Section XI
Appendix H
Supplemental Analysis of Configuration D for Failed Metallic Fuel

1.0 Structural Evaluation of Failed Fuel Cans and Liners (baskets)

This evaluation documents the thermal and structural adequacy of six-element and three-element failed fuel cans (FFCs) and liners (baskets) for the transport of failed fuel and failed fuel filters in the NLI-1/2 Spent Fuel Shipping Cask. The maximum normal operating temperature is calculated to be 216°F. The conservatively calculated minimum margin of safety for any component is +2.23. The failed fuel cans and liners (baskets) are structurally adequate to satisfy all regulatory requirements.

1.1.0 Discussion

Nuclear Assurance Corporation proposes to ship three to six encapsulated failed metallic fuel rods or up to three FFCs containing failed fuel filters in the NLI-1/2 cask. A separate liner (basket) and FFC have been designed for a three FFC shipment and for a six FFC shipment. In each case, the failed fuel can is a sealed, dry aluminum canister. Only one failed metallic fuel rod or up to ten failed fuel filters are placed in each FFC.

The FFC must maintain containment for all loading conditions because it serves as one of the containment barriers required for the transport of high-level radioactive material. Since it is not possible under light water moderation for natural uranium metallic fuel to attain a critical configuration, the liner(s) (basket) acts as a convenient support and spacer in the cask cavity. No permanent deformation of the liner is permitted.

Each metallic fuel rod is assumed to weigh 125 pounds (actual weight is 53 kg or 117 lb) and is approximately 124 inches long. Each failed fuel filter is assumed to weigh 12 pounds and is approximately 11 inches long. The total heat load for six metallic fuel rods is 30 watts. Each FFC containing either a failed fuel rod or up to 10 failed fuel filters will be limited to a heat load of 5 watts.

Page Added
Oct. 1990
Revised
Aug. 1991

1.2.0 Method of Analysis

A one-dimensional thermal analysis of the NLI-1/2 cask with a total heat load of 30 watts was performed using the SCOPE thermal analysis computer program to determine the maximum normal operating temperature of the failed fuel can and the liner (basket).

Classical stress analysis methods are used to evaluated the FFCs for buckling during the end impact and for bending during a side impact. The tubes in the liners (baskets) are also analyzed for bending during side impact. The impact loadings include the g-factors determined in the NLI-1/2 cask Safety Analysis Report (SAR). The calculated stresses in the failed fuel cans and the liners are conservatively compared to the material yield strength to demonstrate that containment is maintained by the failed fuel cans and that no permanent deformation of the failed fuel cans or the liners (baskets) occurs.

1.3.0 Input Geometry & Data

1. Total Heat Load = 30 Watts (For Six Metallic Fuel Rods)
   = 15 Watts (For Three FFCs)

2. Metallic Fuel Rod Weight = 125 Pounds/Rod
   Failed Fuel and Filter Weight = 12 Pounds/Filter

3. NLI-1/2 Cask Geometry: (Ref. SAR, Section XVII)

Inner Shell (Cavity) I.D.	= 13.375 inches
Inner Shell Thickness	= 0.50 inches
Lead Shell Thickness	= 2.125 inches
Uranimum Shell Thickness	= 2.75 inches
Outer Shell Thickness	= 0.875 inches
Neutron Shield Thickness	= 5.0 inches
Neutron Shield Shell Thickness	= 0.25 inches

4. Free Drop Impact G-Loads:

Normal Operation*	
1-Foot Side Drop	16.4 g (Pg. XI-1-44)
Accident*	
30-Foot Top End Drop	39.4 g (Pg. XI-2-4-a)
30-Foot Side Drop	36.3 g (Pg. XI-2-16)
30-Foot Corner Drop	37.5 g (Pg. XI-2-15a)

1.4.0 <u>Mechanical Properties of Materials</u>

1. 6061-T6 Aluminum Alloy (Ref. MIL-HDBK-5E)

$(S_u)_{70}$ = 42 ksi (70°F) $(S_y)_{70}$ = 35 ksi (70°F) (page 3-222)

At 250°F: $(S_u)_{250} = 0.86\ (S_u)_{70}$ = 36.1 ksi (page 3-227)

$(S_y)_{250} = 0.88\ (S_y)_{70}$ = 30.8 ksi (page 3-228)

2. 6063-T832 Aluminum Alloy (Ref. ASME B210)

$(S_u)_{70}$ = 40 ksi $(S_y)_{70}$ = 35 ksi (page 194)

At 250°F: $(S_u)_{250} = 0.86^{**}(S_u)_{70}$ = 34.4 ksi

$(S_y)_{250} = 0.89^{**}(S_y)_{70}$ = 30.8 ksi

---

* Ref. 10 CFR 71 and Regulatory guide 7.8.

** The strength variation with temperature is assumed to be the same as that for 6061-T6 Aluminum Alloy.

Page Added
Oct. 1990
Revised
Aug. 1991

3. 6061-T6511 Aluminum Alloy (Ref. MIL-HDBK-5E)

$(S_u)_{70}$ = 38 ksi $(S_y)_{70}$ = 35 ksi (page 3-225)

At 250°F: $(S_u)_{250} = 0.86^*(S_u)_{70} = 32.7$ ksi

$(S_y)_{250} = 0.88^*(S_y)_{70} = 30.8$ ksi

4. SA 240 Type 304 (Ref. ASME Appendix I)

$(S_u)_{70}$ = 70 ksi $(S_y)_{70}$ = 30 ksi (70°F)

At 250°F: $(S_u)_{250}$ = 63.85 ksi

$(S_y)_{250}$ = 23.75 ksi

1.5.0 Thermal Evaluation

The SCOPE thermal analysis computer program is used to evaluate the NLI-1/2 cask containing the 2.75-inner diameter (I.D.) failed fuel can liner and six 2.75 I.D. Failed Fuel Cans loaded with one metallic fuel rod each for a total heat load of 30 watts. The calculated temperature for the failed fuel can and the liner (basket) is 216°F. This temperature will bound temperatures that will occur in the three-hole liner (basket).

1.6.0 Structural Evaluation

The failed fuel cans are evaluated to demonstrate that containment of the failed fuel rod or the failed fuel filters is maintained for all loading conditions. The maximum stress occurs in the shells of the failed fuel cans for the 30-foot side drop load case. Buckling of the shells is evaluated for the 30-foot end drop load case.

---

*The strength variation with temperature is assumed to be the same as that for 6061-T6 Aluminum Alloy

The liners (baskets) for the failed fuel cans are evaluated to demonstrate that rupture (ultimate failure) does not occur for any loading condition. The maximum stress occurs in the housing (tube) of the liners for the 30-foot side drop load case.

1.6.1 Failed Fuel Can - 2.75 Inner Diameter

1.6.1.1 Shell - Bending

(Ref. Dwg. 340-108-D2, Rev. 10)

Loading

30-Foot Side Drop Acceleration = 36.3 g

Support Spacing = 33.66 in (Ref. Dwg. 347-029-20, Rev. 1)

Weight: Fuel = 125 lb/124 in = 1.008 lb/in

$$\text{Shell} = \frac{\pi}{4}\left(3.0^2 - 2.75^2\right) \; 1 \times 0.10 = \underline{0.113 \text{ lb/in}}$$

Total = 1.121 lb/in

Conservatively assume the shell is simply supported at the support disks; then, the moment during impact is:

$$M = \frac{1}{8} \times 1.121 \times 33.66^2 \times 36.3 = 5{,}763 \text{ in-lb}$$

Shell Properties:

$I/C = 0.7791 \text{ in}^3$

Material Properties: (ASTM B221 Type 6061-T6)

$(S_y)_{250} = 30.8$ ksi

Page Added
Oct. 1990
Revised
Aug. 1991

Stresses:

$$S_b = 5763/0.7791 = 7,397 \text{ psi}$$

$$M.S. = \left[(S_y)_{250}/S_b\right] - 1 = \underline{+3.16}$$

1.6.1.2 Shell - Buckling

(Loading)

Estimated Weight of Can Assembly = 20 lb

Bottom End Drop Deceleration = 39.4 g

The compressive stress in the shell due to its weight during impact is:

$$S_c = \frac{20\ (39.4)}{\frac{\pi}{4}\left(3.0^2 - 2.75^2\right)} = 698 \text{ psi}$$

The margin of safety on yield is:

$$M.S. = \frac{30.8}{0.698} - 1 = \underline{+\text{Large}}$$

The buckling of the cylindrical shell under the action of uniform axial compression may be evaluated using equation 11-1 on page 458 of Theory of Elastic Stability by Timoshenko and Gere.

$$S_{cr} = \frac{Et}{r\left[3\left(1 - \nu^2\right)\right]^{0.5}}$$

$$= 267 \text{ ksi}$$

where,

$E = 0.97\ (10.1E03) = 9.8E03$ ksi at 250°F
$t = 0.125$ in
$r = 2.81$ in, env. radius for all tubes in assembly
$\nu = 0.33$

The margin of safety on buckling is:

$$M.S. = S_{cr}/S_c - 1 = \underline{+Large}$$

1.6.1.3 Conclusion

The stress in the cylindrical shell caused by an end drop with 39.4 g deceleration is much lower than the yield stress and the critical buckling stress.

1.6.2 Liner - Failed Fuel Can - 2.75 Inner Diameter

1.6.2.1 Housing - Bending

(Ref. Dwg. 347-029-20, Rev.1)

Loading

30-Foot Side Drop Deceleration = 36.3 g

Support Spacing = 33.66 in

Weight: Fuel = 125 lb/124 in = 1.008 lb/in

Aluminum Shell = $\frac{\pi}{4}\left(3.^2 - 2.75^2\right) \times 1 \times 0.10$ = 0.113 lb/in

Housing = $\frac{\pi}{4}\left(3.75^2 - 3.5^2\right) \times 1 \times 0.10$ = $\underline{0.142 \text{ lb/in}}$

Total = 1.263 lb/in

Conservatively assume the housing simply supported at the disk supports; then, the moment during impact is:

$$M = \frac{1}{8}\left(1.263 \times 33.66^2\right)(36.3) = 6{,}493 \text{ in-lb}$$

Page Added
Oct. 1990
Revised
Mar. 1991
Aug. 1991

Housing Properties:

$$I/C = \pi \left(d_o^4 - d_i^4\right)/32d_o$$

$$= \pi \left(3.75^4 - 3.5^4\right)/(32 \times 3.75) = 1.2485 \text{ inch}^3$$

Material Properties: (ASTM B210 Type 6063-T832)

$$(S_y)_{250} = 30.8 \text{ ksi}$$

Stresses:

$$S_b = 6{,}493/1.2485 = 5{,}201 \text{ psi}$$

$$M.S. = \left[(S_y)_{250}/S_b\right] - 1 = \underline{+4.92}$$

1.6.2.2 <u>Check Weld Between Bulkhead and Tubes</u>

Peak deceleration = 39.4 g (30-ft end drop)
(Ref. Dwg. 347-029-20, Rev. 1)

Weight of 1 bulkhead $= \frac{\pi}{4} (13^2 - 6 \times 2.75^2) \frac{1}{4} \times 0.1$

= 2.4 lb

Weight of 4-Bolts = <u>1.6 lb</u>

Total = 4.0 lb

Inertial load of bulkhead on welds:

$$p = 4(39.4) = 160 \text{ lb}$$

Total length of weld per bulkhead
(Reference Drawing 347-029-20)

$$L_w = 4(6) + 2(3) = 30 \text{ in}$$

Size of fillet = 1/8 in

Take F_u of aluminum weld = 4000 psi

Allowable shear stress = 0.3(4000) = 1200 psi
(Reference AISC Man. Stl. Const. 8th ed., Sect. 1.5.3)

Working capacity of welds = P_{cap}

$$= 0.707 \times \frac{1}{8} \times 30 \times 1200$$

$$= 3180 \text{ lb}$$

$$M.S. = \frac{P_{cap}}{P_{act.}} - 1 = \frac{3180}{160} - 1 = \underline{+Large}$$

The other accident drop conditions are:

30-Foot End Drop	a = 39.4 g
30-Foot Corner Drop	a = 37.5 g

Compared to a 30-foot side drop accident condition, with a = 36.3 g, the above accident conditions are less critical. Therefore, neither rupture nor yielding of the liner housing will occur.

