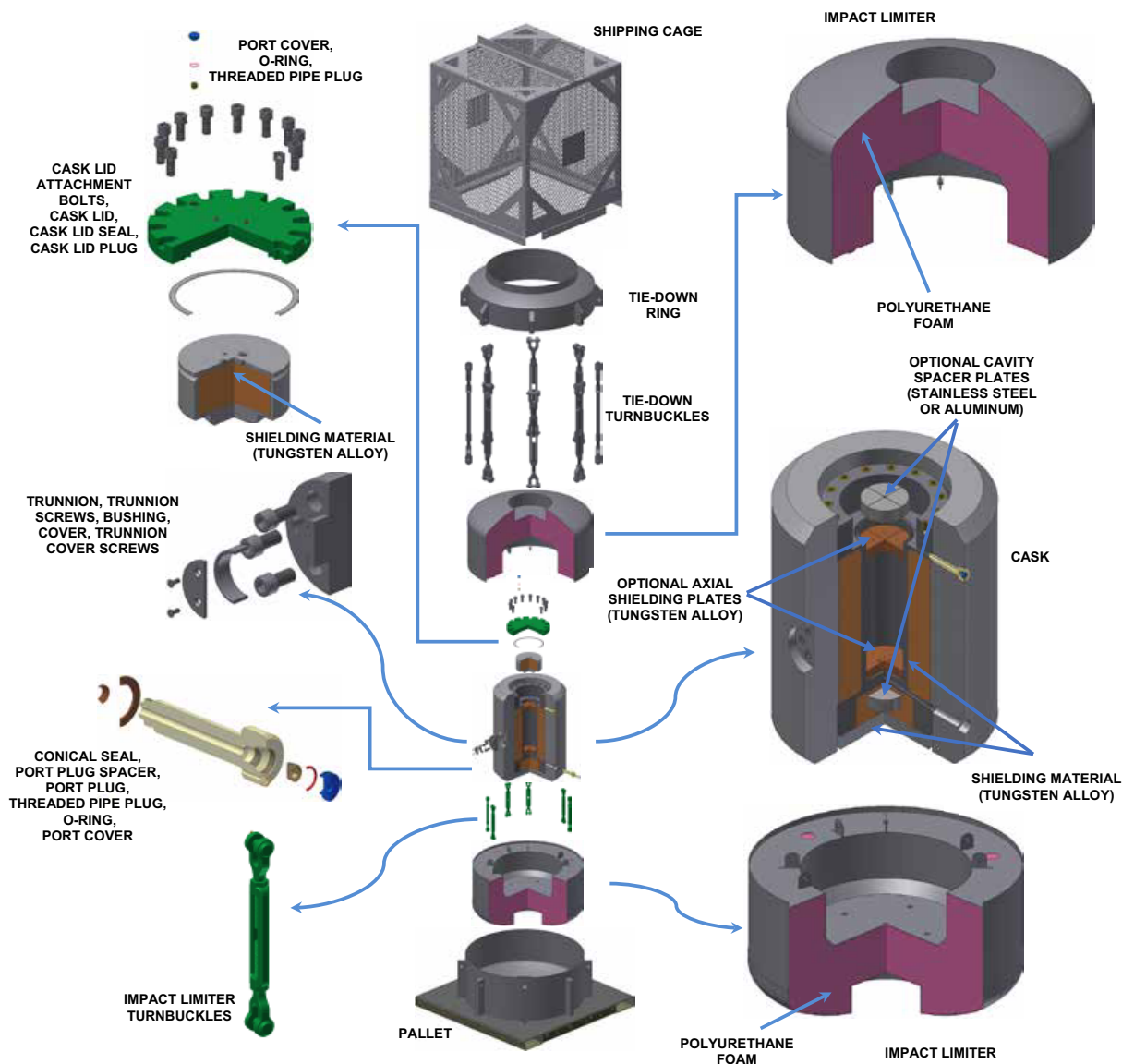


Figure 7-3. Isometric View – Models AOS-100A and AOS-100B

Note: The Model AOS-100B is identical to the Model AOS-100A, with the exceptions that the Model AOS-100B uses carbon steel as its shielding material, and the optional axial shielding plates and cavity spacer plates are not permitted.

