7.0 PACKAGE OPERATIONS

This Section describes the procedures to be used for loading and unloading the 3-60B cask. These procedures are intended to ensure the cask is prepared for transport and generally operated in a manner consistent with Sections 1 through 6, and that exposure to radiation by operating personnel is minimized. The operating procedures in this Section are presented sequentially in actual order of performance, unless otherwise indicated. Actual operations will be conducted using detailed procedures that are consistent with this Section.

7.1 PACKAGE LOADING

Cask loading may be performed either in a pool ("wet") or in cask loading area ("dry"). Cask unloading is normally performed "dry" – typically at a licensed burial facility.

7.1.1 Preparation for Loading

7.1.1.1 Inspect the package to ensure there is no damage to the exterior that will impair its ability to function as intended.
7.1.1.2 Detach each impact limiter from the cask body. Using lifting equipment remove each impact limiter.
7.1.1.3 Disconnect the front and rear trunnion tie down equipment.
7.1.1.4 Attach lifting equipment to the lifting trunnions and remove the packaging from the shipping cradle. Place the cask in the loading area (dry loading) or preparation area (wet loading). If necessary, clean the exterior surfaces.
7.1.1.5 Remove the vent port. Inspect the O-rings and seals and replace them if defects are found that are severe enough to prevent proper sealing.

Note: When O-rings or seals are replaced, leak testing is required as specified in Section 8.2.

7.1.1.6 Remove the lid bolts and attach the lifting attachments to the lid.
7.1.1.7 Remove the lid from the cask.
7.1.1.8 Install lid alignment pins
7.1.1.9 Inspect the lid O-rings and replace them if defects are found that are severe enough to prevent proper sealing. Inspect the bolts and sealing surfaces for damage or defects and clean as necessary. Replace any components when defects or damage is found that will preclude proper sealing.

Note: When O-rings or seals are replaced, leak testing is required as specified in Section 8.2.

7.1.1.10 Dry Loading

a. Inspect accessible areas of the cavity for damage, loose materials, or moisture.
b. Drain port may be removed if necessary. Inspect the O-rings and seals if removed and replace them if defects are found that are severe enough to prevent proper sealing.

Note: When O-rings or seals are replaced in the vent or drain port, leak testing is required as specified in Section 8.2.

7.1.1.11 Wet Loading

a. Remove the drain port plug. Inspect the O-rings and seals and replace them if defects are found that are severe enough to prevent proper sealing.

Note: When O-rings or seals are replaced in the vent or drain port, leak testing is required as specified in Section 8.2.

b. Attach lifting equipment to the upper trunnion and lower the cask into pool.

Note: Precautions may be taken to minimize possible spread of contamination, such as first filling the cavity with clean water or rinsing the sides of the cask with clean water as it is lowered into the pool.

c. Remove the lifting equipment.

7.1.2 Loading of Contents

7.1.2.1 Verify intended contents meet the requirements of the Certificate of Compliance for the 3-60.

a. For contents loaded wet or which contain water, determine the maximum decay heat to limit hydrogen generation per Attachment 7.1, and verify the contents do not exceed this decay heat.

b. Ensure the contents, secondary container, and packaging are chemically compatible, i.e., will not react to produce flammable gases. The EPA's Chemical Compatibility Chart, Attachment 2, should be used to guide the evaluation of chemical compatibility.

7.1.2.2 Load the contents into the cavity.

Note. Shoring may be used as necessary to minimize movement of contents during transport.

7.1.2.3 Dry Loading. .

a. Attach lifting equipment to the closure lid and lower closure lid onto the cask. Survey the cask for safe radiation levels and inspect the lid for proper seating.
b. Install two or more lid bolts hand tight.
c. Go to Step 7.1.2.5

7.1.2.4 Wet Loading.

a. Attach lifting equipment to the closure lid and lower closure lid onto the cask. Visually verify proper lid installation.
b. Install two or more lid bolts hand tight.
c. Attach lifting equipment and lift the cask until it clears the surface of the pool. Survey the cask for safe radiation levels and inspect the lid for proper seating. Leave the cask suspended until no water is exiting the drain port. The cask exterior may be rinsed with demineralized water while it is suspended over the pool.
d. Place the cask vertically in the preparation area.
e. Remove the lifting and handling equipment from the cask lifting trunnions.
f. Do not proceed if water is exiting the drain port.

7.1.2.5 Re-install the vent and drain port plugs with their O-rings and seals. Torque the drain and vent port bolts to 20 ft-lbs.