1.6.3 Failed Fuel Rod Can - 4.00 Inner Diameter (Failed Fuel Rod Loading)

1.6.3.1 Shell - Bending

(Ref. Dwg. 340-108-D1, Rev. 10)

Loading

30-Foot Side Drop Acceleration = 36.3 g

Support Spacing = 50.37 in

Weight: Fuel = 125 lb/124 in = 1.008 lb/in

$$\text{Shell} = \frac{\pi}{4}\left(4.25^2 - 4.0^2\right) \times 1 \times 0.10 = \underline{0.162\ \text{lb/in}}$$

Total = 1.170 lb/in

Conservatively assume the shell is simply supported at the support disks; then, the moment during impact is:

$$M = \frac{1}{8}\left(1.170 \times 50.37^2\right)(36.3) = 13{,}469\ \text{in-lb}$$

Shell Properties: (4.00 I.D., t = 0.125 in)

$$I/C = \pi\left(4.25^4 - 4^4\right)/(32 \times 4) = 1.7243\ \text{in}^3$$

Material Properties: (ASTM B210 Type 6061 T6)

$$(S_y)_{250} = 30.8\ \text{ksi}$$

Stresses:

$$S_b = 13{,}469/1.7243 = 7{,}811\ \text{psi}$$

$$M.S. = \left[(S_y)_{250}/S_b\right] - 1 = \underline{+2.94}$$

1.6.4 <u>Liner - Aluminum - 3 Element NLI-1/2 Cask</u>

1.6.4.1 Tube - Bending

(Ref. Dwg. 347-291-F3, Rev. 4)

Loading

30-Foot Side Drop Acceleration = 36.3 g

Support Spacing = 50.37 in

Weight: Fuel = 125 lb/124 in = 1.008 lb/in

$$\text{Shell} = \frac{\pi}{4}\left(4.25^2 - 4.0^2\right) \times 1 \times 0.10 = 0.162 \text{ lb/in}$$

$$\text{Tube} = \frac{\pi}{4}\left(5.625^2 - 5.375^2\right) \times 1 \times 0.1 = \underline{0.216 \text{ lb/in}}$$

Total = 1.386 lb/in

Conservatively assume the tube is simply supported at the support disks; then, the moment during impact is:

$$M = \frac{1}{8}\left(1.386 \times 50.37^2\right)(36.3) = 15{,}956 \text{ in-lb}$$

Tube Properties:

$$I/C = \pi\left(5.625^4 - 5.375^4\right)/(32 \times 5.625) = 2.9053 \text{ in}^3$$

Material Properties: (ASTM B210 Type 6061-T6)

$$\left(S_y\right)_{250} = 30.8 \text{ ksi}$$

Stresses:

$$S_b = 15{,}956/2.9053 = 5{,}492 \text{ psi}$$

$$M.S. = \left[(S_y)_{250}/S_b\right] - 1 = \underline{+4.60}$$

1.6.4.2 <u>Check Weld Between Bulkhead and Tubes</u>

(Ref. Dwg. 347-291-F3, Rev. 4)

Page Added
Oct. 1990
Revised
Mar. 1991
Aug. 1991

Weight of bulkhead $= \frac{\pi}{4} (13^2 - 2 \times 5.625^2) \frac{1}{4} \times 0.1$

$= 1.5$ lb

Weight of 4-Bolts = 1.5 lb

Total = 3.0 lb

Inertial load of bulkhead on welds:

$$p = 3.0(39.4) = 120 \text{ lb}$$

Total length of weld per bulkhead:

$$L_w = 3(3.0) = 9.0 \text{ inch minimum}$$

Size of fillet $= \frac{3}{32}$ in

Working capacity of welds:

$$P_{cap} = 0.707 \times \frac{3}{32} \times 9.0 \times 1200$$

$$= 716 \text{ lb}$$

$$M.S. = \frac{P_{cap}}{P_{act}} - 1 = \frac{716}{120} - 1 = \underline{+4.96}$$

1.6.5 Liner - Stainless Steel 304 - 3 Element NLI-1/2 Cask

(Tube - Bending)

(Ref. Dwg. 347-291-F12, Rev. 2)

Loading

30-Foot Side Drop Acceleration = 36.3 g

Support Spacing = 50.37 in

Weight: Fuel = 125 lb/124 in = 1.008 lb/in

$$\text{Shell} = \frac{\pi}{4}\left(4.25^2 - 4.0^2\right) \times 1 \times 0.10 = 0.162 \text{ lb/in}$$

$$\text{Tube} = \frac{\pi}{4}\left(5.625^2 - 5.375^2\right) \times 1 \times .288 = \underline{0.622 \text{ lb/in}}$$

Total = 1.792 lb/in

Conservatively assume the tube is simply supported at the support disks; then, the moment during impact is:

$$M = \frac{1}{8}\left(1.792 \times 50.37^2\right)(36.3) = 20{,}630 \text{ in-lb}$$

Tube Properties:

$$I/C = \pi\left(5.624^4 - 5.375^4\right)/(32 \times 5.625) = 2.9053 \text{ in}^3$$

Material Properties: (SA240 Type 304)

$$\left(S_y\right)_{250} = 23.75 \text{ ksi}$$

Stresses:

$$S_b = 15{,}956/2.9053 = 5{,}492 \text{ psi}$$

$$M.S. = \left[(S_y)_{250}/S_b\right] - 1 = \underline{+2.34}$$

1.6.6 <u>Failed Fuel Rod Can - 4.00 Inner Diameter (Ten Failed Fuel Filter Elements/Can)</u>

1.6.6.1 <u>Shell - Bending</u>

Ref. Dwg 340-108-D1, Rev. 10

Page Added
Oct. 1990
Revised
Aug. 1991

Loading

30-Foot Side Drop Acceleration = 36.3 g

Support Spacing = 50.37 in

Weight: Fuel = 12 lb/11.2 in = 1.071 lb/in

(Assumed to be effectively a distributed load; actual loading will occur near the ends of each failed fuel filter element)

$$\text{Shell} = \frac{\pi}{4}\left[(4.25)^2 - (4.0)^2\right](1)(0.10) = \underline{0.162\ \text{lb/in}}$$

Total = 1.233 lb/in

Conservatively assume the shell is simply supported at the support disks; then, the moment during impact is:

$$M = \frac{1}{8}\left[(1.233)(50.37)^2\right](36.3)$$
$$= 14{,}195\ \text{in-lb}$$

Shell Properties: (4.00 I.D., t = 0.125 in)

$$I/C = [\pi][(4.25)^4 - (4)^4]/[(32)(4.25)]$$
$$= 1.623\ \text{in}^3$$

Material Properties: (ASTM B221 Type 6061 T6)

$$(S_y)_{250} = 30.8\ \text{ksi}$$

Stresses:

$$S_b = 14{,}195/1.623 = 8746\ \text{psi}$$

$$\text{M.S.} = [(S_y)_{250}/S_b] - 1 = \underline{+2.52}$$

1.6.7 Liner - 3 Element - Aluminum (Ten Failed Fuel Filter Elements/Can)

1.6.7.1 Tube - Bending

Ref. Dwg 347-291-F3, Rev. 4
Ref. Dwg 491-042, Rev. 1

Loading

30-Foot Side Drop Acceleration = 36.3 g

Support Spacing = 50.37 in

Weight: Fuel = 12 lb/11.2 in = 1.071 lb/in

$$\text{Shell} = \frac{\pi}{4}\left[(4.25)^2 - (4.0)^2\right](1)(0.10) = 0.162 \text{ lb/in}$$

$$\text{Tube} = \frac{\pi}{4}\left[(5.625)^2 - (5.375)^2\right](1)(0.1) = \underline{0.216 \text{ lb/in}}$$

Total = 1.449 lb/in

Conservatively assume the tube is simply supported at the support disks; then, the moment during impact is:

$$M = \frac{1}{8}\left[(1.449)(50.37)^2\right](36.3)$$
$$= 16{,}681 \text{ in-lb}$$

Tube Properties:

$$I/C = [\pi][(5.625)^4 - (5.375)^4]/[(32)(5.625)]$$
$$= 2.9053 \text{ in}^3$$

(The FFC is conservatively not considered to provide any bending strength for this analysis.)

Material Properties: (ASTM B210 Type 6061-T6)

$$(S_y)_{250} = 30.8 \text{ ksi}$$

Page Added
Aug. 1991

Stresses:

$$S_b = 16{,}681/2.9053 = 5742 \text{ psi}$$

$$M.S. = [(S_y)_{250} / S_b] - 1 = \underline{+4.36}$$

1.6.8 <u>Liner - Stainless Steel 304 - 3 Element NLI-1/2 Cask (Ten Failed Fuel Filters/Can)</u>

1.6.8.1 <u>Tube - Bending</u>

(Ref. Dwg. 347-291-F12, Rev. 2)
(Ref. Dwg. 491-042, Rev. 1)

Loading

30-Foot Side Drop Acceleration = 36.3 g

Support Spacing = 50.37 in

Weight: Fuel = 12 lb/11.2 in = 1.071 lb/in

$$\text{Shell} = \frac{\pi}{4}\left(4.25^2 - 4.0^2\right) \times 1 \times 0.10 = 0.162 \text{ lb/in}$$

$$\text{Tube} = \frac{\pi}{4}\left(5.625^2 - 5.375^2\right) \times 1 \times .288 = \underline{0.622 \text{ lb/in}}$$

Total = 1.855 lb/in

Conservatively assume the tube is simply supported at the support disks; then, the moment during impact is:

$$M = \frac{1}{8}\left(1.855 \times 50.37^2\right)(36.3) = 21{,}355 \text{ in-lb}$$

Tube Properties:

$$I/C = \pi\left(5.624^4 - 5.375^4\right)/(32 \times 5.625) = 2.9053 \text{ in}^3$$

Material Properties: (SA240 Type 304)

$$\left(S_y\right)_{250} = 23.75 \text{ ksi}$$

Stresses:

$$S_b = 21{,}355/2.9053 = 7350 \text{ psi}$$

$$\text{M.S.} = \left[(S_y)_{250}/S_b\right] - 1 = \underline{+2.23}$$

1.7.0 Results and Conclusion

The maximum normal operating temperature of the failed fuel cans and the liner (basket) is calculated to be 216°F. The structural evaluation conservatively uses material properties at 250°F.

The calculated margins of safety are:

1. Failed Fuel Can - 2.75 Inner Diameter

Shell - Bending	+3.16
Shell - Buckling	+Large

2. Liner - Failed Fuel Can - 2.75 Inner Diameter

Housing - Bending	+4.92
Weld - Buklhead/Tube	+Large

3. Failed Fuel Rod Can - 4.00 Inner Diameter (Failed Fuel Rod Loading)

Shell - Bending	+2.94

Page Added
Oct. 1990
Revised
Aug. 1991

4. Liner - 3-Element (Aluminum)

Tube - Bending	+4.60
Weld - Bulkhead/Tube	+4.96

5. Liner - 3-Element (Stainless Steel Type 304)

Tube - Bending	+2.34

6. Failed Fuel Rod Can - 4.00 Inner Diameter (Ten Failed Fuel Filter Elements/Can)

Shell - Bending	+2.52

7. Liner - 3-Element (Ten Failed Fuel Filter Elements/Can)

Tube - Bending	+4.36

8. Liner - 3-Element Stainless Steel Type 304 (Ten Failed Fuel Filter Elements/Can)

Tube - Bending	+2.23

No permanent deformation occurs in the failed fuel cans or the liners for the critical loading conditions. Containment of the failed metallic fuel rods and failed fuel filters is maintained and the liner structure remains intact; therefore, structural adequacy is ensured.

1.8.0 References

1. NAC Drawing: 340-108-D1, Revision 10, Failed Fuel Rod Can - 4.00 I.D.

2. NAC Drawing: 340-108-D2, Revision 10, Failed Fuel Rod Can - 2.75 I.D.

3. NAC Drawing: 347-291-F3, Revision 4, Liner-3 Element - NLI-1/2 Cask, Fuel Movement Project, Assembly of.

4. NAC Drawing: 347-029-20, Revision 1, Liner - Failed Fuel Cans, 2.75 I.D., NLI-1/2 Cask, Safety Analysis Report.

5. NAC Drawing: 347-291-F12, Revision 2, Liner-3 Element, NLI 1/2 Cask, Fuel Movement Project.

6. NAC Drawing: 491-042, Revision 1, Failed Fuel Filter.

7. MIL-HDBK-5E, "Metallic Materials and Elements for Aerospace Vehicle Structures," U.S. Department of Defense, May 1989.

8. "ASME Boiler and Pressure Vessel Code," Section II, Material Specifications, Part B-Nonferrous Materials, The American Society of Mechanical Engineers, 1989.

9. Timoshenko and Gere, Theory of Elastic Stability, 2nd Edition, New York, McGraw-Hill, 1961.

10. F. Kreith, Principles of Heat Transfer, 2nd Edition, Scranton, PA., International Textbook Company, 1965.

2.0 Containment Analysis for Severely Failed Metallic Fuel in Filters

2.1 Calculation of Equivalent A_2 Value

The releasable source term for severely failed metallic fuel assemblies is quite different from that of a normal fuel assembly, because the fuel has degraded into an oxide powder form. Because the fuel is not a solid, all fission product and actinide radioactive materials could be released through the smallest of openings in the cask. Thus, the number of releasable isotopes is much more than the krypton-85 and tritium gas which is normally considered.

The metallic fuel rods are limited to 1600 MWD/MTU burnup. For a minimum cool time of 10 years, this results in a total radioactive inventory of 916 curies for one metallic fuel rod, which has a mass of 53.75 kilograms. Thus, the specific activity for metallic fuel rods can be calculated as follows:

Specific Activity = 916 Ci / 53.75 kg = 0.0170 Ci/g

Next, the equivalent A_2 value for the fuel is calculated, using methodology presented in ANSI N14.5-1987, Appendix B, Example 27. The significant isotopes, their corresponding A_2 values from 10 CFR 71, and their fraction of total radioactivity are listed in Table H-1. These values are used to calculate the equivalent A_2 value for the mixture, based on this methodology. The equivalent A_2 value is calculated according to the following formula:

$$A_2 = \frac{1}{\sum \frac{f}{A_2}}$$

As shown in Table H2.1, the equivalent A_2 value is 0.25 curies.

2.2 Determination of Maximum Leakage Rate for Oxide Powders

The NLI 1/2 cask has a design leak rate of 1.0×10^{-6} cc/sec or better. For intact fuel assemblies, this number is used to determine the maximum release of radioactivity from fission product gases. However, for the solid radioactive materials, the use of a volumetric leak rate is overly conservative, as many solids cannot be released through the small openings of the o-rings. In the design of the PAT-1 transport package (NUREG-0361), a reference is made to a report which studied the leak rates of oxides from shipping containers. Although the referenced report is not readily available, the data presented in the PAT-1 SAR can be applied to this case.

The PAT-1 SAR states that, for an upstream pressure of 500 psi and a maximum hole diameter of 6.6×10^{-4} cm, the maximum release rate of oxide powders is 2.9×10^{-8} g/10 minutes, or $\underline{1.74 \times 10^{-7}\ g/hr}$. The maximum hole diameter through the o-ring in the NLI 1/2 is 3.03×10^{-4} cm, according to Table B2 of ANSI N14.5-1987, for a leak rate of 1.0×10^{-6} cc/sec. This hole diameter is smaller than that used in the PAT-1 SAR, also, the upstream pressure of 500 psi from the PAT-1 SAR is much larger than that of the NLI 1/2; thus, it is conservative to use the mass leakage rate from the PAT-1 SAR for the maximum leakage rate for this analysis.