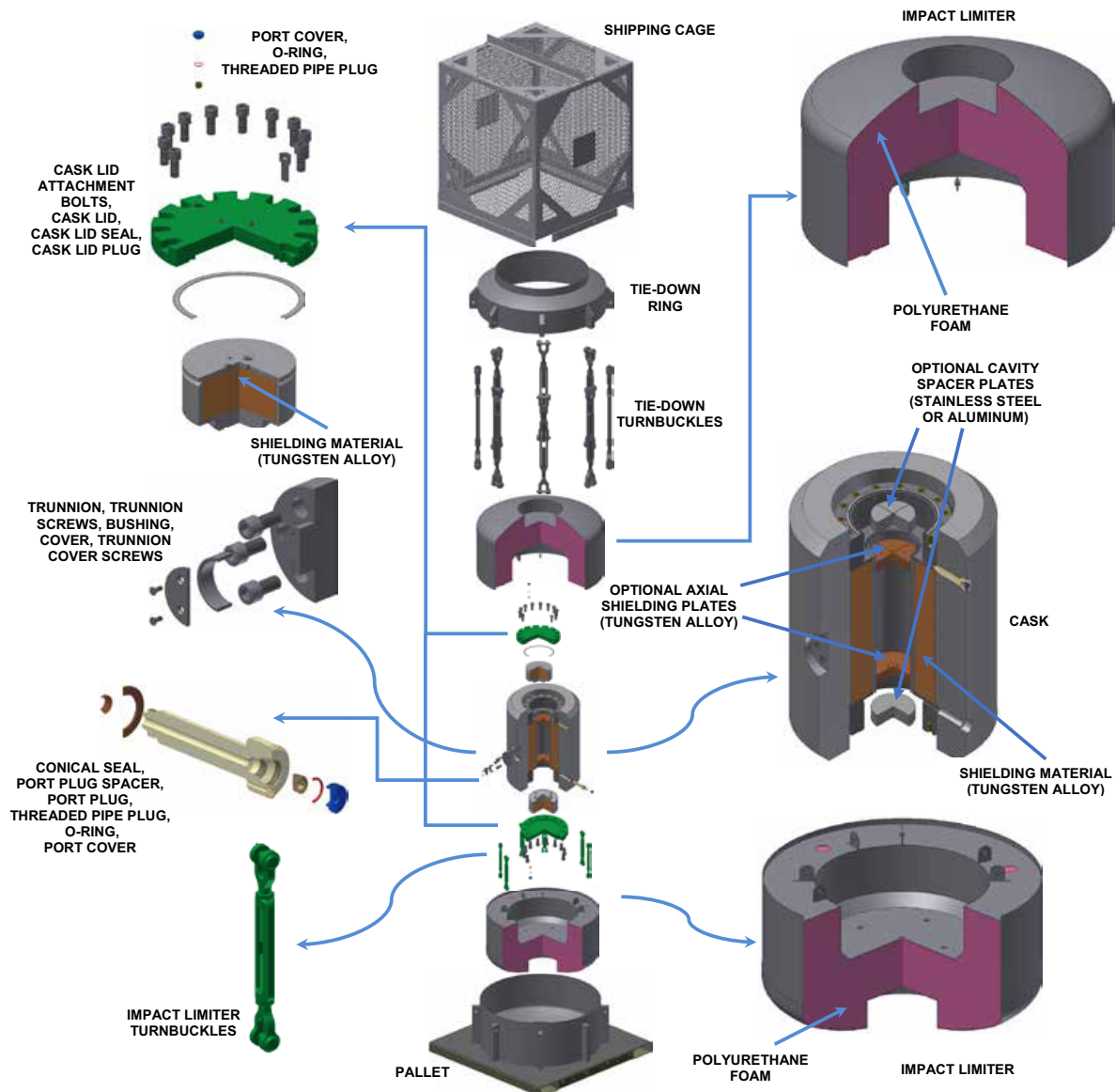


Figure 7-3a. Isometric View – Model AOS-100A-S

7.1 PACKAGE LOADING

Note: The operational steps provided in this section apply to all AOS Radioactive Material Transport Packaging System models (Models AOS-025A, AOS-050A, AOS-100A, AOS-100B, and AOS-100A-S). Any step specific to a given Model is identified within the step.

Part of the transport package loading preparation is to perform a Pre-Shipment Engineering Evaluation following IAEA TS-R-1, Paragraph 502, 10 CFR 71.87, and 49 CFR 173.475 (References [7.1], [7.2], and [7.3], respectively). The evaluation is used to ensure that the packaging, with its proposed contents, satisfies the applicable requirements of the transport package's license or certificate. This evaluation includes, but is not limited to, the review of the following:

- Proposed contents' isotopic composition, quantities, and decay heat;
- Proposed contents' form, weight, and geometry. If the content is defined as *Special form*, verify its certification from the competent authorities;
- Identify shoring device to be used. All structural shoring materials used within the cask cavity must have a melting point greater than (i) 600°F for Co-60 in metallic form and Cs-137 in the form of cesium chloride and (ii) 900°F for all other contents;
- Shielding requirements (use of additional shielding devices may be required for shipment);
- Structural requirements;
- Thermal requirements;
- Pressure requirements;
- Shipping hardware (such as liners, racks, dividers, baskets, and shoring devices);
- Maintenance records.
- Personnel qualification.

In addition, operations at the loading facility must safely support a range of activities, from receiving and inspecting the package, to preparing the loaded transport package for shipment. Each loading facility must provide fully trained personnel and detailed operating procedures to cover these activities.

7.1.1 Preparation for Loading

7.1.1.1 Receiving and Inspecting the Empty Transport Package

To receive and inspect the empty transport package:

- a. Position the transport vehicle in the Receiving Inspection area.
- b. Visually inspect the transport package for damage and proper labeling and marking. Refer to the shipping paper for shipment category and compare the marking and labels on the package to the requirement of Reference [7.3].

7.1.1.2 Removing the Transport Package from the Transport Vehicle

To remove the transport package from the transport vehicle:

- a. Position the transport vehicle, in the job staging area, for transport package removal. This operation can be aided by the use of a overhead crane or forklift truck.
- b. Position the spreader bar or forks, then connect the appropriate slings and shackles to remove the shipping cage.
- c. Remove the shipping cage and tie-down hardware.
- d. Verify that the radiation and external contamination levels are in compliance with regulatory requirements *IAEA TS-R-1, Paragraph 508*, *10 CFR 71.87(i)*, *49 CFR 173.428*, and *10 CFR 20.1906* (References [\[7.1\]](#), [\[7.2\]](#), [\[7.3\]](#), and [\[7.4\]](#), respectively).

Note: *The transport package's bottom surface is not accessible until the transport package is removed from the pallet. As a result, when measurements are required, the radiation and external contamination levels on the transport package's bottom surface are assessed after the shipping cask is removed in step [g](#).*

- e. Record any finding(s), and notify the Job Supervisor for disposition of the finding(s). Findings must be evaluated against *10 CFR 71.95* [\[7.2\]](#), to determine whether they require regulatory notification, so that proper action can be taken. The Job Supervisor is responsible for direct oversight of the personnel that are performing the work.
- f. Depending upon site-specific constraints, do one of the following:
 - Remove the upper impact limiter from the cask, then place the impact limiter into temporary storage.
 - Install trunnions. Prior to the installation, apply an anti-vibration compound on the trunnion bolt threads.
 - Lift and remove the entire package from the transport vehicle, then set down the package in an appropriate location. Next, remove the impact limiters from the shipping cask, then place the impact limiters in temporary storage.
- g. Remove the cask, using the appropriate rigging equipment.
- h. Transfer the cask to the loading area.

7.1.2 Loading of Contents

7.1.2.1 Preparing for Loading

To prepare the transport package for loading:

- a. Verify that the content to be loaded is authorized by the current transport package's Certificate of Compliance. (Refer to the Pre-Shipment Engineering Evaluation in [Section 7.1](#) and guidance in [Appendix 7.5.1](#).)
- b. Perform a visual inspection. Note any damage or unusual conditions. If part functionality is impaired, repair or replace the part, as required, and document the repair or replacement, then re-inspect the part. Notification and approval of AOS is required. Replacement or repair of any component requires that all original examinations and tests initially prescribed be performed.
- c. Depending upon the particular transport package model, remove the cask trunnions and install a lifting device specific to the facility. If using a forklift to transport the cask, protect the cask surface and secure the cask to the forks with straps. If lifting by crane, with or without a spreader bar, the lifting slings must not make an angle greater than 30°, measured from the vertical.
- d. With proper radiological protection and monitoring, remove the cask lid and cask lid plug for visual inspection of the cavity.
- e. Record any finding(s), and notify the Job Supervisor for disposition of the finding(s). Findings must be evaluated against *10 CFR 71.95* [\[7.2\]](#), to determine whether they require regulatory notification, so that proper action can be taken.
- f. Visually inspect the cask and cask lid sealing surfaces for damage or foreign material. The presence of foreign material or deep radial scratches that may result in a failed Pre-Shipment Leakage Rate test should be repaired or replaced, as required, and AOS is to be notified for written disposition.
- g. Remove the cask drain port, test port, and cask vent port covers, and pipe plugs. Completely remove all thread sealant from the pipe plugs.
- h. **Optional** – Install the lid guide pins, 90° apart. Use of the lid guide pins is mainly needed for proper alignment of the cask lid with the cask lid attachment bolt holes. The lid guide pins also protect the cask lid elastomeric or metallic seal.