7.1.2.6 Remove the alignment pins from the lid bolt holes.

7.1.2.7 Install the remaining lid closure bolts. Torque all bolt to 300 ft-lbs.

7.1.2.8 Decontaminate the exterior surfaces of the cask as necessary.

7.1.3 Preparation for Transport

7.1.3.1 Pre-shipment leak tests of the cask lid, vent port, and drain port shall be performed in accordance with the requirements and procedures in Chapter 8.
7.1.3.2 Attach lifting and handling equipment to the cask lifting trunnions, move the cask to the conveyance loading area, and mount the cask in its shipping cradle on the transport trailer.
7.1.3.3 Attach the impact limiters to the cask.
7.1.3.4 Attach the tamper-indicating seals to the cask as required.
7.1.3.5 Verify that external radiation and contamination levels do not exceed the limits of 49 CFR 173.441 or .443.
7.1.3.6 Verify that the exterior surface of the package does not exceed the temperature limits specified in 49CFR173.442.

7.2 PACKAGE UNLOADING

Packages containing radioactive material in excess of Type A quantities shall be received, monitored, and handled by the licensee receiving the package in accordance with requirements in 10CFR20.1906 as applicable.

7.2.1 Receipt of Package from Carrier

7.2.1.7 Inspect the package to ensure there is no damage to the exterior that will impair its ability to function as intended. Perform a radiation and contamination survey of the exterior. Verify that the tamper-indicating seals are still attached.
7.2.1.8 Detach each impact limiter from the cask body. Using lifting equipment remove each impact limiter from the package.
7.2.1.9 Disconnect the front and rear trunnion tie down equipment.
7.2.1.10 The cask can be removed from the shipping cradle in either the vertical or horizontal orientation. If removed in the vertical orientation, the lifting equipment is to be attached to the lifting trunnions. If it is removed in the horizontal orientation, attach the lifting equipment to all four trunnions.
7.2.1.11 Place the cask in the work area in either the vertical or horizontal orientation.

7.2.2 Removal of Contents

7.2.2.1 (Optional Step). Open the vent port in the cask lid. Precautions must be taken to protect personnel opening the port from gases escaping while it is being opened.
7.2.2.2 Loosen the lid bolts and remove the lid.
7.2.2.3 Remove the contents from the cavity.
7.2.2.4 The cask may be removed from service for maintenance or other purposes, or it may reassembled per steps 7.1 or 7.3.

7.3 PREPARATION OF AN EMPTY PACKAGE FOR TRANSPORT

7.3.1 Preparation

7.3.1.1 Confirm the cavity is empty of contents are far as practicable
7.3.1.2 Survey the interior; decontaminate the interior if the limits of 10 CFR 428(e) are exceeded

7.3.1.3 Install the lid.
7.3.1.4 Install the lid closure bolts. Torque all bolt to 300 ft-lbs.
7.3.1.5 Re-install the vent and drain port plugs with their O-rings and seals. Torque the drain and vent port bolts to 20 ft-lbs.
7.3.1.6 Decontaminate the exterior surfaces of the cask as necessary.
7.3.1.7 Inspect the exterior and confirm it is unimpaired.
7.3.1.8 Attach lifting and handling equipment to the cask lifting trunnions, move the cask to the conveyance loading area, and mount the cask in its shipping cradle on the transport trailer.
7.3.1.9 Install the impact limiters.
7.3.1.10 Attach the tamper-indicating seals.
7.3.1.11 Confirm the requirements of 49 CFR 173.428 are met.

7.3.2 Special Preparations

No special preparations or procedures are required for transporting the 3-60B empty.

ATTACHMENT 7.1

DECAY HEAT LIMIT

The maximum allowable decay heat, W, that will result in a 5% hydrogen concentration at the end of the shipping period, T (conservatively set at 60 days), can be determined from the weight fraction of water in the contents and the void fraction, which is the smallest void volume in which hydrogen could collect divided by the cask cavity volume, V_{CC}, (105231 in^3 or 1,724,000 cm^3). With the shipment decay heat limited to W, the flammable gas (hydrogen) concentration is limited to less than 5% and the cask limit is not exceeded. W is determined as follows:

$$W = 4.46\text{watt} \times F_V \times F_{H2O}^{-1} \text{ or 500 watt, whichever is less}$$

where,
W = the maximum allowable decay heat in watts
F_V = void fraction
F_{H2O} = weight fraction of water in the contents

Decay Heat Limit Calculation Process (performed by the shipper's engineering staff or approved consultants)