2.3 Determination of Maximum Release Rate

The maximum release rate of radioactive material from the NLI 1/2 can be calculated based on the specific activity of the contents, the equivalent A_2 value of the contents, and the maximum mass leakage rate from the cask. The specific activity of the fuel in units of A_2 can be calculated by dividing the specific activity in units of curies by the A_2 value for the fuel.

$$0.0170\ Ci/g \ / \ 0.25\ Ci/A_2 = 0.068\ A_2/g$$

Page Added
Oct. 1991

This value can then be multiplied by the maximum mass leakage rate from the cask to determine the maximum release rate from the cask.

$$0.068\ A_2 \ * \ 1.74 \times 10^{-7}\ g/hr \ = \ 1.18 \times 10^{-8}\ A_2/hr$$

This release rate is a factor of 100 lower than that required by 10 CFR 71 of $1 \times 10^{-6}\ A_2/hr$. In addition, since the containment integrity of the cask is not affected by the hypothetical accident condition sequence, the maximum accident condition release rate criteria of one A_2/week is also satisfied.

Table H2.1 - Metallic Fuel Rod Significant Isotopics

Based on : 1600 MWD/MTU Burnup
10 years cool time

Isotope	A_2 Value	Fraction of Total Activity,f	$\frac{f}{A_2}$
Sr-90	0.4	0.19	0.475
Y-90	10.0	0.19	0.019
Cs-137	10.0	0.24	0.024
Pm-147	25.0	0.067	0.00268
Pu-239	0.002	0.0047	2.35
Pu-240	0.002	0.0016	0.80
Pu-241	0.1	0.029	0.29

$$\sum \frac{f}{A_2} = 3.96/Ci$$

$$A_2 = \frac{1}{\sum \frac{f}{A_2}} = 0.25\ Ci$$

Page Added
Oct. 1991

THIS PAGE INTENTIONALLY LEFT BLANK

FIGURE WITHHELD UNDER 10 CFR 2.390

FAILED FUEL ROD CAN-4.00 ID, FUEL ROD CONTAINERIZATION				
340	10B	D1	10	A

Page Added Oct. 1990
Revised Aug. 1991

XI-H20-1

9603010265-02

FIGURE WITHHELD UNDER 10 CFR 2.390

FAILED FUELROD CAN-2751D FUEL ROD CONTAINERIZATION				
FULL RAPSTER	340	108	D2	10

A

Page Added Oct. 1990 Revised Aug. 1991

2 1 XI-H21

9603010285-03

FIGURE WITHHELD UNDER 10 CFR 2.390

NUCLEAR ASSURANCE CORPORATION

LINER–FAILED FUEL CAN,
2.75 I.D., NLI 1/2 CASK
SAFETY ANALYSIS REPORT

347	029	20	1
1/2	150 lbs.	1 of 1	

A

Page Added
Oct. 1990
Revised
Aug. 1991

9603010285-04

FIGURE WITHHELD UNDER 10 CFR 2.390

LINER-3 ELEMENT - NLI 1/2
CASK, FUEL MOVEMENT
PROJECT, ASSY OF

347	291	F3	4

A

Page Added
Oct. 1990
Revised
Feb. 1991
Aug. 1991

XI-H23

9603010285-05

FIGURE WITHHELD UNDER 10 CFR 2.390

NUCLEAR ASSURANCE CORPORATION

LINER-3ELEMENT, NLI 1/2 CASK, FUEL MOVEMENT PROJECT

HALF			
D. FUCHS	347	291	F12	2

A

Page Added Aug. 1991

XI-H24

9603010285-06

FIGURE WITHHELD UNDER 10 CFR 2.390

NUCLEAR ASSURANCE CORPORATION

FAILED FUEL FILTER

PROJECT 491		DRAWING 042	REV 1
SCALE 1/1		1 of 1	

A

Page Added
Aug. 1991

XI-H25

9603010285-07

Section XII

DELETED

QA/QC to be in accordance with 10 CFR 71, Appendix E.

QUALITY CONTROL AND MANUFACTURING

SECTION XII

This page intentionally left blank.

Section XIII

SECTION XIII

FUNCTIONAL TEST PROCEDURES

This page intentionally left blank.

SECTION XIII

FUNCTIONAL TEST PROCEDURES

1. Load Test

Load test shall be performed on only those pieces of equipment which are used to lift or by which the equipment is lifted. The test loads shall represent 200% of the gross dead weight of the component. Test load to be held for ten (10) minutes.

Component	Test Load
Cask Trunnions	48,000 lbs. per trunnion
Outer Closure Head Lugs	545 lbs. per lug
Inner Closure Head Lugs	670 lbs. per lug

Acceptance Criteria:

There shall be no visual deformation. All attachment welds of trunnions and lift lugs shall be liquid penetrant inspected for cracks.

2. Mechanical Fit

a. Fit of inner container in cask cavity

b. Fit of BWR fuel basket in inner container

c. Fit of PWR fuel basket in inner container

d. Fit of inner closure head on inner can. Use lift rig to install closure head. Install closure head nuts.

e. Fit of outer closure head on cask. Use lift rig to install closure head. Install closure head bolts.

f. Using lift rig, position cask over trunnion supports on trailer bed and engage sockets in bottom of cask. Rotate cask to horizontal position engaging saddle support for top end of cask. Install tie-down bolts.

Check the following:

1. Fit of trunnion supports in sockets on bottom of cask.
2. Clearance between lift rig and cask body while rotating cask from vertical to horizontal.
3. Fit of cask in front saddle support.

g. Fit of top and bottom impact structure.

h. Fit of personnel barrier over cask and matching of attachment points to trailer bed.

3. Pressure Tests

a. Cask Cavity - Helium Leak Test/Hydrostatic Pressure Test

Test Condition:

1. Inner Container is not in cask cavity.
2. Outer closure head seal installed and closure head bolted in place.

Test procedure - Helium Leak Test:

Introduce helium to cask cavity and pressurize cavity to a pressure greater than atmospheric. With a sniffer probe connected to the mass spectrometer, all areas to be checked are scanned with probe at a maximum speed of 15 inches per minute. If a leak exists, helium passes through the sniffer into the mass spectrometer where it is converted into leak rate detected.

Acceptance Criteria:

Any leak which exceeds a leak rate of 1×10^{-6} cc/sec. STP shall be considered rejectable and shall be repaired.

Test Procedure - Hydrostatic Pressure Test:

Fill cask cavity with distilled water thru closure head cavity drain valve. Pressurize cavity to 220 psig and hold pressure for 30 minutes.

Acceptance Criteria:

Visually inspect all joints for leaks. There shall be no evidence of leakage or pressure drop during the test period.

b. Inner Container - Helium Leak Test/ Hydrostatic Pressure Test :

Test Condition:

1. Inner container tested separately from shipping cask.
2. Inner container closure head seal installed and closure head bolted in place.

Test Procedures - Helium Leak Test:

Introduce helium to container and pressurize to a pressure greater than atmospheric. With a sniffer probe connected to the mass spectrometer, all areas to be checked are scanned with the probe at a maximum scan speed of 15 inches per minute. If a leak exists, helium passes through the sniffer into the mass spectrometer where it is converted into leak rate detected.

Acceptance Criteria:

Any cask which exceed a leak rate of 1×10^{-6} cc/sec/ STP shall be considered rejectable and shall be repaired.

Test Procedure - Hydrostatic Pressure Test:

Fill the inner container with distilled water thru the drain valve on the closure head. Pressurize inner container to 220 psig and hold pressure for 30 minutes.

Acceptance Criteria:

Visually inspect all joints for leaks. There shall be no evidence of leakage or pressure drop during the test period.

c. Water Jacket

Test Condition:

1. Remove relief valve and replace with pressure gage and vent valve.
2. Connect pump and supply of distilled water to quick disconnect valved coupling at bottom end of water jacket.
3. Temporary plug at inlet to expansion tank.

NOTE: This Hydrostatic Test must be performed before the expansion tank is assembled into place, as one circumferential weld on the water jacket shell will not be accessible for inspection after the expansion tank is in place.

Test Procedure - Hydrostatic Test

Open vent valve and fill water jacket with distilled water until overflow occurs thru vent valve. Close vent valve and pressurize water jacket to 405 psig. Close off water supply. Monitor pressure gage for 30 minutes.

Acceptance Criteria

Visually inspect all joints for leaks. There shall be no evidence of leakage or pressure drop during the test period.

d. Water Jacket Expansion Tank

Test Condition:

1. Remove water jacket relief valve and replace with pressure gage and vent valve.
2. Connect pump and supply of distilled water to quick disconnect valved coupling at bottom end of water jacket.

Test Procedure: Hydrostatic Test

Open vent valve and fill water jacket and expansion tank with distilled water until overflow occurs thru vent valve. Close vent valve and pressurize both water jacket and expansion tank to 405 psig. Close off water supply. Monitor pressure gage for 30 minutes.

Acceptance Criteria:

Visually inspect all expansion tank joints for leaks. There shall be no evidence of leakage or pressure drop during the test period.

e. Relief Valve Test

Test Condition:

The relief valve shall be bench mounted.

Test Procedure: Hydrostatic Test

The test set-up will consist of a pressure pump and gauge. The valve inlet pressure will be raised and the cracking and reseat points observed. The unit will be cycled ten (10) times to demonstrate repeatability.

Acceptance Criteria:

Allowable variation shall be ± 5% of the nominal cracking pressure of 200 psig.

4. Shielding Test

a. Components to be inspected

1. Cask body

2. Inner closure head

b. Inspection Method

Inspection of the cask will be performed by vertical continuous scanning over normally 100% of all accessible surfaces using the 3" detector and a Co60 source of sufficient strength to produce a count rate which is equal to or exceed 3 times background count rate. Scan path spacing will be 2-1/2". Scan speed will be 4-1/2 feet per minute maximum.

c. Acceptance Criteria:

Acceptance will be based on a 12" square lead test block whose thickness will be equivalent to the minimum design thickness less 5%. The maximum area of any one defect shall not exceed six (6) inches square. The total of all such areas shall not exceed 25% of the total area inspected.

APPENDIX A

SECTION XIII

FUNCTIONAL TEST PROCEDURES

1. Load Test

Load test shall be performed on only those pieces of equipment which are used to lift or by which the equipment is lifted. The test loads shall represent 200% of the gross dead weight of the component. Test load to be held for ten (10) minutes.

Component	Test Load
Cask Trunnions	48,000 lbs. per trunnion
Outer Closure Head Lugs	341 lbs. per lug
Inner Closure Head Lugs	496 lbs. per lug

Acceptance Criteria:

There shall be no visual deformation. All attachment welds of trunnions and lift lugs shall be liquid penetrant inspected for cracks.

2. Mechanical Fit

a. Fit of BWR fuel basket in cask cavity

b. Fit of PWR fuel basket in cask cavity

c. Fit of inner closure head on cask. Install closure head nuts.

d. Fit of outer closure head on cask. Use lift rig to install closure head. Install closure head bolts.

e. Using lift rig, position cask over trunnion supports on trailer bed and engage sockets in bottom of cask. Rotate cask to horizontal position engaging saddle support for top end of cask. Install tie-down bolts.

Check the following:

1. Fit of trunnion supports in sockets on bottom of cask.

2. Clearance between lift rig and cask body while rotating cask from vertical to horizontal.

3. Fit of cask in front saddle support.

f. Fit of top and bottom impact structure.

g. Fit of personnel barrier over cask and matching of attachment points to trailer bed.

3. <u>Pressure Tests</u>

a. Cask Cavity - Helium Leak Test/Hydrostatic Pressure Test

Test Condition:

1. Inner closure head seal installed and closure head bolted in place.

Test Procedure - Helium Leak Test:

Introduce helium to cask cavity and pressurize cavity to a pressure greater than atmospheric. With a sniffer probe connected to the mass spectrometer, all areas to be checked are scanned with probe at a maximum speed of 15 inches per minute. If a leak exists, helium passes through the sniffer into the mass spectrometer where it is converted into leak rate detected.

Acceptance Criteria:

Any leak which exceeds a leak rate of 1×10^{-6} cc/sec. STP shall be considered rejectable and shall be repaired.

Test Procedure - Hydrostatic Pressure Test

Fill cask cavity with distilled water thru inner closure head drain valve. Pressurize cavity to 220 psig and hold pressure for 30 minutes.

Acceptance Criteria:

Visually inspect all joints for leaks. There shall be no evidence of leakage of pressure drop during the test period.

b. Outer Closure Head - Helium Leak Test/ Hydrostatic Pressure Test

Test Condition:

1. Inner Closure Head is removed.

2. Outer Closure Head seal installed and closure head bolted in place.

Test Procedures - Helium Leak Test

Introduce helium to cask and pressurize to a pressure greater than atmospheric. With a sniffer probe conrected to the mass spectrometer, all areas to be checked are scanned with a probe at a maximum scan speed of 15 inches per minute. If a leak exists, helium passes through the sniffer into the mass spectrometer where it is converted into leak rate detected.

Acceptance Criteria:

Any cask which exceeds a leak rate of 1×10^{-6} cc/sec/STP shall be considered rejectable and shall be repaired.

Test Procedure - Hydrostatic Pressure Test

Fill the cask cavity with distilled water with both closure heads removed. Install outer closure head. Pressurize cask cavity to 220 psig and hold pressure for 30 minutes.

Acceptance Criteria:

Visually inspect all joints for leaks. There shall be no evidence of leakage or pressure drop during the test period.

c. Water Jacket

Test Condition:

1. Remove relief valve and replace with pressure gage and vent valve.

2. Connect pump and supply of distilled water to quick disconnect valved coupling at bottom end of water jacket.

3. Temporary plug at inlet to expansion tank.

NOTE: This Hydrostatic Test must be performed before the expansion Tank is assembled into place, as one circumferential weld on the water jacket shell will not be accessible for inspection after the expansion tank is in place.

Test Procedure - Hydrostatic Test

Open vent valve and fill water jacket with distilled water until overflow occurs thru vent valve. Close vent valve and pressurize water jacket to 405 psig. Close off water supply. Monitor pressure gage for 30 minutes.