7.1.2.2 Loading Irradiated Hardware or Other Contents

To load contents:

- a. Place the radioactive contents to be shipped into a shoring device (such as a rack, basket, or other such device).
The liner, axial shielding plates, and/or cavity spacer plates are used as necessary, per the requirements listed in [Table 7-1](#).
- b. Shore the load within the cavity, if needed.
- c. Place the cask lid plug into the cask.

**Table 7-1. Additional Required Shielding –
Models AOS-025A, AOS-050A, AOS-100A, and AOS-100A-S**

Model	Component	Certification Drawing ^a	Comments
AOS-025A	Liner	183C8485	Shielding liner is mandatory for all contents. (Refer to the current revision of the current revision of the NRC Certificate of Compliance 9316.)
AOS-050A	Axial Shielding Plates ^b	183C8519	Used when shipping Ir-192 and Ir-194 isotopes. (Refer to the current revision of the NRC Certificate of Compliance 9316.)
AOS-100A AOS-100A-S	Axial Shielding Plates	183C8491	Used when additional shielding is required for Co-60. (Refer to the current revision of the current revision of the NRC Certificate of Compliance 9316.)
	Cavity Spacer Plates	183C8518	

- a. Refer to [Table 1-5, “AOS Transport Packaging System Certification Drawing List – All Models,”](#) for drawing revision levels.
- b. If the Model AOS-050A axial shielding plates include threaded screw holes, each hole must be filled with a setscrew during shipment.

7.1.2.3 Installing the Cask Lid

Note: Visually inspect the cask and lid sealing surfaces, as well as the cask lid seal to be used, for damage that can prevent proper sealing of the sealing joint. Refer to [Subsection 8.2.2, “Leakage Tests \[8.4\],”](#) for detailed inspection of these items. If the metallic cask lid seal is replaced, prior to the shipment of Normal Form material, a Maintenance Test must be performed, in accordance with ANSI N14.5 (Reference [\[7.8\]](#)). The elastomeric seal option is acceptable for use only with Special Form contents, in which the cask contents provide containment for the radioactive contents.

To install the cask lid, after verifying that the cask lid seal is properly installed, use proper rigging to slowly lower the cask lid onto the cask. Carefully monitor this operation to ensure that the cask lid is properly aligned. During the placement of the cask lid, two lid guide pins may be installed in the cask lid threaded holes perpendicular to each other to maintain alignment of the cask lid attachment bolt holes with the cask lid threaded holes.

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, 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.
 - 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.
 - 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.

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 \pm 0.5 psig.
 - h. [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.
- 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.

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).

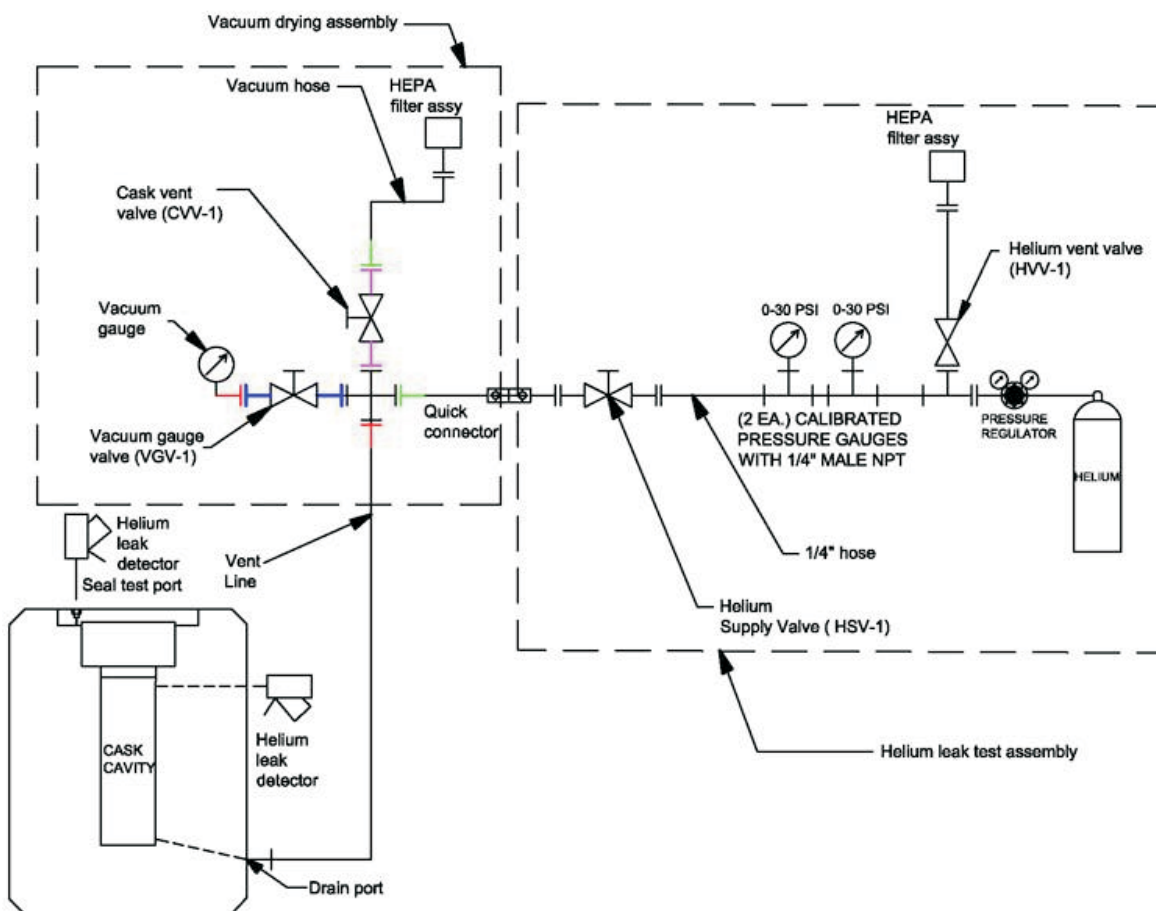


Figure 7-4. Typical Vacuum Drying System Setup and Equipment

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 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.*

Test A1 – Gas Pressure Rise: When Using Elastomeric Cask Lid Seals 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.

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.*

- 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 hold time. After the hold time, the acceptance criterion is a pressure rise that is less than or equal to 0.1 psig.

Test A2 – Gas Pressure Drop: When Using Elastomeric Cask Lid Seals 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.

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.*

- 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 pump and then wait for the prescribed hold time. After the hold time, the acceptance criterion is a pressure drop that is less than or equal to 0.1 psig.

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)

To leak test the containment system:

- 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-cm³/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-cm³/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-cm³/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.