1. Water Weight Fraction Determination
   1.1. Determine the mass of the secondary container (liner), M_L.
   1.2. Determine the mass of contents, M_C.
   1.3. Determine the mass of water in the cask, M_W, after de-watering, if applicable, and draining the cavity, if applicable.
   1.4. Calculate the water weight fraction, F_{H2O}

   $$F_{H2O} = M_W / (M_L+M_C+M_W)$$

2. Void Fraction Determination
   2.1. Determine the volume of contents, V_C
   2.2. Determine the interior volume (cavity) of the secondary container (liner), V_{IL}.
   2.3. Determine the exterior volume of the liner, V_{EL}.
   2.4. Calculate the void, V

   for a sealed liner,

   $$V = V_{IL} - V_C$$

   for an open or screened liner,

   $$V = V_{CC} - V_C - (V_{EL} - V_{IL})$$

   2.5. Calculate the void fraction, F_V

   $$F_V = V / V_{CC}$$

3. Decay Heat Limit Determination
   3.1. Calculate the decay heat limit, W, in watts

   $$W = 4.46 \times F_V \times F_{H2O}^{-1} \text{ or 500 (the cask heat limit), whichever is less}$$

   3.2. Ensure the radionuclide decay heat of the shipment contents does not exceed W.

Several examples of the calculation of the maximum decay heat for various contents and configurations follow.

EXAMPLE 1 - IRRADIATED HARDWARE

The hydrogen generation calculation for typical irradiated hardware waste forms loaded underwater depends on the amount of water in the cask cavity after the cask is drained. Acceptance testing of the cask after fabrication has demonstrated that no more than 2 gallons of water is retained in the cavity after draining. The liner is a screened steel canister 34" OD x 108"L with ½" walls, base, and lid. The measured mass of the liner, M_L, is 1858 lbs. An engineering assessment of the irradiated hardware loaded into the liner by plant engineering staff has determined that no more than 2 gallons of water will be retained in the liner after draining. Thus, the total amount of water retained in the cask is 4 gallons, weighing 33 lbs (M_w). The cask contents are limited to 9500 lbs. To ensure compliance, the solid contents are limited by the user to 9400 lbs.

The mass of irradiated hardware, M_H, is 9400-1858 = 7542 lbs.

The water weight fraction, F_w, is:

$$F_w = M_w / (M_L + M_H + M_w)$$

$$F_w = 0.0035$$

The density of the irradiated hardware and the liner, ρ, is 8 g/cc or 0.289 lb/in^3

The volume of the cask cavity, V_{CC}, is 105231 in^3.

The volume of the contents, V_H, is:

$$V_H = M_H / \rho$$

The interior volume of the liner, V_{IL}, is

$$V_{IL} = \pi r^2 H = \pi \times (33/2)^2 \times (108-1)$$

The exterior volume of the liner, V_{EL}, is:

$$V_{EL} = \pi r^2 H = \pi \times (34/2)^2 \times (108)$$

Since the liner has open screens at the bottom, the void, V, is

$$V = V_{CC} - V_H - (V_{EL} - V_{IL}) = 72573 \text{ in}^3$$

The void fraction, F_V, is:

$$F_V = VOID_H / V_{cavity}$$

$$F_V = 0.69$$

Thus, the decay heat limit, W, is:

$$W = 4.46 \text{ watts} \times F_V / F_w \text{ or } 500 \text{ watts, whichever is less}$$

$$W = 879 \text{ watts or } 500 \text{ watts, whichever is less}$$

$$W = 500 \text{ watts}$$

EXAMPLE 2 - DEWATERED SWARF

Swarf is contained in a sealed steel liner, 34" OD x 108"L, dewatered to 1% of the waste volume. The mass of swarf is limited so the cask contents limit is not exceeded. The cask contents are limited to 9500 lbs. To ensure compliance, the solid contents are limited by the user to 9400 lbs.
The liner is a sealed steel canister with ½" walls, base, and lid. The mass of the liner, M_L, is 1858 lbs. The liner has an internal volume of 1500 L.

The mass of swarf, M_{sw}, is:

$$M_{sw} = 9400-1858 = 7542 \text{ lbs}$$

Swarf has a measured density of 4.0 g/cc. Therefore, the volume of the swarf, V_{sw} is:

$$V_{sw} = 7542 \text{ lbs x } 454 \text{ g/lb} \div 4.0 \text{ g/cc} = 856{,}000 \text{ cc}$$

The volume of water, V_w, after dewatering, is 1% of the swarf volume or:

$$V_w = 1\% \text{ x } V_{sw} = 8{,}560 \text{ cc}$$

With a density of 1 g/cc, the mass of water, M_w, is:

$$M_w = V_w \text{ x } 1 \text{ g/cc} = 8{,}560 \text{ g} = 18.9 \text{ lbs}$$

The water weight fraction, F_w, is:

$$F_w = M_w / (M_L + M_{sw} + M_w) = 0.002$$

The calculated volume of the cask cavity, V_{cavity}, is 105231 in^3 or 1,724,000 cc