Acceptance Criteria

Visually inspect all joints for leaks. There shall be no evidence of leakage or pressure drop during the test period.

d. Water Jacket Expansion Tank

Test Condition:

1. Remove water jacket relief valve and replace with pressure gage and vent valve.
2. Connect pump and supply of distilled water to quick disconnect valved coupling at bottom end of water jacket.

Test Procedure: Hydrostatic Test

Open vent valve and fill water jacket and expansion tank with distilled water until overflow occurs thru vent valve. Close vent valve and pressurize both water jacket and expansion tank to 405 psig. Close off water supply. Monitor pressure gage for 30 minutes.

Acceptance Criteria:

Visually inspect all expansion tank joints for leaks. There shall be no evidence of leakage or pressure drop during the test period.

e. Relief Valve Test

Test Condition:

The relief valve shall be bench mounted.

Test Procedure: Hydrostatic Test

The test set-up will consist of a pressure pump and gauge. The valve inlet pressure will be raised and the cracking and reseat points observed. The unit will be cycled ten (10) times to demonstrate repeatability.

Acceptance Criteria:

Allowable variation shall be ± 5% of the nominal cracking pressure of 200 psig.

4. Shielding Test

a. Components to be inspected

1. Cask body

2. Inner closure head

b. Inspection Method

Inspection of the cask will be performed by vertical continuous scanning over normally 100% of all accessible surfaces using the 3" detector and a Co60 source of sufficient strength to produce a count rate which is equal to or exceed 3 times background count rate. Scan path spacing will be 2-1/2". Scan speed will be 4-1/2 feet per minute maximum.

c. Acceptance Criteria:

Acceptance will be based on a 12" square lead test block whose thickness will be equivalent to the minimum design thickness less 5%. The maximum area of any one defect shall not exceed six (6) inches square. The total of all such areas shall not exceed 25% of the total area inspected.

Section XIV

SECTION XIV

THERMAL TEST PROCEDURES

This page intentionally left blank.

SECTION XIV

THERMAL TEST PROCEDURE

Thermal tests will be performed in accordance with detailed thermal test procedures to verify the thermal performance of the shipping cask. The thermal tests will also be used to establish operational parameters relative to preparing a loaded cask for shipment and unloading the cask at the reprocessing plant.

As established in Section III, "Fuel Description and Source Data", the source strengths for the one PWR cask loading are more restrictive than for the two BWR loading. Therefore the heat source for the thermal test shall be equivalent to the calculated decay heat source for a single PWR fuel assembly of 10.63 kw. The heat source shall be provided by electrical heaters designed and located to simulate the active region of a PWR fuel assembly. A mockup of the inner and outer cask closure heads shall be provided which will simulate the actual closure head configuration and approximate the same thermal characteristics. There will be additional penetrations in the closure head mockups to provide for heater leads and thermocouple wire installation.

The thermal tests are to be performed within an enclosure which will provide essentially a still air environment. The cask shall be completely assembled i.e., the PWR fuel basket installed in the inner container, inner container seated in cask cavity, closure head mockups with heater and thermocouples leads in place, top and bottom impact structures in place. The assembled cask will be positioned horizontally to simulate the shipping attitude. The personnel barrier will be positioned over the shipping cask.

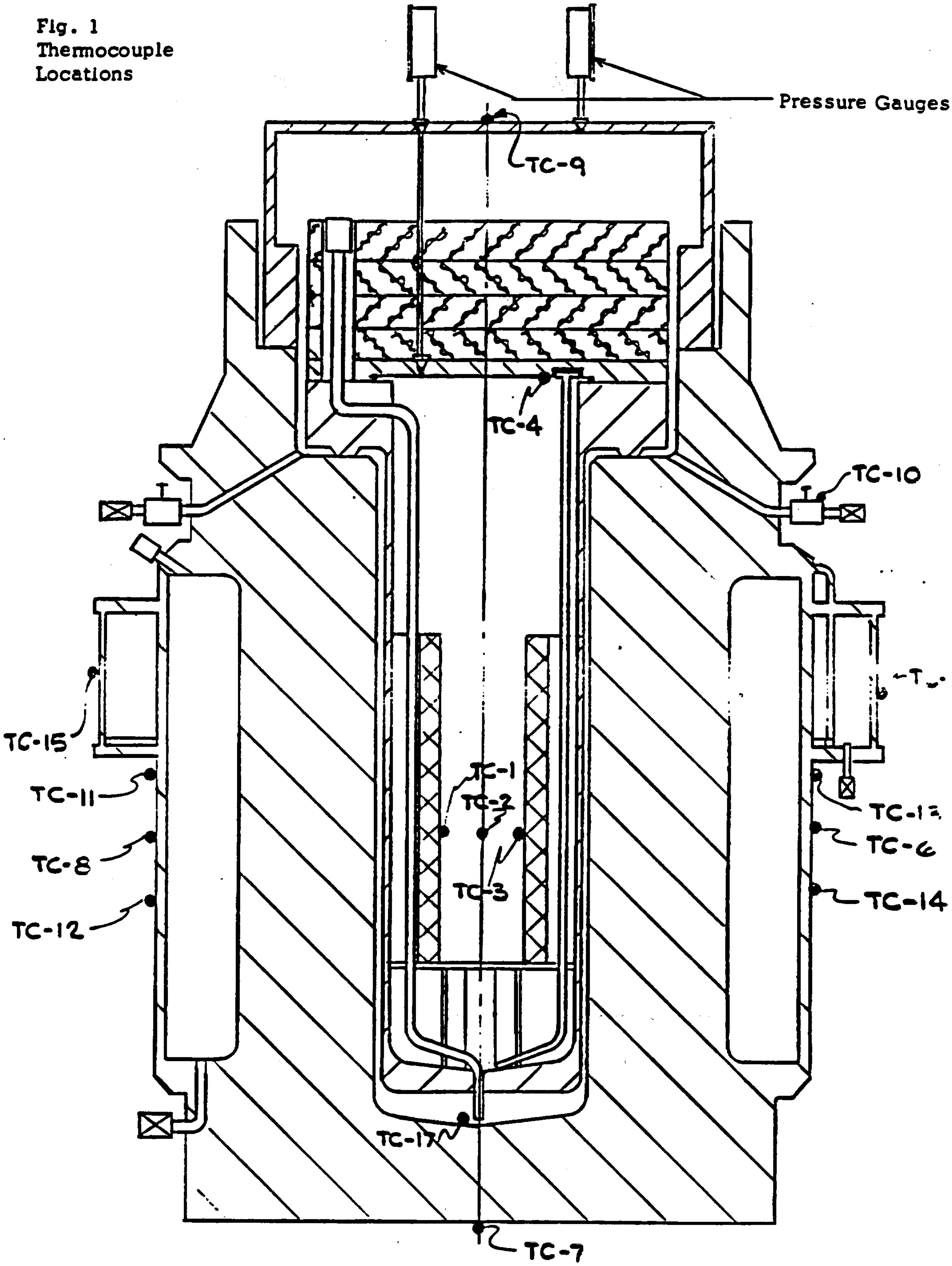
The assembled shipping cask shall be instrumented such that temperatures and pressures of the various elements of the system can be monitored and at established time intervals all data will be recorded. To obtain the necessary temperature data thermocouples will be installed on the inside surface of the aluminum basket; inside surfaces of the cask cavity; on the bottom head ; outside surface of the water jacket shell, on the ends of the cask; and on the surface of the personnel barrier. Thermometers will be used to monitor ambient air temperatures. Pressure gages will be mounted on the closure heads to indicate cavity and inner container pressures and on the water jacket. Power imput to the electrical heaters shall be instrumented to permit monitoring to assure that the required power level is maintained throughout the test.

The thermal performance of the cask shall be documented in a Thermal Test Report. The report is to include the time/temperature readings for each point of temperature measurement as well as pressure gage and heater power level from time of start up to thermal equalibrium. The results of the thermal test shall be evaluated against the results of the thermal analysis to determine the degree of agreement.

Acceptance Criteria:

The measured internal basket wall temperature shall not exceed the calculated steady state internal basket wall temperature by more than 15% after correcting the measured temperature for ambient test temperature conditions. Steady state conditions (thermal equilibrium) will be considered as being achieved if the two thermocouples at the cask mid-point (TC-8 and TC-6 Fig. 1) fail to raise more than two degrees (F) over a two hour period. As confirmation, the test will be conducted for an additional hour using the same criterion.

Fig. 1
Thermocouple
Locations



This page intentionally left blank.

APPENDIX A

SECTION XIV

THERMAL TEST PROCEDURE

Thermal tests will be performed in accordance with detailed thermal test procedures to verify the thermal performance of the shipping cask. The thermal tests will also be used to establish operational parameters relative to preparing a loaded cask for shipment and unloading the cask at the reprocessing plant.

As established in Section III, "Fuel Description and Source Data", the source strengths for the one PWR cask loading are more restrictive than for the two BWR loading. Therefore the heat source for the thermal test shall be equivalent to the calculated decay heat source for a single PWR fuel assembly of 10.63 kw. The heat source shall be provided by electrical heaters designed and located to simulate the active region of a PWR fuel assembly. A mockup of the inner and outer cask closure heads shall be provided which will simulate the actual closure head configuration and approximate the same thermal characteristics. There will be additional penetrations in the closure head mockups to provide for heater leads and thermocouple wire installation.

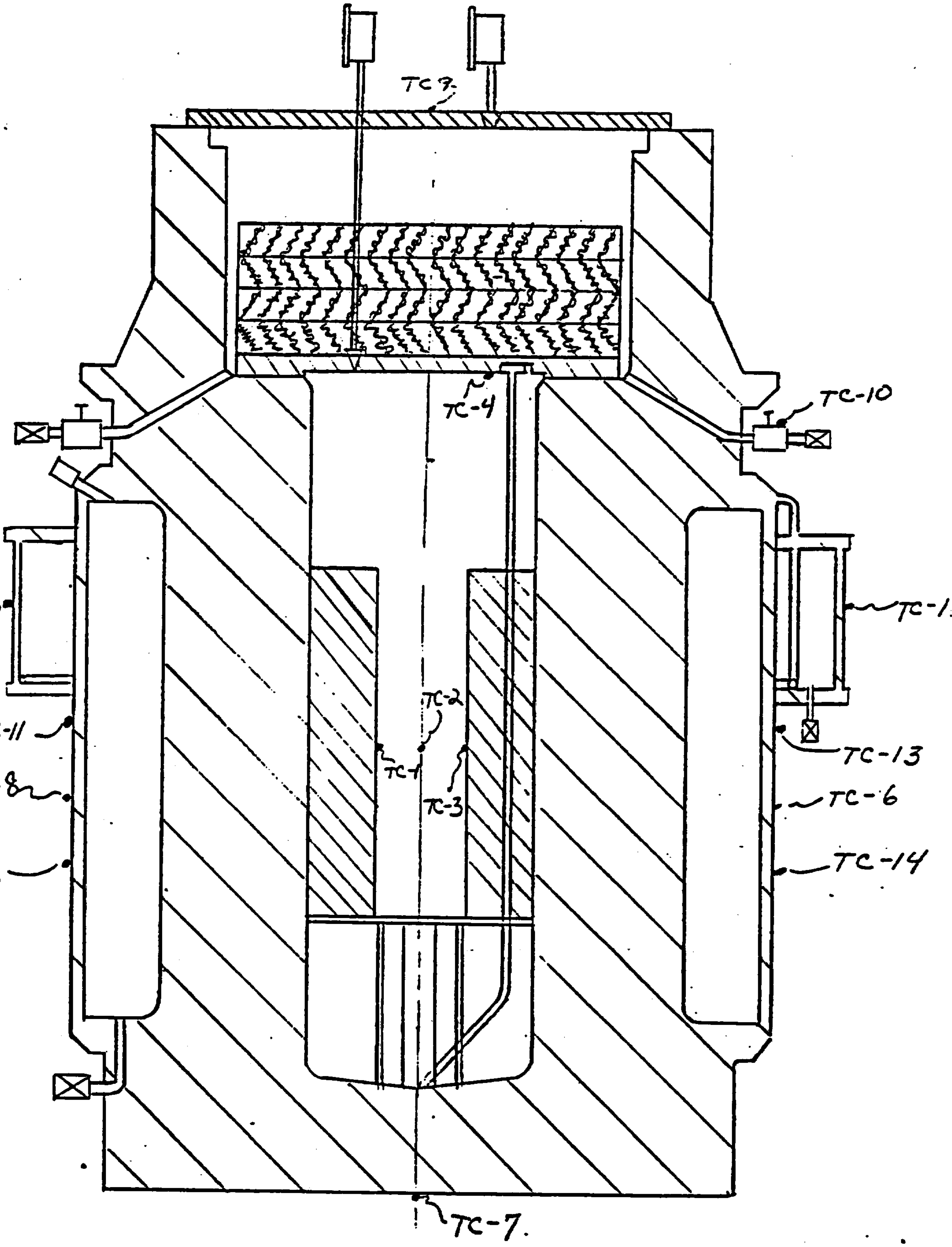
The thermal tests are to be performed within an enclosure which will provide essentially a still air environment. The cask shall be completely assembled i.e., the PWR fuel basket installed in the cask cavity, closure head mockups with heater and thermocouples leads in place, top and bottom impact structures in place. The assembled cask will be positioned horizontally to simulate the shipping attitude. The personnel barrier will be positioned over the shipping cask.

The assembled shipping cask shall be instrumented such that temperatures and pressures of the various elements of the system can be monitored and at established time intervals all data will be recorded. To obtain the necessary temperature data thermocouples will be installed on the inside surface of the aluminum basket; inside surfaces of the cask cavity; on the bottom head |; outside surface of the water jacket shell, on the ends of the cask; and on the surface of the personnel barrier. Thermometers will be used to monitor ambient air temperatures. Pressure gages will be mounted on the closure heads to indicate cask cavity and closure head cavity pressures.and on the water jacket, Power imput to the electrical heaters shall be instrumented to permit monitoring to assure that the required power level is maintained throughout the test.