7.1.3.4 Preparing the Cask for Transport of Radioactive Material

To prepare the cask for transporting radioactive material:

- a. Transport the cask to the staging area.
- b. Perform radiological surveys to demonstrate compliance with transport package surface dose rate requirements (refer to [Table 7-3](#)), consistent with *IAEA TS-R-1, Paragraph 531*, *10 CFR 71.47* and *71.87(j)*, and *49 CFR 173.441* (References [\[7.1\]](#), [\[7.2\]](#), and [\[7.3\]](#), respectively).

Table 7-3. Maximum Distance from Loaded Cask Surface to Take Transport Package Surface Dose Rate Measurements – All Models

Model	Axial Dose Point Maximum Distance from Cask Surface ^a	Radial Dose Point Maximum Distance from Cask Surface
	in.	in.
AOS-025	2	2
AOS-050	4	–
AOS-100	8	–

a. Equivalent to the minimum distance provided by the impact limiters to the transport package surface.

- c. Remove any site-specific lifting devices from the cask.

Note: The transport packages require that the lower impact limiter must first be installed on the pallet, before placing the cask in the impact limiter.

- d. Verify that the contamination levels on the outer shipping cask surfaces and impact limiters (both inner and outer surfaces) are in compliance with regulatory requirements *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).
- e. Verify that the lower impact limiter is installed on the pallet:
 1. **If the lower impact limiter was left on the pallet** – Place the cask into the impact limiter/pallet assembly.
 2. **If the complete transport package was removed** – Place the lower impact limiter on the pallet, then place the cask into the lower impact limiter.
- f. Install and secure the upper impact limiter.
- g. Verify that the lettering on the identification nameplate is distinguishable and conforms to the Packaging Certification drawing requirement. Re-stamp the lettering or replace the nameplate, if necessary.
- h. Remove old shipping labels and apply new ones, based upon the proposed payload, meeting the requirements of *IAEA TS-R-1, Paragraphs 526* and *541* through *543* and/or *49 CFR 172.403* (References [\[7.1\]](#) and/or [\[7.7\]](#), respectively).
- i. Apply security seals to two (2) opposite latch pins or turnbuckles, as illustrated in [Figure 7-5](#) and [Figure 7-6](#), respectively. (Alternatively, refer to step k.)

- j. Complete the radiological survey of the transport package and transport vehicle, consistent with IAEA TS-R-1, Paragraphs 530 through 532, 10 CFR 71.47 and 71.87(j), and 49 CFR 173.441 (References [7.1], [7.2], and [7.3], respectively).

Note: For the 1-m TI dose rate, the 1-m distance is from the transport package surface (that is, the shipping cask or impact limiter surface), **not** the shipping cage surface.

- k. Install the shipping cage. If the shipping cage includes the optional lifting bar, install the lifting bar guards so that the lifting bar cannot be used for lifting of the entire package or for tie down. If the security seals were not applied in step i, apply two (2) security seals between the shipping cage and pallet, on opposing sides.
- l. Apply any additional shipping label or marking that might be required to properly represent the transport package and its content, in accordance with Reference [7.3].
- m. Apply the security seal, if used, to the shipping cage, as illustrated in Figure 7-7.