The void in the liner is:

$$VOID = V_L - V_{sw} = 1{,}500{,}000 - 856{,}000 = 644{,}000 \text{ cc}$$

The void fraction, F_V, is:

$$F_V = VOID / V_{cavity}$$

$$F_V = 0.37$$

Thus, the decay heat limit, W, is:

$W = 4.46$ watts x F_V / F_w or 500 watts, whichever is less
$W = 825$ watts or 500 watts, whichever is less
$W = 500$ watts

Example 3 – De-watered Inorganic Resin

The resin is contained in a sealed metal liner, 34" OD x 108"L, dewatered to 1% of the waste volume. The filling/dewatering process results in the liner being 85% full. The de-watered resin has a measured density of 0.65 g/cc. The liner is a sealed metal canister with ½" walls, base, and lid having a calculated internal volume of 1500 L (V_{IL}). The measured weight of the liner, M_L, is 1950 lbs.

The volume of the resin, V_R is:

$$V_R = 1500 \text{ L} \times 85\% = 1,275,000 \text{ cc}$$

The mass of resin, M_R, is:

$$M_R = 1,275,000 \times 0.65 = 828750 \text{ g} = 1825 \text{ lbs}$$

The volume of water, V_w, after dewatering, is 1% of the resin volume or:

$$V_w = 1\% \times V_R = 12,750 \text{ cc}$$

With a density of 1 g/cc, the mass of water, M_w, is:

$$M_w = V_w \times 1 \text{ g/cc} = 12,750 \text{ g} = 28.1 \text{ lbs}$$

The water weight fraction, F_{H2O}, is:

$$F_{H2O} = M_w / M_L + M_{sw} + M_w = 0.007$$

The calculated volume of the cask cavity, V_{CC}, is 105231 in^3 or 1,724,000 cc

The void in the liner is:

$$VOID = V_{IL} - V_R = 1,500,000 - 1,275,000 = 225,000 \text{ cc}$$

The void fraction, F_V, is:

$$F_V = VOID / V_{CC}$$

$$F_V = 0.13$$

Thus, the decay heat limit, W, is:

$W = 4.46 \text{ watts} \times F_V \times F_{H2O}^{-1}$ or 500 watts, whichever is less
W = 83 watts or 500 watts, whichever is less
W = 83 watts

Example 4 – Solidified Liquid

An aqueous radioactive liquid is solidified with cement. Surrogate testing has established that a 60/40 cement to liquid ratio produces an acceptable solid product and a drying test shows that 50% of the water is unbound after curing. Only unbound water is subject to radiolysis. The solidified waste is contained in a sealed metal liner, 34" OD x 108"L. The filling process results in the liner being 85% full. The surrogate waste has a measured density of 2 g/cc. The liner is a sealed metal canister with ½" walls, base, and lid having a calculated internal volume of 1500 L(V_{IL}). The measured weight of the liner, M_L, is 1950 lbs.

The volume of the solidified waste, V_{sw} is:

$$V_{sw} = 1500 \text{ L} \times 85\% = 1{,}275{,}000 \text{ cc}$$

The mass of solidified waste, M_{sw}, is:

$$M_{sw} = 1{,}275{,}000 \times 2 = 2{,}550{,}000 \text{ g} = 5617 \text{ lbs}$$

The mass of unbound water, M_{uw}, is:

$$M_{uw} = M_{sw} \times 0.4 \times 0.5 = 1124 \text{ lbs}$$

The mass of bound water, M_{bw}, is:

$$M_{bw} = M_{sw} \times 0.4 \times 0.5 = 1124 \text{ lbs}$$

The mass of cement, M_c, is:

$$M_c = M_{sw} \times 0.6 = 3370 \text{ lbs}$$

The water weight fraction, F_{H2O}, is:

$$F_{H2O} = M_{uw} / M_L + M_c + M_{uw} + M_{bw} = 0.15$$

The calculated volume of the cask cavity, V_{CC}, is 105231 in^3 or 1,724,000 cc

The void in the liner is:

$$VOID = V_{IL} - V_{sw} = 1{,}500{,}000 - 1{,}275{,}000 = 225{,}000 \text{ cc}$$

The void fraction, F_V, is:

$$F_V = VOID / V_{CC}$$

$$F_V = 0.13$$

Thus, the decay heat limit, W, is:

$W = 4.46$ watts x $F_V \times F_{H2O}^{-1}$ or 500 watts, whichever is less

$W = 3.9$ watts or 500 watts, whichever is less

$W = 3.9$ watts