The thermal performance of the cask shall be documented in a Thermal Test Report. The report is to include the time/temperature readings for each point of temperature measurement as well as pressure gage and heater power level from time of start up to thermal equalibrium. The results of the thermal test shall be evaluated against the results of the thermal analysis to determine the degree of agreement.

Acceptance Criteria:

The measured internal basket wall temperature shall not exceed the calculated steady state internal basket wall temperature by more than 15% after correcting the measured temperature for ambient test temperature conditions. Steady state conditions (thermal equilibrium) will be considered as being achieved if the two thermocouples at the cask mid-point (TC-8 and TC-6 Fig. 1) fail to raise more than two degrees (F) over a two hour period. As confirmation, the test will be conducted for an additional hour using the same criterion.


TC-9
TC-4
TC-10
TC-15
TC-1
TC-2
TC-11
TC-13
TC-1
TC-8
TC-3
TC-6
TC-12
TC-14
TC-7.

This page intentionally left blank.

Section XV

SECTION XV
OPERATING PROCEDURES

This page intentionally left blank.

SECTION XV

OPERATING PROCEDURES
INTRODUCTION

This procedure is intended to serve as a reference, generic in nature, delineating those operations and tests which must be performed, in order to use the cask in accordance with its certificate. This procedure is incorporated into a detailed operating procedure that is provided to each user before first use. The detailed operating procedure further amplifies or explains the operating steps presented here.

Each cask system, and related equipment, must be maintained in accordance with the tests and inspections given in Section XVI, Maintenance Program, of this Report. Those tests required to be performed with each use of the cask shall be incorporated into the facilities' Operating Procedure with accompanying check lists and sign-off verifying acceptable completion of those steps.

The generic procedure assumes that the shipping cask arrives at the shipping facility with the appropriate basket and spacer installed in the cask.

The steps, which are identified with an asterisk (*), apply only to the Configuration A.

Known or suspected failed fuel assemblies or fuel rods with cladding defects greater than pin holes and hairline cracks must be shipped in Configuration (A) unless the failed fuel rod is individually encapsulated in a sealed container.

Part G of the operating procedures contains the steps to be used when loading sound metallic fuel, failed metallic fuel, or oxide powder generated from severly failed metallic fuel rods.

Revised
Oct. 1990
Oct. 1991

OPERATING PROCEDURES

A. Preparation of Cask for Loading

1. Health Physics survey trailer and personnel barrier.
2. Inspect trailer and personnel barrier for damage. Note any discrepancy on shipping document.
3. Position trailer in assigned area. Set brakes and block wheel against movement in either direction.
4. Remove personnel barrier and set aside.
5. Health Physics survey cask and adjacent surfaces of trailer.

   Note: A receiving survey of the cask and transporter must be performed as soon as practicable after arrival at the site to assure compliance with 10 CFR 71.87(i), 10 CFR 71.47 and to assure timely reporting of any transportation non-compliance.
6. Inspect cask and trailer for damage. Report any damage to the cask owner.
7. Remove top and bottom impact structures.
8. Remove bolts from cask tiedown.
9. Using cask lifting yoke, engage trunnions on front end of cask. Raise cask to a vertical position on rear support, moving the crane as required to keep the cask engaged in the trailer rear support and the crane cable vertical. When cask is fully vertical, lift the cask from the trailer.
10. Place cask in the decontamination pit. Disengage lifting yoke. Clean cask surfaces as required for entry into spent fuel pool.
11. Disengage outer closure head bolts. Remove caps from the two closure head cavity drain valves.
12. Verify neutron shield fluid level.

    Note: For multi-shipment, extended shipping campaigns, it is necessary to verify fluid level for the initial shipment and thereafter only monthly, if there is no evidence of leakage. Test for leakage of neutron shield fluid by comparing neutron dose readings circumferentially at the cask midpoint when it is in the horizontal position at Step E-36. These readings must agree or loss of neutron fluid is indicated.

13. Using shackles, attach lifting slings to lift lugs on the outer closure head. Remove outer closure head and set it on supports which are suitable for radiological control and for maintaining the cleanliness of closure head. Carefully inspect "O" Ring seal in the underside of the closure head. If "O" Ring shows any damage, replace "O" Ring. Be certain that replacement "O" Ring is properly installed and seated.
14. Disengage inner closure head bolts. Attach slings to lifting lugs on inner closure head. Remove inner closure head and set on support which are suitable for radiological control and for maintaining the cleanliness of closure head. Replace the metallic "O" Ring and carefully inspect the elastomer "O" Ring seal in underside of closure head. If the elastomer "O" Ring shows any damage, replace it. Be certain that replacement "O" Ring(s) are properly installed and sealed. Note any damage or repairs. A spacer may be bolted to the underside of the inner closure head.
15. Remove valve caps from valves on inner head. Inspect seal rings for damage and replace if necessary. Visually inspect valved quick disconnect nipples and replace if they appear not to be seating properly.

*16. Open inner container closure head valves.

*17. Remove fuel assembly spacer plug (if used).

18. Visually inspect inner cavity for foreign material, damage, etc. Also inspect gasket in suction drain line flange and replace, if damaged. Note any discrepancies.
19. Fill cask cavity with demineralized water.
20. Engage cask lifting yoke with cask trunnions and pick up cask. Position cask over spent fuel storage pool and lower cask to bottom of pool.

---

*Configuration A only.

21. Disengage lifting yoke from cask and remove yoke from spent fuel storage pool.

B. Loading the Cask

1. Identify the item to be loaded.
   Note: An ORIGEN analysis must be completed on fuel bearing components prior to loading to ensure that the proposed contents conform to C of C requirements.
2. Pick up fuel assembly (or material container) using grapple system required.
3. Position fuel over cask, then carefully lower into cask. Confirm that fuel assembly is fully seated, then release grapple from fuel assembly and raise to full up position.
4. If BWR fuel is being loaded, repeat steps (1) through (3) above for the second assembly.

C. Removal of Cask from Spent Fuel Pool and Preparation for Shipment

*1. Install fuel assembly spacer plug in cask (if required).
2. Position cask lifting yoke over cask inner closure head. Attach sling to closure head lifting lugs.
3. Attach a valve access attachment to each valve. This provides an "open" condition for these penetrations.
4. Position inner closure head over cask and slowly lower into place. Guide pins which are located in the cask flange provide final alignment. Visually confirm that closure head is seated.
5. Lower cask handling yoke to slack closure head cables. Engage cask trunnions and begin lifting.
6. Raise cask until head is near the surface of the pool, then hand tighten twelve closure head bolts.

---

*Configuration A only.

7. Raise cask clear of pool, rinsing yoke, cask, etc., with clean water. Partially replace pool water in head cavity with clean water from the supply hose.
8. Remove cask to decontamination area.
9. Remove the two guide pins and install shipping bolts. Tighten all twelve inner head bolts and the two shipping bolts to the specific torque. (See Table 1 for Torque & Lubricating Requirements.)
10. Connect deionized water line to upper access valve and flush cask with two volumes of clean water. Disconnect water supply.
11. Connect air (or helium) supply line to fitting on inner head upper access valve.
12. Connect drain hose to fitting on inner head drain valve.
13. Open upper access, drain, and air (or helium) supply valves (or in-line counterparts) and pressurize container to force out approximately five gallons of water.
14. Close drain valve and allow inner cavity to pressurize to 10 psig. Close upper access valve and air (or helium) supply valve.

*15. Remove drain and air (or helium) lines.

16. Check for five minutes for leaks through inner head seal ring (*and valves) by observing the presence of bubbles. The presence of bubbles requires corrective measures and the repeating of all operational steps subsequent to that step at which corrective measures were effective.
17. Drain water from closure head cavity (*by opening closure head cavity drain valves) by attaching fixtures with valved couplers to valved nipples.
18. Reattach air (or helium) line to upper access valve and drain hose to drain valve.
19. Open the upper access valve, drain line and air (or helium) supply valve and force out the remaining water. When water flow stops, close air supply. When air (or helium) flow stops, disconnect air line and drain line (or helium).

*Configuration A only

Note: If the heat load is 2.0 kw or less, and if air was used in step 19, then the cavity must be purged a minimum of three times, to ensure that all air is removed. Following this purge, disconnect the helium purge lines and proceed to step 23, using the drain and vent valve connections.

For heat loads greater than 2.0 kw, all residual water and air must be removed from the cavity by vacuum drying and backfilling with helium as described in steps 20 through 22.

**20. Connect vacuum pump to the vent valve. Connect vacuum gauge to drain valve. Connect a helium line regulated to 5-10 psig to a valve at vacuum pump line header.

**21. Pump inner container until a pressure less than 3 mm is indicated on the vacuum gauge and maintain a pressure less than 3 mm for at least five minutes.

**22. Close valve in vacuum line and open valve in helium inlet line. When gauge on drain line reads "0", shut off helium supply. Disconnect vacuum line and both valve access attachments from the inner head valves. Stop vacuum pump.

23. If the Configuration A is used, attach suction pump line to annulus valve and remove water from outer cavity.

24. Connect valve access attachments to outer cavity drain valves and drain innr head cavity. Blot up any freestanding water on the inner head.

25. Inspect seals on valve covers; replace as required. Place valve covers over inner head valves and tighten bolts to specified torque. (See Table 1 for Torque & Lubricating Requirements.)

26. Attach air line regulated to 5 psig to fitting on each valve cap successively, pressurizing the annulus between the two seal rings to 5 psig. Observe the air gauge for five minutes after closing the

---

**Operations is required if thermal output of package contents exceeds 2.0 kw.

isolation valve. If no drop in air pressure is observed, the seal is acceptable. If air pressure drops, remove cap, replace seals, and repeat test.

27. Attach sling to outer closure head lugs, position outer closure head on cask and tighten head bolts to specified torque. (See Table 1 for Torque & Lubricating Requirements.)
28. Connect compressed air supply line to closure head cavity drain valve.
29. Connect pressure gauge and isolation valve assembly to quick disconnect fitting on opposite closure head cavity drain valve. Close isolation valve and open drain valve.
30. Open compressed air line supply valve and pressurize closure head cavity to 10 psig. Close air supply valve and drain valve and remove air supply line at source, leaving line open to atmosphere. Hold pressure for ten minutes. If there is no drop in pressure, the outer closure head seal is satisfactory.
31. Open isolation valve and relieve pressure in closure head cavity.

**32. Connect vacuum gauge to one outer closure head drain valve and the vacuum line from the vacuum pump to the other. Vacuum pump the inner head cavity until a pressure of less than 3 mm is indicated on the vacuum gauge and maintain a pressure less than 3 mm for at least five minutes.

33. Close valve in vacuum line on vacuum pump header and open air bleed valve. When system has reached one atmosphere (0 psig), disconnect attachments.
34. Remove gauge and isolation valve assembly and valve access attachments.
35. Bolt valve caps into place using specified torque. (See Table 1 for Torque and Lubricating Requirements.) Attach air line regulated to 5 psig to fitting on each valve cap successively, pressurizing the annulus between the two seal rings to 5 psig. Close isolation valve

---

**Operation is required if thermal output of package contents exceeds 2.0 kw.

and observe for 5 minutes. If no drop in air pressure is observed the seal is acceptable. If air pressure drops, remove cap and replace seals.

36. Survey cask for surface contamination and radiation dose rates. Note: Assure compliance with 10 CFR 71.87(i) and 10 CFR 71.47.
37. Using lifting yoke, lower cask to trailer. Engage cut-outs in bottom end of cask with rear tie-down trunnion. Lower cask to rest on front tie-down saddle, moving cask lifting yoke as required to keep crane cables vertical. Disengage cask lifting yoke from cask trunnions and set aside.
38. Survey cask for surface contamination and dose rates. Assure compliance with 10 CFR 71.47 and 10 CFR 71.87(i).
39. Install tie-down bolts. Install top and bottom impact structures.
40. Install seals on two adjacent bolts of Top Import Limiter.
41. Install personnel barrier on trailer.
42. Health Physics survey and record vehicle radiological compliance data. Assure compliance with 10 CFR 71.87(i) and 10 CFR 71.47.
43. Display shipping placards and labels as required by 49 CFR.
44. Review shipping document for completeness and accuracy.

D. Preparation of Cask for Unloading

1. Health Physics preliminary survey, trailer and personnel barrier. (See Step 5)
2. Inspect trailer and personnel barrier for damage. Note any discrepancy.
3. Position trailer in assigned area. Set brakes and block wheels against movement in either direction.
4. Remove personnel barrier and set aside.

5. Health Physics survey cask and adjacent surfaces of trailer.
   Note: In accordance with 10 CFR 20.205, a receiving survey of the cask and transporter must be performed as soon as practicable after arrival at the site to assure compliance with 10 CFR 71.87(i), 10 CFR 71.47, and to assure timely reporting of any transportation non-compliance.
6. Inspect cask and trailer for damage. Advise cask owner of any damage.
7. Remove top and bottom impact structures. Remove bolts from cask tie-downs.
8. Using cask listing yoke, engage trunnions on front end of cask. Raise cask to certical position on rear support, moving the crane as required to keep rear end of cask engaged on trailer rear support and crane cable vertical. When cask is fully vertical, remove it from trailer.
9. Place cask in suitable work area. Remove caps from closure head cavity drain valves.
10. Connect pressure gauge and isolation valve assembly to one valve access attachment. Close isolation valve. Connect attachment to one of the drain valves. Record internal pressure reading (if any). Using a suitable air line and the gauge/valve assembly, vent the closure head cavity to an off-gas handling unit.
11. Remove all outer closure head bolts.
12. Attach two-legged sling to outer closure head lift lugs. Remove outer closure head. Place outer closure head on supports which are suitable for radiological control and maintaining cleanliness.
    Note: If cask is to be unloaded dry (as in a hot cell), references to pool-associated operations will be modified accordingly.
13. Connect vent and water flush lines to upper access valves.