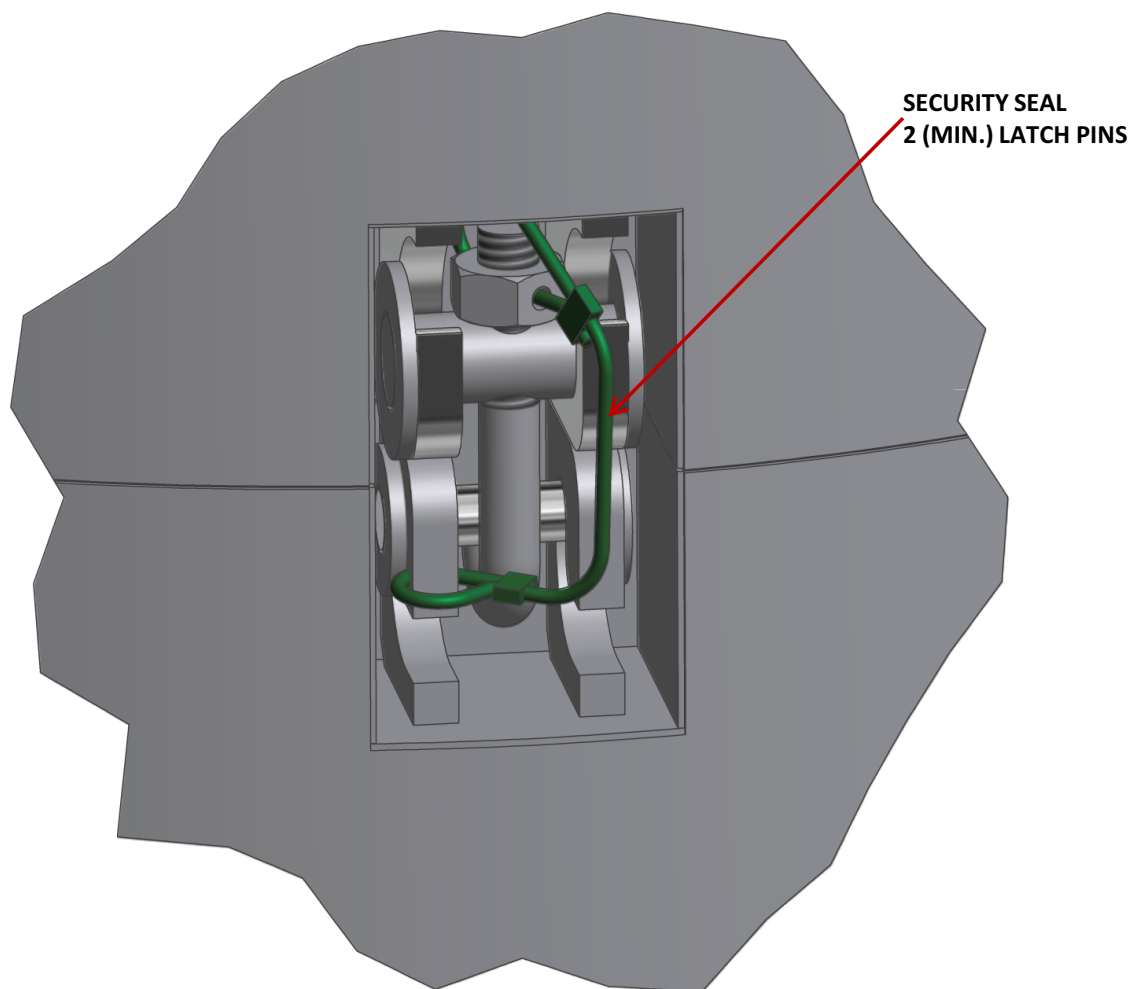


Figure 7-5. Latch Pin Security Seal

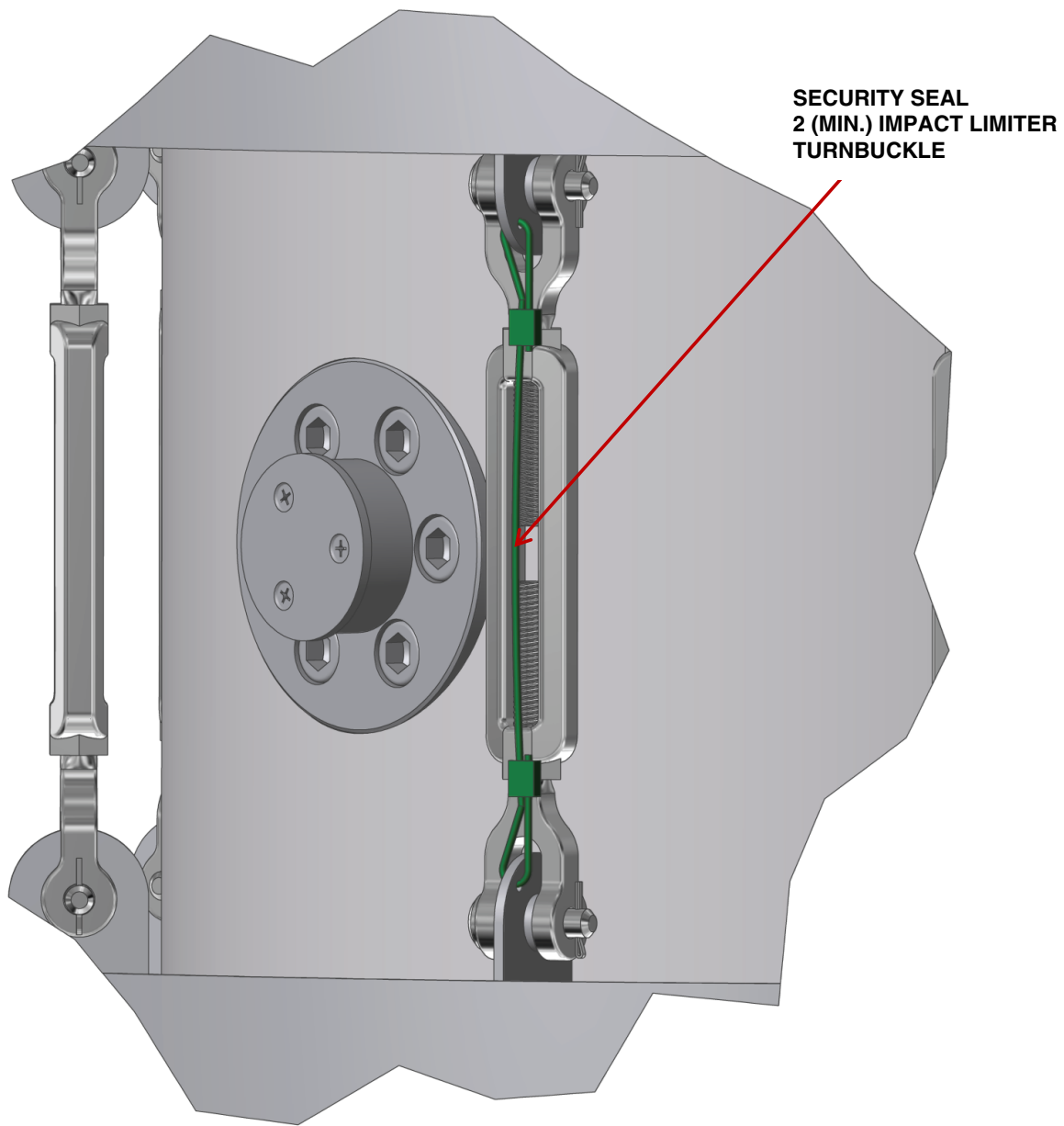


Figure 7-6. Turnbuckle Security Seal

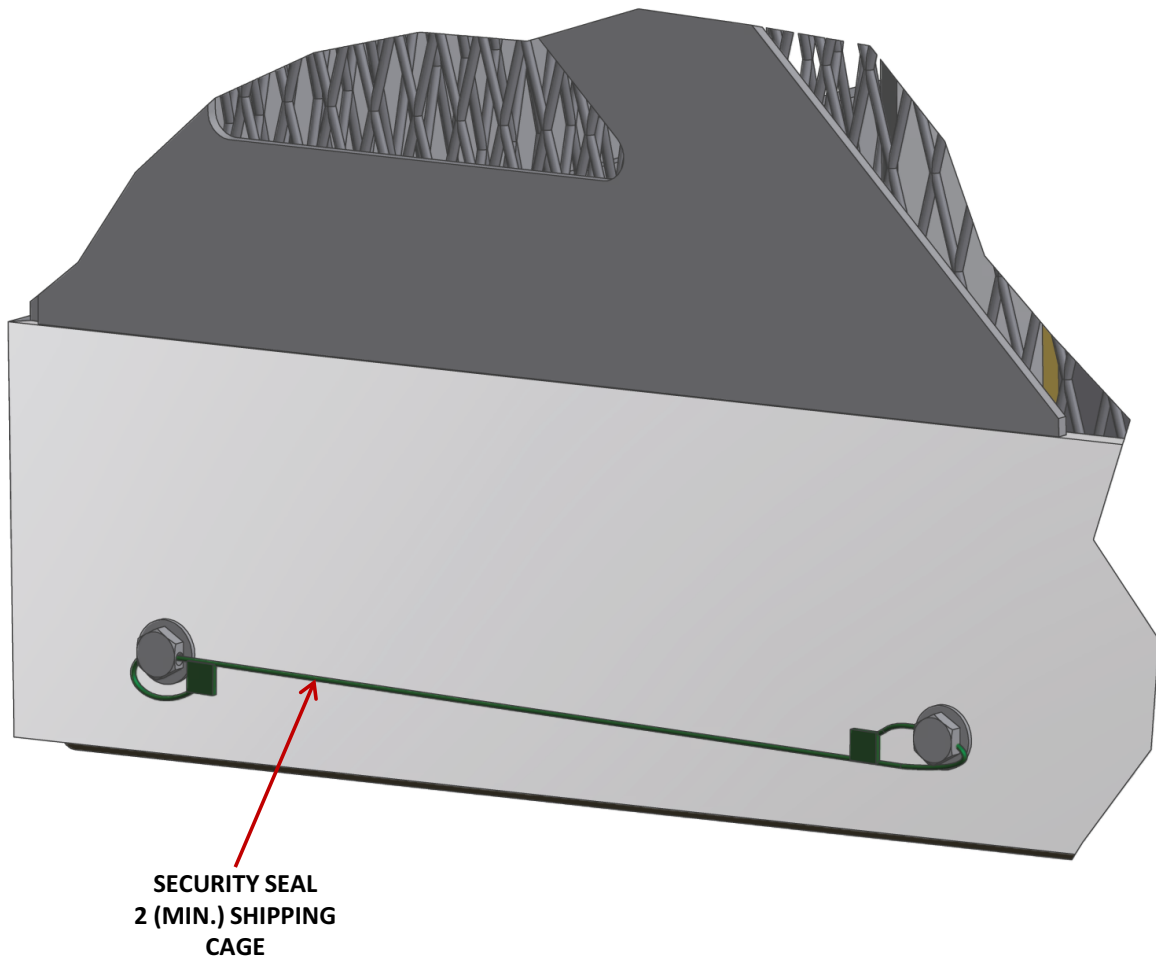


Figure 7-7. Shipping Cage Security Seal

7.2 PACKAGE UNLOADING

Note: The operational steps provided in this section apply to all AOS Radioactive Material Transport Packaging System models (Models AOS-025A, AOS-050A, AOS-100A, AOS-100B, and AOS-100A-S). Any step specific to a given Model is identified within the step.

Operations at the unloading facility are largely the reverse of the loading operations. Each unloading facility must provide fully trained personnel, and supply detailed operating procedures to cover all activities. As required by 10 CFR 71.89 [7.2], the consignor shall send to the consignee, in advance of the shipment, instructions for safely opening the transport package.

Before handling the packages, consider the following items:

- a. Review all shipping manifests against what is expected.
- b. Ensure that personnel involved in operations of the AOS Transport Packaging System are familiar with all documents pertinent to the operation and maintenance of the transport packages, and that they have received HAZMAT training, per 49 CFR 172.704 [7.7].
- c. Review [Table 2-7, “AOS Transport Packaging System Maximum Authorized Package Weight and Cg Locations – All Models”](#) (which lists the packages and their components weights), for the purpose of selecting the proper handling devices.
- d. Review [Table 3-3, “Maximum Temperature Summary, Normal Conditions of Transport – All Models,”](#) [Table 3-4, “Maximum Temperature Summary, Hypothetical Accident Conditions of Transport \(Condition 3\) – All Models,”](#) [Table 4-6, “Maximum Cask Cavity Pressure Due to Normal Conditions of Transport – All Models,”](#) and [Table 4-7, “Maximum Cask Cavity Pressure Due to Fire Condition – All Models,”](#) to be apprised of the packaging surface temperature and cavity pressures. These values represent maximum conditions.
- e. Review the Activity Limits listed in the current revision of the NRC Certificate of Compliance 9316. These values represent maximum conditions. For shipping multiple isotopes, or isotopes that emit only low-energy gamma/beta emitters (that is, all emissions, including those from their progeny, are ≤ 0.3 MeV), refer to the guidance provided in [Appendix 7.5.1](#).
- f. Review the AOS Transport Packaging System certification drawings listed in the current revision of the NRC Certificate of Compliance 9316 and [Table 1-5, “AOS Transport Packaging System Certification Drawing List – All Models,”](#) in preparation for Receiving Inspection.
- g. All repairs require AOS approval prior to performing the repairs. Any replacement of components requires notification to AOS.

7.2.1 Receipt of Package from Carrier

To receive the transport package from the carrier:

- a. Verify the integrity of the transport package's security seals. If seals are broken, indicating package tampering, isolate the transport package and immediately notify the site's Safeguards organization, then wait for their instructions. Otherwise, if the security seals are on the shipping cage, remove the security seals by cutting the wires, then properly dispose of the security seals. If the security seals are connected to the impact limiters, remove the seals after the shipping cage is detached.

Note: "Safeguards organization" refers to the organization or person at the facility responsible for radioactive material control and accounting.