*14. Open upper access valve.

---

*Configuration A only

15. Open demineralized water valve to allow water to slowly enter the cask cavity.

CAUTION

The hot gases exiting from the fill valve could be highly radioactive. The exhaust gases must therefore be contained and disposed of accordingly.

Any system for cooling down the package shall be provided with a pressure relief device set so that the maximum pressure in the containment vessel does not exceed 310 psig for the Configuration A or 365 psig for the cask cavity.

Coolant flow rates must be controlled to avoid thermal shock to the cask internals.

16. Continue filling procedure until inner container is filled with water. Remove flush and vent lines.
17. Connect valve access attachments to both valves on closure head.
18. Loosen all closure head bolts, but do not disengage threads.
19. Using lifting yoke with slings attached, engage the cask lift trunnions and connect lifting device on lugs on inner head.
20. Position cask over spent fuel storage pool and lower cask until top of cask is at elevation which permits access to the inner closure head bolts.
21. Disengage all inner closure head bolts.

22. Lower cask to rest on bottom of spent fuel storage pool. Disengage lifting yoke from cask and slowly raise yoke until inner closure head is raised clear of cask.
23. Remove closure head from spent fuel storage pool and set it on supports suitable for radiological control and for maintaining cleanliness.
*24. Remove fuel assembly spacer plug (if installed) and set on supports which are suitable for radiological control and for maintaining cleanliness.

E. Unloading Fuel from Cask

1. Pick up fuel assembly using fuel grapple.
2. Set fuel assembly in pool storage rack or other container. Release grapple from fuel assembly.
3. If BWR fuel is being unloaded, repeat Steps 1 and 2 above, to unload second assembly.

F. Preparation for Returning Unloaded Cask

(Empty cask located in spent fuel storage pool.)

1. Engage cask trunnions with lifting yoke and raise cask.
2. Commence washing cask down as it emerges from pool water.
3. Move cask to decontamination area and set down. Disengage cask lifting yoke. Commence decontamination.
4. Inspect both closure heads for damage and condition of gaskets. Replace all gaskets which have surface defects.
5. Set inner closure head into place.
6. Open drain and upper access valves.

---

*Configuration A only.

7. Connect line between inner head drain valve and contaminated drain. Connect line between closure head cavity drain valve and contaminated drain.
8. Connect line between cask cavity drain line and demineralized water supply and begin flushing outer cavity.
9. Connect supply of demineralized water to inner head fill valve. Open valves and flush inner container and cask cavity. (Replace cavity volume at least 3 times--195 gallons minimum).
10. Stop water flow and disconnect demineralized water supply lines.
11. Connect compressed air line to inner head fill valve. Torque inner closure head bolts to 150 10, -0, foot/pounds. Open air line fill valve and blow inner container dry.
12. Disconnect compressed air line and drain line from inner head.
13. Remove inner head and perform the following radiological surveys:
    a. dose rates at plane of seal surface (inner head) and at least 1 foot down into the cask cavity from the inner head seal surface.
    b. Smears of accessible surfaces at least 1 foot down into the cask cavity from the inner head seal surface.

    These results shall be reported to the Cognizant NAC Person who will decide if additional decon of the cask cavity is required prior to shipment. After release by NAC re-install the inner head and proceed with subsequent operations.
*14. Pump water from annulus between cask cavity and inner container using cask cavity suction drain line.
*15. Disconnect line from cask cavity suction drain line.
*16. Close suction drain valve and fill valve.
17. Check valves caps for defective seals. Replace caps using one-half of the specified torque.
18. Install outer closure head. Torque closure head bolts to one-half required foot/pounds.

---

*Configuration A only.

19. Survey cask for surface contamination.
    Note: Assure compliance with 10 CFR 71.47 and 10 CFR 71.87.
20. Engage cask trunnions with cask lifting yoke.
21. Pick up cask and position over trailer.
22. Lower cask to trailer. Engage cut-outs in bottom of cask with rear tie-down saddle, moving cask lifting yoke as required to keep crane cables vertical. Disengage cask lifting yoke from cask trunnions and set aside.
23. Install tie-down bolts. Install top and bottom impact structures.
24. Install seal on adjacent bolts of top impact limiter.
25. Install personnel barrier on trailer and bolt in place.
26. Display shipping placards and labels as required by 40 CFR.
27. Survey cask and trailer for compliance with 10 CFR 71.47 and 10 CFR 71.87(i). Review shipping document for completeness and accuracy. Sign off as ready for shipment.

G. Procedures for Loading Sound and Failed Metallic Fuel

1.0 Loading of Metallic Fuel

NOTE: The procedure for loading dry metallic sound (intact) fuel baskets, small diameter failed fuel canisters (FFCs) and large diameter FFCs into the cask is the same; however, only three large diameter FFCs or three sound fuel baskets can be placed into the cask, while six of the smaller FFCs can be used.

1.1.1 Perform a receiving survey of the empty cask and closed container and inspect for damage.

1.1.2 Position the trailer in the designated area. Set the trailer brakes and block the wheels against movement in either direction.

1.1.3 Remove the lid from the ISO container.

1.1.4 Health Physics survey cask and adjacent surfaces of trailer. NOTE: A receiving survey of the cask and transporter must be peformed as soon as practicable after arrival at the site to assure compliance with 10 CFR 71.87(i), 10 CFR 71.47 and to assure timely reporting of any transportation non-compliance.

1.1.5 Inspect cask and trailer for damage. Report any damage to the cask owner.

1.1.6 Remove top and bottom impact structures.

1.1.7 Remove bolts from cask tiedown.

1.1.8 Using cask lifting yoke, engage trunnions on front end of cask. Raise cask to a vertical position on rear support, moving the crane as required to keep the cask engaged in the trailer rear support and the crane cable vertical. When cask is fully vertical, lift the cask from the container.

1.1.9 Place cask in the dry loading stand. Disengage lifting yoke.

1.1.10 Disengage outer closure head bolts. Remove caps from the two closure head cavity drain valves.

1.1.11 Using shackles, attach lifting slings to lift lugs on the outer closure head. Remove outer closure head and set it on supports which are suitable for radiological control and for maintaining the cleanliness of closure head. Carefully inspect o-ring seal in the underside of the closure head. If o-ring shows any damage, replace o-ring. Be certain that replacement o-ring is properly installed and seated.

1.1.12 Disengage inner closure head bolts. Attach slings to lifting lugs on inner closure head. Remove inner closure head and set on support which are suitable for radiological control and for maintaining the cleanliness of closure head. Replace the metallic o-ring and carefully inspect the elastomer o-ring seal in underside of closure head. If the elastor o-ring shows any damage, replace it. Be certain that replacment o-ring(s) are properly installed and sealed. Note any damage or repairs.

1.1.13 Remove valve caps from valves on inner head. Inspect seals rings for damage and replace if necessary. Visually inspect valved quick disconnect nipples and replace if they appear not to be seating properly.

1.1.14 Visually inspect inner cavity for foreign material, damage, etc. Also inspect gasket in suction drain line flange and replace, if damaged. Note any discrepancies.

1.1.15 Replace the closure lid, but not the lid bolts.

1.1.16 Identify the fuel to be loaded.

NOTE: An ORIGEN (or equivalent) analysis must be completed on the fuel bearing components prior to loading to ensure that the proposed contents conform to the Certificate of Compliance.

Page Added
Oct. 1990

1.1.17 Place the carriage assembly on top of dry loading stand.

1.1.18 Position the carriage assembly for cask lid removal. Connect the cask lid to the removal cylinder and remove the lid from the cask.

1.1.19 Position the carriage for fuel loading.

1.1.20 Match mark the carriage assembly and turntable to each fuel canister location in the cask cavity. For sound fuel, there will be three canisters with five rods each; and with large diameter FFCs, there will be three canisters with one rod each.

1.1.21 Move the carriage and turntable to fuel canister position number 1.

1.1.22 After retrieving the fuel (sound or failed) from the pool, place the shielded transfer cask containing a fuel canister (as many as seven sound or one failed metallic fuel rods) onto the turntable.

1.1.23 Lower the fuel canister from the canister from the transfer cask into the shipping cask.

1.1.24 Repeat steps 1.1.21, 1.1.22 and 1.1.23 to access fuel canister positions 2 and 3 and complete the cask loading. For small diameter FCC load repeat for all six positions.

1.1.25 Replace both o-rings on the closure lid.

1.1.26 Replace the closure lid onto the cask by re-positioning the carriage assembly and actuating the cask lid cylinder. Visually confirm that the lid is properly seated.

1.1.27 Remove the carriage assembly from the loading stand.

1.1.28 Install the twelve inner lid closure bolts. Tighten all twelve inner head bolts and the two shipping bolts to the specific torque.

1.1.29 Fill the head cavity with demineralized water.

1.1.30 Connect the pressure/test fixture to V-1, and using air or an inert gas pressurized the cask cavity to 15 psig. Then close the supply line.

1.1.31 Open the pressure relief valve on the pressure/test fixture to allow the pressure to bleed down to 10 psig. Then close the relief valve.

1.1.32 Observe the water contained in the head cavity for any bubbles coming from inner cavity seal. If a leak is detected within 5 minutes it must be corrected before continuing with step.

1.1.33 Remove the water from the head cavity.

1.1.34 Attach helium line to upper access valve and drain hose to drain valve.

1.1.35 Open the upper access valve, drain line and helium supply valve and pump the air in the cask cavity. After a period of time disconnect helium line and drain line.

1.1.36 Connect valve access attachments to outer cavity drain valves and drain inner head cavity. Blot up any freestanding water on the inner head.

1.1.37 Inspect seals on valve covers; replace as required. Place valve covers over inner head valves and tighten bolts to specified torque. (See Table XV-1 for Torque & Lubricating Requirements.)

1.1.38 Attach air line regulated to 5 psig to fitting on each valve cap successively, pressurizing the annulus between the two seals rings to 5 psig. Observe the air gauge for five minutes after closing the isolation valve. If no drop in air pressure is observed, the seal is acceptable. If air pressure drops, remove cap, replace seals, and repeat test.

1.1.39 Attach sling to outer closure head lugs, position outer closure head on cask and tighten head bolts to specified torque. (See Table XV-1 for Torque & Lubricating Requirements).

1.1.40 Connect compressed air supply line to closure head cavity drain valve.

1.1.41 Connect pressure gauge and isolation valve assembly to quick disconnect fitting on opposite closure head cavity drain valve. Close isolation valve and open drain valve.

1.1.42 Open compressed air line supply valve and pressurize closure head cavity to 10 psig. Close air supply valve and drain valve and remove air supply line at source, leaving line open to atmosphere. Hold pressure for ten minutes. If there is no drop in pressure, the outer closure head is satisfactory.

1.1.43 Open isolation valve and relieve pressure in closure head cavity.

1.1.44 Remove gauge and isolation valve assembly and valve access attachments.

1.1.45 Bolt valve caps into place using specified torque. (See Table 1 for Torque and Lubricating Requirements). Attach air line regulated to 5 psig to fitting on each valve cap successively, pressurizing the annulus between the two seal rings to 5 psig. Close isolation valve and observe for 5 minutes. If no drop in air pressure is observed the seal is acceptable. If air pressure drops, remove cap and replace seals.

1.1.46 Decontaminate the cask. Survey the cask for surface contamination and radiation dose rates.

1.1.47 Using the cask lifting yoke, transfer and lower the cask to the trailer. Engage the lower rotation trunnions with the rotation supports in the container. Lower the cask to rest on the upper trunnion saddles, moving the cask lifting yoke as required to keep the crane cables vertical. Disengage the cask lifting yoke from the cask lifting trunnions and set it aside.

1.1.48 Install the cask tiedowns; then install the cask impact limiter.

1.1.49 Install the container lid.

1.1.50 Complete a Health Physics survey and record vehicle radiological compliance data. Ensure compliance with 10 CFR 71.87(i) and 10 CFR 71.47. Complete the shipping documents and apply placards and labels to the cask and container.

2.0 Loading Metallic Fuel and Filters Containing Oxide Powder from Failed Metallic Fuel into into Failed Fuel Canisters

2.1 Small Diameter Canisters (Failed Metallic Fuel Rods)

2.1.1 Examine the small diameter failed fuel canister (FFC) and check it for damage.

2.1.2 Place the FFC inside the containment barrier portion of the pool. Position the FFC in the failed rod loading station.

2.1.3 After verifying the accountability records, place the designated failed fuel rod into the FFC. If the rod is broken into two or more pieces, verify that the lid thread and seal area is not fouled during rod insertion.

2.1.4 When the can is loaded, install the lid using the FFC Lid Installation Tool.

Page Added
Oct. 1990
Revised
Oct. 1991

2.1.5 Using the FFC handling tool, move the loaded FFC through the containment barrier door and place the FFC horizontally into the upender.

2.1.6 Operate the hand winch to move the FFC to the vertical position.

2.1.7 Torque the FFC lid to 100 foot-pounds for the small canister.

2.1.8 Connect the nitrogen supply line to the vent valve.

2.1.9 Open nitrogen supply valve and pressurize the FFC to force out the water. Blow gas through the FCC for 5 minutes after the first visible traces bubbles appear. Remove the gas supply line.

2.1.10 Invert the FFC in the upender and install the pipe plug.

2.1.11 Re-invert the FFC in the upender.

2.1.12 Attach the vacuum pump to the FFC vent valve. Evacuate the FFC to a pressure below 1 inch of mercury for 15 minutes. Remove the vacuum pump and backfill with nitrogen.

2.1.13 Remove the FFC from the upender and place it into temporary storage.

2.2 Large Diameter Canisters (Failed Metallic Fuel Rods)

2.2.1 Examine the large diameter FFC and check it for damage.

2.2.2 Place the FFC inside the containment barrier portion of the pool. Position the FFC in the failed rod loading station.

2.2.3 This step is to be used when loading a previously canned fuel rod into the large diameter canister. After verifying the accountability records, remove the ceramic filter from the top of the original failed rod can. Position the can plug with aluminum screen onto the open can. Install the plug.

2.2.4 Verify the accountability records for the fuel to be loaded.

2.2.5 Place the designated fuel into the FFC. If the rod is broken into two or more pieces, verify that the lid thread and seal area is not fouled during rod or can insertion.

2.2.6 When the canister is loaded, install the lid using the FFC Lid Installation Tool.

2.2.7 Using the FFC handling tool, move the loaded FFC through the containment barrier door and place the FFC horizontally into the upender.

2.2.8 Operate the hand winch to move the FFC to the vertical position.

2.2.9 Torque the FFC lid to 130 foot-pounds for the large canister.

2.2.10 Connect the nitrogen supply line to the vent valve.

2.2.11 Open the nitrogen supply valve and pressurize the FFC to force out the water. Blow gas through the FFC for 5 minutes after the first visible traces of bubbles appear. Remove the gas supply line.

2.2.12 Invert the FFC in the upender and install the pipe plug.

2.2.13 Re-invert the FFC in the upender.

2.2.14 Attach the vacuum pump to the FFC vent valve. Evacuate the FFC to a pressure below 1 inch of mercury for 15 minutes. Remove the vacuum pump and backfill with nitrogen.

2.2.15 Remove the FFC from the upender and place it into temporary storage.

Page Added
Oct. 1990
Revised
Oct. 1991

2.3 Large Diameter Canisters (Severely Failed Metallic Fuel in Filters)

2.3.1 Examine the large diameter FFC and check it for damage.

2.3.2 Place the FFC inside the containment barrier portion of the pool. Position the FFC in the failed rod loading station.

2.3.3 Verify the accountability records for the fuel in the filter set to be loaded into the FFC. The curie limits as stated in 10 CFR 71.63(a) can not be exceeded for the package into which the loaded FFC will be placed.

2.3.4 Place the designated filter set into the FFC. Verify that the lid thread and seal area is not fouled during the filter set insertion.

2.3.5 When the canister is loaded, install the lid using the FFC Lid Installation Tool.

2.3.6 Using the FFC handling tool, move the loaded FFC through the containment barrier door and place the FFC horizontally into the upender.

2.3.7 Operate the hand winch to move the FFC to the vertical position.

2.3.8 Torque the FFC lid to 130 foot-pounds for the large canister.

2.3.9 Connect the nitrogen supply line to the vent valve.

2.3.10 Open the nitrogen supply valve and pressurize the FFC to force out the water. Blow gas through the FFC for 5 minutes after the first visible traces of bubbles appear. Remove the gas supply line.

2.3.11 Invert the FFC in the upender and install the pipe plug.

2.3.12 Re-invert the FFC in the upender.

2.3.13 Attach the vacuum pump to the FFC vent valve. Evacuate the FFC to a pressure below 1 mm of mercury for 15 minutes. Remove the vacuum pump and backfill with nitrogen.

2.3.14 Remove the FFC from the upender and place it into temporary storage.

Table XV.1

BOLT, WRENCH, AND TORQUE TABLE

Bolts	No. Used	Fastener	Wrench	Torque Value Ft. Lbs.	Lubrication
Personnel Barrier Bolts	4	5/8 " - 11 UNC-2A - Hex Head Bolt	15/16" Socket[1]	40-50	
Top Impact Limiter Bolts	4	3/4" - 10 UNC-2A - Hex Head Bolt	1 1/8" Box or Socket[2]	10 +2 -0	
Bottom Impact Limiter Bolts	4	3/4" - 10 UNC-2A - Hex Head Bolt	1 1/8" Box or Socket[2]	10 +2 -0	
Tie-down Bolts	2	1 3/8" - 6 UNC-2A - Hex Socket Head Cap Screw	1" Hex Key	200 +20 -0	
Outer Closure Head Bolts	8	1" - 8 UNC-2A - Socket Head Cap Screw	3/4" Socket	75 +10 -0	See Note
Inner Closure Head Bolts	12	1" - 8 UNC-2A - Hex Head Bolts	1 1/2" Socket	300 +20 -0	
Inner Closure Head Valve Cap Bolts	6	1/2" - 13 UNC-2A - Hex Head Bolts	3/4" Socket	21 +2 -0	
Closure Head Cavity Drain Valve Cap Bolts	6	1/2" - 13 UNC-2A - Hex Head Bolts	3/4" Socket	7 +2 -0	
Water Jacket Drain - Valve Box Cover Bolts	4	3/4" - 16 UNC-2A - Socket Head Cap Screws	5/16" Hex Key	23 +2 -0	
Inner Closure Head	2	1" - 8UNC-2A - Hex Head Bolts	1 1/2" socket	10 +5 -0	

[1] If Heavy Hex Bolts are used, 1-1/16" wrench will be required.

[2] If Heavy Hex Bolts are used, 1-1/4" wrench will be required.

Note: All bolts shall be lightly lubricated using Nuclear Grade Pure Nickle Neversieze or equivalent.

APPENDIX A

SECTION XV

OPERATING PROCEDURES

SPECIFIC REQUIREMENTS RELATED TO THE LOADING OF MARK 42 OR MARK 22 FUELS

The cask shall be configured with the Fermi Fuel basket (Configuration C).

Mark 42 Loading

Only one irradiated Mark 42 fuel assembly, either intact or sectioned form, may be shipped at any one time. If sectioned, each section must be seal welded in a shipping can as shown on Martin Marietta Energy Systems (MMES) Drawing Nos. M-12821-CP-105E Rev. 1 and M-12821-CP-106E Rev. 3. Four shipping cans will be loaded into a Mark 42 Segment Dry Shipping Canister as shown on MMES Drawing No. M-12821-CP-102 Rev. 2, along with a shipping canister spacer, as shown on MMES Drawing No. M-112821-CP-103 Rev. 2. The shipping canister will be loaded on top of a carrier spacer as shown on MMES Drawing No. M-12821-CP-112 Rev. 1. A maximum of 2 shipping canisters may be loaded into a cask. Intact fuel assemblies will be shipped in a Mark 42 Element Wet Shipping Canister as shown on MMES Drawing No. M-12821-CP-114 Rev. 2.

Mark 22 Loading

Two Mark 22 fuel assemblies or one Mark 22 fuel assembly with the two cores separated may be shipped at any one time. Each assembly or core will be shipped in a shipping canister as shown on Sandia National Laboratory Drawing No. R21563, Sheet 1, Issue B.

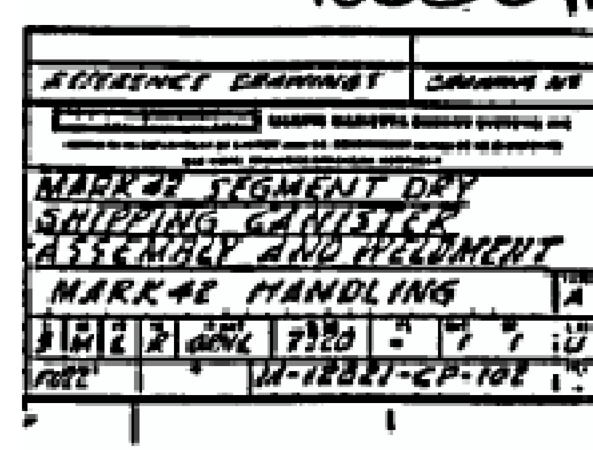
All other requirements of Section XV apply to both the Mark 22 and Mark 42 loading and testing for shipment.

Page Added
Feb. 1991

This page intentionally left blank.

FIGURE WITHHELD UNDER 10 CFR 2.390

9603010285-08



Page Added
Feb. 1991

FIGURE WITHHELD UNDER 10 CFR 2.390

9603010285-09

MARK-42 SEGMENT DRY SHIPPING CANISTER SPACER ASSEMBLY & WELDMENT

MARK 42 HANDLING

ORNL

Page Added
Feb. 1991

FIGURE WITHHELD UNDER 10 CFR 2.390

SHIPPING CAN WELDMENT & DETAILS	[illegible]
REFERENCE DRAWINGS	DWG. NO.

SHIPPING CAN ASSEMBLY

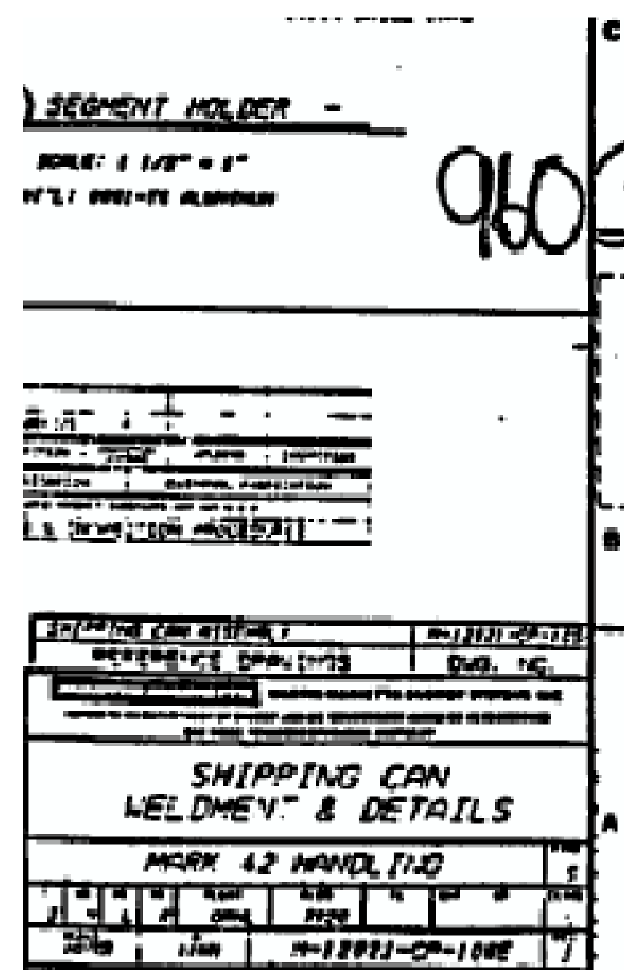
MARK 42 HANDLING

9603010285-10

Page Added
Feb. 1991

XV-A4

FIGURE WITHHELD UNDER 10 CFR 2.390



9603010285-11

Page Added
Feb. 1991

FIGURE WITHHELD UNDER 10 CFR 2.390

9603010285-12

MARK-42 SEGMENT DRY SHIPPING CANISTER CARRIER SPACER ASSEMBLY & WELDMENT

MARK-42 HANDLING

ORNL

FULL

M-12821-EP-112

Page Added
Feb. 1991

XV-A6

FIGURE WITHHELD UNDER 10 CFR 2.390

9603010285-13

REFERENCE DRAWINGS | DRAWING NO
MARK 42 ELEMENT MTR SHIPPING CANISTER ASSEMBLY AND WELDMENT
MARK 42 HANDLING

Page Added
Feb. 1991

FIGURE WITHHELD UNDER 10 CFR 2.390

TAB				5
...ODD TAG		8		4
...AL BOLT				3
...STER LID WELDMENT				2
...PLATE				1
...ATION OF HELICAL ... SCREW THREAD INSERTS		2		
...ING, ALUMINUM ALLOYS		1		
...AL REQUIREMENTS				
DESCRIPTION / MATERIAL		NOTE		ITEM

LIST OF MATERIAL

(U) TITLE CLASSIFICATION

SHIPPING CANISTER

(SANDIA NATIONAL LABS)

UNCLASSIFIED

UNCLASSIFIED

E R21963

9603010285-14

Page Added
Feb. 1991

XV-A8

Section XVI

SECTION XVI
MAINTENANCE PROGRAM

This page intentionally left blank.

SECTION XVI
MAINTENANCE PROGRAM

Each cask shall be subjected to a series of tests and inspections prior to each shipment as indicated in the following maintenance program schedule. These tests ensure the leak-tightness of the properly sealed package. Periodically (annually) each cask shall be leak tested to ensure that no degradation of the package integrity has occurred over time. In addition to testing, certain components are replaced and a comprehensive visual inspection of the cask surfaces and major components is completed. Annual tests, inspections and part replacements are shown on the following maintenance program schedule.

Each cask must have a current annual inspection prior to its use. Each required annual servicing of a cask shall be performed normally during or before the calendar month in which the annual servicing is due. In every case, however, it shall be performed no later than thirty (30) days following the date the servicing is due. During inactive periods, the maintenance and testing frequency may be disregarded provided that the package is brought into full compliance prior to the next use of the package.

Engineering approval is required prior to making any repairs of damaged areas or areas that need refurbishing due to normal wear and tear. All such repairs will be fully documented. The replacement valves, pressure gages, fittings, seals, and thread fasteners is considered normal maintenance and would not require engineering approval.

Seals, O-rings, and gaskets described in the following schedule must be visually inspected for wear or damage and replaced as necessary during cask use.

Maintenance Program

Periodic maintenance and testing of sealing surfaces, containment boundaries, and relief valves of the cask are shown below. Certain seals and O-rings must be replaced prior to testing.

1. <u>Inner Closure Head Seal and Inner Cavity</u>

Each Shipment	Air Bubble Test 10 psig
Annually	Helium Leak Test[1]
Annually	Seal Replacement
Annually	Visual Inspection

2. <u>Inner Closure Head Valve Caps, Cavity Drain Valve Caps</u>

Each Shipment	Visual Inspection
	Air Pressure Test at 5 psig
Annually	Helium Leak Test[1]
Annually	Seal Replacement
Annually	Visual Inspection

3. <u>Drain Line Gasket</u>

Each Shipment	Visual Inspection, Replace as Necessary
Annually	Seal Replacement

4. <u>Outer Closure Head</u>

Each Shipment	Air Pressure Test to 10 psig
Annually	Helium Leak Test[1]
Annually	Seal Replacement
Annually	Visual Inspection

5. <u>Water Jacket & Expansion Tank; Valves</u>

Annually	Check Fluid Level, Specific Gravity and Boron Concentration[2]
Annually	Visual Inspection
Each Shipment	Check Fluid Level

6. <u>Water Jacket Relief Valve</u>

Annually	Verify cracking and reseating pressure; allowable variation is +5% - 12% of nominal cracking pressure

7. Fasteners, Studs, Washers - "O" Ring Clips

Each Shipment	Replace as Necessary

8. Valve Box Gasket

Each Shipment	Visual Inspection; Replace as Necessary
Annually	Gasket Replacement

ADDITIONAL TESTS AND INSPECTIONS FOR CONFIGURATION A:

9. Inner Container Closure Head Valves

Each Shipment	Air Bubble Test 10 psig
Annually	Helium Leak Test[1]
Annually	Seal Replacement
Annually	Visual Inspection

10. Inner Container

Annually	Helium Leak Test[1]
Annually	Visual Inspection

1. Introduce helium and pressurize cavity to a pressure (greater than atmospheric). Using a sniffer probe connected to a mass spectrometer, scan the joint, moving at a rate not to exceed 15 inches per minute. A leak rate greater than 1×10^{-6} STP cc/sec. will be cause for rejection.