- b. Position the transport vehicle in the Receiving Inspection area.
- c. Visually inspect the transport package for damage and proper labeling and marking. Refer to the shipping paper for shipment category and compare the marking and labels on the package to the requirement of Reference [7.3].
- d. Position the transport vehicle in the job staging area, for transport package removal. This operation can be aided by the use of an overhead crane or forklift truck.
- e. Position the spreader bar or forks, then connect the appropriate slings and shackles to remove the shipping cage.
- f. Remove the shipping cage and tie-down hardware.
- g. Verify that the radiation and external contamination levels are in compliance with regulatory requirements *IAEA TS-R-1, Paragraphs 508 and 530 through 532, 10 CFR 71.47 and 71.87(i), 49 CFR 173.441 and 173.443, and 10 CFR 20.1906* (References [7.1], [7.2], [7.3], and [7.4], respectively).

Note: The transport package's bottom surface is not accessible until the transport package is removed from the pallet. As a result, when measurements are required, the radiation and external contamination levels on the transport package's bottom surface are assessed after the shipping cask is removed in step j.

- h. Record any finding(s), and notify the Job Supervisor for disposition of the finding(s). Findings must be evaluated against *10 CFR 71.95* [7.2], to determine whether they require regulatory notification, so that proper action can be taken. The Job Supervisor is responsible for direct oversight of the personnel that are performing the work.
- i. Depending upon site-specific constraints, do one of the following:
 - Remove the upper impact limiter from the cask, then place the impact limiter into temporary storage.
 - Install trunnions. Prior to the installation, apply an anti-vibration compound on the trunnion bolt threads.
 - Lift and remove the entire transport package from the transport vehicle, then set down the package in an appropriate location. Next, remove the impact limiters from the shipping cask, then place the impact limiters in temporary storage.
- j. Remove the cask, using the appropriate rigging equipment.
- k. Perform radiological and smear surveys of the cask surfaces, as described in step a in Paragraph 7.2.2.

7.2.2 Removal of Contents

Note: The removal of content for all AOS Radioactive Material Transport Packaging System models (Models AOS-025A, AOS-050A, AOS-100A, and AOS-100B) is in the vertical orientation, with the exception of the Model AOS-100A-S, which is in the horizontal orientation.

To prepare to unload contents:

- a. Perform radiological and smear surveys of the cask surfaces. Compare the survey results with the pre-shipment data survey. Report any major discrepancies in the readings to the Job Supervisor, for disposition.
- b. Break the tamper-indicating device(s), if applied. In the event that the device is broken, indicating tampering, isolate the cask and immediately notify the site's Safeguards organization, then wait for their instructions.
- c. Release the torque of the cask lid attachment bolts, then remove all but five (5) of the bolts, with the exception of the Model AOS-100A-S. For the Model AOS-100A-S, all bolts should remain in place, until the cask is ready to be unloaded.

Note: At least five (5) cask lid attachment bolts must remain connected, while the cask is in transit within the site facility, for all models except the Model AOS-100A-S.