2. For single shipment campaigns the neutron shield fluid level must be checked prior to the shipment. For multi-shipment, extended campaigns, the level may be checked periodically (monthly) throughout the campaign, in accordance with the operating procedures. For shipment of PWR assemblies having a maximum average burnup between 40,000 MWD/MTU and 56,000 MWD/MTU, the neutron shield fluid must be verified to contain 1.0 weight percent boron. (Borated fluid may be left in the shielding tanks during shipment of other contents permitted by the Certificate.)

THIS PAGE INTENTIONALLY LEFT BLANK

Section XVII

SECTION XVII

ENGINEERING DRAWINGS

This page intentionally left blank.

SECTION XVII
ENGINEERING DRAWINGS

General

70514F	Sheet 1	Rev. 8	NLI 1/2 Cask and Trailer General Arrangement
70514F	Sheet 2	Rev. 8	NLI 1/2 Cask and Trailer General Arrangement
70885F	Sheet 1	Rev. 3	Spent Fuel Cask Details
70885F	Sheet 2	Rev. 2	Spent Fuel Cask Details
70885F	Sheet 3	Rev. 2	Spent Fuel Cask Details
70885F	Sheet 4	Rev. 1	Spent Fuel Cask Details
70887F	Sheet 1	Rev. 1	Outer Closure Head
70888F	Sheet 1	Rev. 3	Spent Fuel Cask General Assembly

Configuration (A)

70516F	Sheet 1	Rev. 8	Spent Fuel Cask General Assembly
70562F	Sheet 1	Rev. 10	Inner Container
70562F	Sheet 2	Rev. 6	Inner Container
70562F	Sheet 3	Rev. 0	Inner Container
70562F	Sheet 4	Rev. 0	Inner Container

Configuration (B)

70886F	Sheet 1	Rev. 2	Basket Concept
70884F	Sheet 1	Rev. 2	Inner Closure Head

Configuration (C)

460-052-F8	Sheet 1	Rev. 4	Rockwell Fuel Basket - NLI 1/2 Cask
460-052-F9	Sheet 1	Rev. 3	Container - Fermi Fuel, Rockwell Basket - NLI 1/2 Cask, Assembly of

Configuration (D)

347-291-F12		Rev. 1	Liner - 3 Element, NLI 1/2 Cask, Fuel Movement Project

Revised
Oct. 1990

This page intentionally left blank.

FIGURE WITHHELD UNDER 10 CFR 2.390

NATIONAL LEAD COMPANY

NLI 1/2 CASK & TRAILER

GENERAL ARRANGEMENT

This page intentionally left blank.

FIGURE WITHHELD UNDER 10 CFR 2.390

NATIONAL LEAD COMPANY

NUCLEAR DIVISION

NLI 1/2 CASK & TRAILER

GENERAL ARRANGEMENT

A-5325

T0514F

0

This page intentionally left blank.

FIGURE WITHHELD UNDER 10 CFR 2.390

NATIONAL LEAD COMPANY

NUCLEAR DIVISION

NLI 1/2 SPENT FUEL CASK

DETAILS

CONFIGURATION "B"

This page intentionally left blank.

FIGURE WITHHELD UNDER 10 CFR 2.390

NATIONAL LEAD COMPANY

NUCLEAR DIVISION

NL 1/2 SPENT FUEL CASK

DETAILS

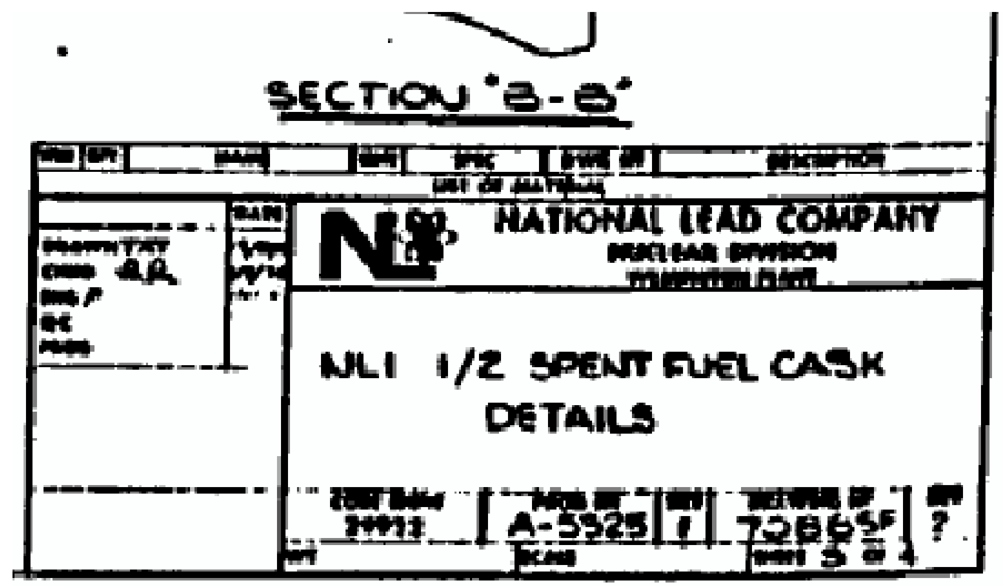
ALTERNATE CONFIGURATION

A-5325

70885F

This page intentionally left blank.

FIGURE WITHHELD UNDER 10 CFR 2.390



This page intentionally left blank.

FIGURE WITHHELD UNDER 10 CFR 2.390

NATIONAL LEAD COMPANY

NUCLEAR DIVISION

NL1 1/2 SPENT FUEL CASK

URANIUM SHIELD DETAIL

A-3515

I-

This page intentionally left blank.

FIGURE WITHHELD UNDER 10 CFR 2.390

NL INDUSTRIES
NUCLEAR DIVISION

OUTER CLOSURE HEAD
NLI 1/2 SPENT FUEL CASK

A-5328

This page intentionally left blank.

FIGURE WITHHELD UNDER 10 CFR 2.390

NL INDUSTRIES

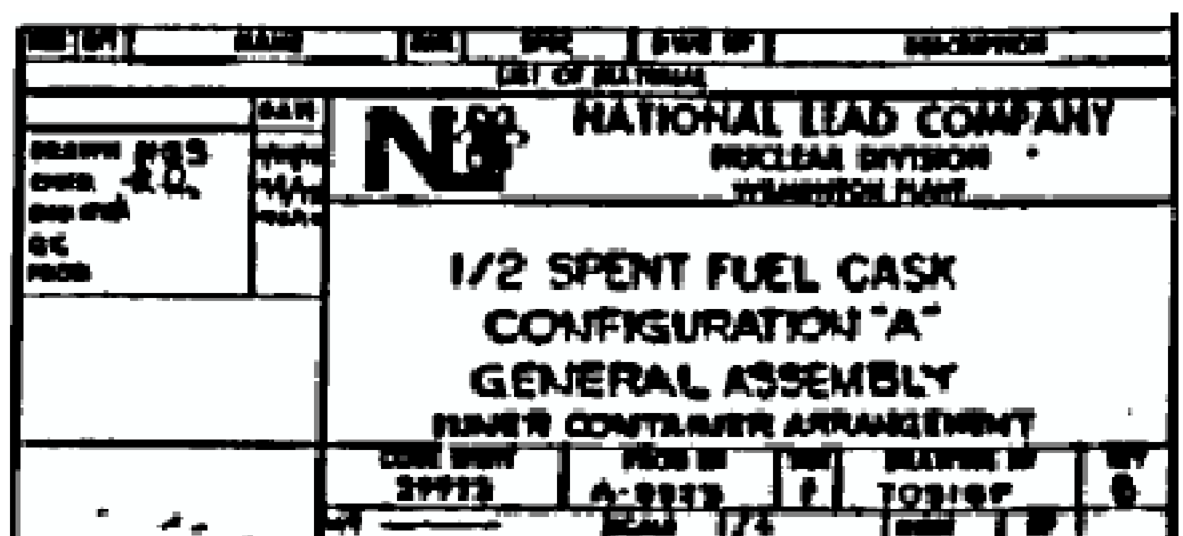
NUCLEAR DIVISION

1/2 SPENT FUEL CASK

GENERAL ASSEMBLY

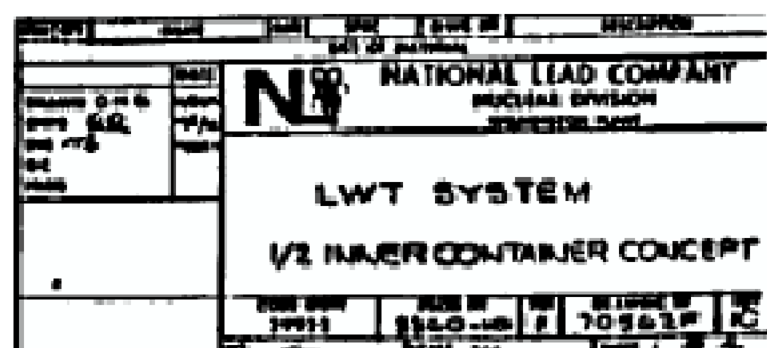
CONFIGURATION "B"

FIGURE WITHHELD UNDER 10 CFR 2.390



This page intentionally left blank.

FIGURE WITHHELD UNDER 10 CFR 2.390



This page intentionally left blank.

FIGURE WITHHELD UNDER 10 CFR 2.390

NATIONAL LEAD COMPANY	NUCLEAR DIVISION
LWT SYSTEM	1/2 RAJER CONTAINER CONCEPT

This page intentionally left blank.

FIGURE WITHHELD UNDER 10 CFR 2.390

UNIT SYSTEM 1/2
INNER CONTAINER CONCEPT

SH 3 OF 4 1

This page intentionally left blank.

FIGURE WITHHELD UNDER 10 CFR 2.390

NUCLEAR ASSURANCE CORPORATION

INNER CONTAINER CONCEPT

This page intentionally left blank.

FIGURE WITHHELD UNDER 10 CFR 2.390

NL INDUSTRIES

NUCLEAR DIVISION

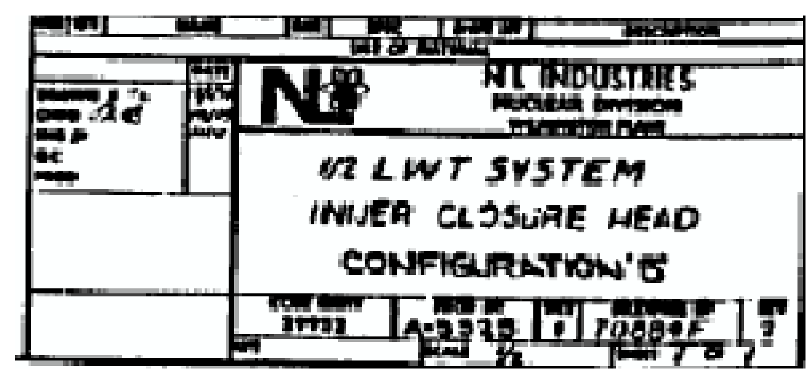
LWT SYSTEM

BASKET CONCEPT

CONFIGURATION "B"

This page intentionally left blank.

FIGURE WITHHELD UNDER 10 CFR 2.390



This page intentionally left blank.

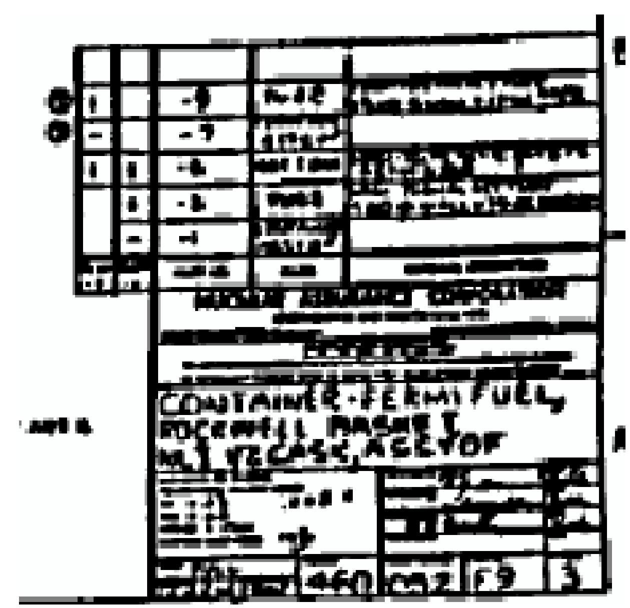
FIGURE WITHHELD UNDER 10 CFR 2.390

ROCKWELL FUEL BASKET -
NA 1 1/2 CASK

460	052	F8	4

This page intentionally left blank.

FIGURE WITHHELD UNDER 10 CFR 2.390



This page intentionally left blank.

FIGURE WITHHELD UNDER 10 CFR 2.390

NUCLEAR ASSURANCE CORPORATION

LINER-3ELEMENT, UNIT 1/2
CASK FUEL MOVEMENT
PROJECT

347	291	E12	1

This page intentionally left blank.