- d. Transfer the cask to the unloading area.
- e. Remove the payload from the cask, following the detailed procedure developed for the facility, based upon the guidelines provided in this chapter.
- f. If the cask contents are unloaded underwater or in a hot cell facility, perform the work as specified by the user (site) procedure.
- g. After the cask contents are removed, confirm that the cask cavity is empty.

7.2.3 Installing the Cask Lid

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

To install the cask lid:

- a. Using proper rigging, slowly lower the cask lid, over the lid guide pins (if used) and onto the cask. Carefully monitor this operation, to ensure that the cask lid is properly aligned.
- b. After the cask lid is seated, remove the lid guide pins (if used).

Note: Verify that the cask contents have been removed and that the cask cavity is empty of all material, before placing the lid onto the cask.

7.2.4 Removing the Cask from the Staging Area

To remove the cask from the staging area:

- a. Install and hand-tighten the cask lid attachment bolts.
- b. Remove the cask to the storage area, per user (site) procedure.

7.2.5 Securing the Cask Lid

To secure the cask lid, perform steps [b](#) and [c](#) in [Paragraph 7.3.2](#).

7.3 PREPARATION OF EMPTY PACKAGE FOR TRANSPORT

Note: The operational steps provided in this section apply to all AOS Radioactive Material Transport Packaging System models (Models AOS-025A, AOS-050A, AOS-100A, AOS-100B, and AOS-100A-S). Any step specific to a given Model is identified within the step.

This section describes operations that are typically performed after transporting radioactive material.

7.3.1 Inspecting the Cask Cavity

To inspect the cask cavity:

- a. Remove the cask lid and cask lid plug from the empty cask and verify that the cask is empty.
- b. Gather the necessary information, per site procedure, so that personnel can certify the transport package is “empty.”
- c. Perform a radiological survey of the cavity, to determine the extent of any contamination, in accordance with user (site) procedures.
- d. If the cask is shipped as “empty,” decontaminate the cavity to the limits defined in IAEA TS-R-1, Paragraph 520, and 49 CFR 173.428 (References [7.1] and [7.3], respectively).
- e. Visually inspect the cask cavity and ensure that there is no free-standing water. If free-standing water is present, dry the cask cavity. (The drying instructions are provided in Paragraph 7.1.3.1.)

7.3.2 Installing and Securing the Cask Lid

Note: Re-use of the lid seal is allowed for empty packaging.

To install and secure the cask lid:

- a. Using proper rigging, slowly lower the cask lid plug and lid onto the cask, over the lid guide pins (if used). Carefully monitor this operation, to ensure that the cask lid is properly aligned.

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

- b. Torque the cask lid attachment bolts (refer to Table 7-2) in a crisscross pattern, with a final pass all the way around, to ensure even seal compression.
- c. Inspect the cask, to ensure that the cask drain port plugs, cask vent port plugs, and covers are properly installed.

7.3.3 Leak Testing to Verify the Assembly

Not applicable. Leak testing is not performed on empty packaging.

7.3.4 Preparing the Empty Cask for Transport

Decontaminate the external surfaces of the empty cask, to a level consistent with *IAEA TS-R-1, Paragraph 508*, and *49 CFR 173.443* (References [\[7.1\]](#) and [\[7.3\]](#), respectively). Perform a dose rate survey to demonstrate compliance with regulatory requirements *IAEA TS-R-1, Paragraph 516*, and *49 CFR 173.428* (References [\[7.1\]](#) and [\[7.3\]](#), respectively).

7.4 OTHER OPERATIONS

7.4.1 Records and Reporting Requirements

7.4.1.1 Records for Each Shipment

AOS Transport Packaging System users must maintain records of their shipments, per the requirements of *10 CFR 71.91* [7.2], for at least three (3) years. In addition, shipment radiological surveys and monitoring must be recorded, per *10 CFR 20.2103* [7.4]. All records must be maintained, as per requirements documented in *10 CFR 21.51* [7.5].

7.4.1.2 Package History Records

AOS maintains all historical records of the AOS Transport Packaging System, at their headquarters QA office. These records fulfill the requirements of *10 CFR 71.91* [7.2], and are available to the NRC for inspection, upon request.

7.4.1.3 Reports

All notifications shall be as required by the applicable portion of *10 CFR 21* (Reference [7.5]).

Report all incidents that involve any significant reduction in package effectiveness during use, as well as any defect of safety significance, found after the first use of the package and thereof, any loss or theft of licensed material, radiation exposure to personnel or to the public above the limits specified in *10 CFR 20.1301* [7.4], contamination or suspected contamination, and any fire, spillage, or breakage, as required by *10 CFR 21*, *10 CFR 20*, *49 CFR 171*, and *49 CFR 172* (References [7.2], [7.4], [7.6], and [7.7], respectively).

7.5 APPENDIX

7.5.1 Dose Rate and Decay Heat Limit Compliance

Dose rate and decay heat limit compliance should be demonstrated through one of the following methods:

- **Shipping cask contents that contain a single radioisotope (or mixture of only Ir-192 and Ir-194)** – Ensure that the isotope’s activity does not exceed its limit for the appropriate shipping cask variant listed in the current revision of the NRC Certificate of Compliance 9316. If the limits determined based on *10 CFR 71.47(b)* [7.2] are used, the transport package must be shipped as exclusive use. If the isotope is not listed for the shipping cask variant, –or– the isotope’s activity within the shipping cask contents is greater than the listed activity limit, the shipping cask contents are not acceptable for shipment.
- **Shipping cask contents that contain multiple radioisotopes, including low-energy gamma and/or beta emitters** (as defined in [Appendix 5.5.6, “Isotopes Insignificant to External Dose Rates”](#)) – Calculate the external dose rates and shipping cask contents’ total decay heat, using the method defined in [Appendix 5.5.5, “Shipments of Multiple Isotopes under 10 CFR 71.47\(a\),”](#) and [Appendix 5.5.7, “10 CFR 71.47\(b\) Exclusive Use Activity Limits for Models AOS-100A and AOS-100A-S.”](#) All dose rate and decay heat calculations should be documented on an AOS QA program-approved form, similar to the example provided in [Figure 7-8](#) for the external dose rate calculation methodology. The following items outline dose rate limits and shipping cask decay heat limit *10 CFR 71.47(a, b)* (Reference [7.1]) compliance:

A Dose Rate Limit and Shipping Cask Decay Heat Limit 10 CFR 71.47(a) Compliance

For each shipping cask model, demonstrate compliance with shipping cask decay heat limits and *10 CFR 71.47(a)* dose rate limits, using the decay heat limit of the respective shipping cask from [Table 1-3, “Content Limitations – All Models,”](#) the equations in [Table 5-34, “10 CFR 71.47\(a\) Dose Rate Acceptance Criteria for Multiple Isotopes,”](#) and the values from the respective [Appendix 5.5.5 Multiple Isotope Calculation Reference Value Summary tables \(Table 5-35, Table 5-35a, Table 5-35b, and Table 5-35c for Models AOS-100A and AOS-100A-S, AOS-025A, AOS-050A, and AOS-100B, respectively\).](#)

B Dose Rate Limit and Shipping Cask Decay Heat Limit 10 CFR 71.47(b) Compliance

For Models AOS-100A and AOS-100A-S, if it is determined that the contents’ radionuclide inventory results in external dose rates that exceed *10 CFR 71.47(a)* limits, *10 CFR 71.47(b)* regulatory dose rate limits may be used, provided that:

- Transport package is shipped as exclusive use, and
- Compliance with external dose rate limits are calculated using the equations listed in [Table 5-40a, “10 CFR 71.47\(b\) Dose Rate Acceptance Criteria for Multiple Isotopes,”](#) and isotope values listed in [Table 5-41, “Multiple Isotope Exclusive Use Calculation Reference Values – Models AOS-100A and AOS-100A-S.”](#)

Low energy gamma and beta emitters (that is, all emissions, including those from their progeny, are ≤ 0.3 MeV) are permitted in Models AOS-100A and AOS-100A-S, without accounting for any contribution to external dose rates. To clarify, this requirement applies to the full beta spectrum, **not** the average beta energy (that is, $E_{\max,\beta} \leq 0.3$ MeV). For each isotope within this category, the decay heat Q-value (in W/Ci) shall be determined using the SCALE 6.1 ORIGEN (Reference [\[7.9\]](#)) decay library *origen.rev03.decay.data*, and the contribution to the total decay heat from these isotopes and their progeny shall be included. This applies to contents under both [A](#) and [B](#) above. Based on these requirements, transporting a single low energy gamma and/or beta emitter is acceptable, given that the procedures provided above are followed, and the contents do **not** exceed the Model AOS-100A and AOS-100A-S shipping cask 400-W decay heat limit.

Low energy gamma and beta emitters are **not** permissible contents in the Model AOS-025A, AOS-050A, and AOS-100B shipping cask models. These shipping cask models are restricted to isotopes that are specifically listed in the respective tables of the current revision of the current revision of the NRC Certificate of Compliance 9316 and [Appendix 5.5.5](#).

**Calculation Sheet - Procedure for Mixing
Isotopes in AOS-100A**

PR9110.5 Table 1 Column No. 1	Enter proposed shipment activity in this column (Ci)	PR9110.5 (6.3) Table 1 Column No. 2	PR9110.5 (6.5) Table 1 Column No. 3	PR9110.5 (6.4) Table 1 Column No. 4	PR9110.5 (6.6) Table 1 Column No. 5
A_i Isotope		R_{Si} Dose Rate/ Curie on External Surface (mrem/hr/Ci)	R_{1mCi} Dose Rate/ Curie at 1m from Shipping Cask Surface (mrem/hr/Ci)	R_{1mPi} Dose Rate/ Curie at 1m from Transport Package Surface (mrem/hr/Ci)	Q_i Heat Generation Rate (W/Ci)
Co-60		3.912E-01	5.545E-02	3.292E-02	1.550E-02
Co-60-B		1.139E-01	1.833E-02	1.093E-02	1.550E-02
Co-60-C		1.868E-02	1.833E-02	5.314E-04	1.550E-02
Cs-137		3.188E-03	4.152E-04	2.570E-04	4.990E-03
Hf-181		2.595E-04	3.413E-05	2.182E-05	4.330E-03
Ir-192		5.802E-04	7.547E-05	4.898E-05	6.130E-03
Ir-194		4.502E-03	6.536E-04	3.871E-04	5.300E-03
Zr-95/Nb-95		3.098E-02	4.106E-03	2.571E-03	1.620E-02
H-3		0	0	0	3.380E-05
C-14		0	0	0	2.940E-04
V-49		0	0	0	2.640E-05
Fe-55		0	0	0	3.470E-05
Ni-63		0	0	0	1.040E-04
I-125		0	0	0	3.590E-04

Calculated Total Radiation Levels:

Dose Rate on External Surface = 0.00E+00 mrem/hr
 Dose Rate at 1m from Shipping Cask Surface = 0.00E+00 mrem/hr
 Dose Rate at 1m from Transport Package Surface = 0.00E+00 mrem/hr

Maximum Value:

TRUE 180 mrem/hr maximum
 TRUE 900 mrem/hr maximum
 TRUE 9.0 mrem/hr maximum

Calculated Total Heat:

Total Heat Generation = 0.00E+00 W

TRUE 400 W maximum

NOTE: Only those isotopes identified in the SAR, AOS Document No. FM9054 and low energy gamma/beta emitters are to be evaluated and shipped (See PR9110.5 Table 1)

Document Approval:			
Completed By:		Engineering Approval:	
Name/Signature:	Date:	Name/Signature:	Date:
QA:		President:	
Name/Signature:	Date:	Name/Signature:	Date:

**Figure 7-8. Example Dose Rate/Decay Heat Calculation Sheet
(Model AOS-100A Non-Exclusive Shipment Version Shown)**

7.6 REFERENCES

- [7.1] *International Atomic Energy Agency (IAEA) Safety Standards Series No. TS-R-1 (IAEA TS-R-1)*, “Regulations for the Safe Transport of Radioactive Material,” 1996 Ed. (as amended 2003).
- [7.2] U.S. Nuclear Regulatory Commission (NRC), *Title 10, Code of Federal Regulations, Part 71 (10 CFR 71)*, “Packaging and Transportation of Radioactive Material.”
- [7.3] U.S. Department of Transportation (DOT), *Title 49, Code of Federal Regulations, Part 173 (49 CFR 173)*, “Shippers – General Requirements for Shipments and Packagings.”
- [7.4] U.S. Nuclear Regulatory Commission (NRC), *Title 10, Code of Federal Regulations, Part 20 (10 CFR 20)*, “Standards for Protection Against Radiation.”
- [7.5] U.S. Nuclear Regulatory Commission (NRC), *Title 10, Code of Federal Regulations, Part 21 (10 CFR 21)*, “Reporting of Defects and Noncompliance.”
- [7.6] U.S. Department of Transportation (DOT), *Title 49, Code of Federal Regulations, Part 171 (49 CFR 171)*, “General Information, Regulations, and Definitions.”
- [7.7] U.S. Department of Transportation (DOT), *Title 49, Code of Federal Regulations, Part 172 (49 CFR 172)*, “Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements.”
- [7.8] American National Standards Institute, *ANSI N14.5-2014*, “Radioactive Materials – Leakage Tests on Packages for Shipment,” June 19, 2014.
- [7.9] Oak Ridge National Laboratory, *ORNL/TM-2005/39 Version 6.1*. “SCALE: A Comprehensive Modeling and Simulation Suite for Nuclear Safety Analysis and Design,” June, 2011.