71-9235

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U.S. Nuclear Regulatory Commission
11555 Rockville Pike
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Attention: Document Control Desk

Subject: Request for Amendment of the NAC-STC Certificate of Compliance (No. 9235) to Incorporate Directly Loaded AFA-2G and AFA-3G Fuel as Approved Contents for Transport in the NAC-STC

Docket No. 71-9235

References:
1. Certificate of Compliance No. 9235 for the Model No. NAC-STC, Revision 3, United States Nuclear Regulatory Commission (NRC), August 8, 2001
2. International Programs Discussion, DOT/NRC/NAC/CNNC, August 13, 2001

NAC International (NAC) herewith requests that Reference 1, Certificate of Compliance (CoC) No. 9235 for the NAC-STC, be amended to incorporate AFA-2G and AFA-3G Fuel Assemblies, as approved contents for transport in the NAC-STC in the "directly loaded", i.e., uncanistered, configuration. NAC is under contract with China Nuclear Energy Industry Corporation (CNEIC) to provide NRC-licensed NAC-STC casks for the transport of these fuel assemblies in China. This proposed amendment for the NAC-STC was discussed with members of the NRC International Programs Office and Spent Fuel Projects Office staff in the Reference 2 discussion.

This amendment request is in the form of revised license drawings and Revision STC-01A changed pages for the NAC-STC Safety Analysis Report (SAR), Revision 13, to incorporate the requested changes in the CoC. A detailed description of the drawing revisions is provided in Attachment 1. Revision bars on the Revision STC-01A pages indicate where changes have been made to incorporate the requested amendment. Pages with text flow changes are only indicated by the Revision STC-01A in the page header. For the convenience of double-sided copying, some front or backing pages are included, and they retain any revision bars from their previous submittal as indicated in the page header. Ten copies of the amendment request, the revised license drawings and the SAR changed pages are provided.

The AFA-2G and AFA-3G fuel assemblies, proposed for transport in the NAC-STC as directly loaded (i.e., uncanistered) fuel, were fabricated by Framatome-Cogema and are very similar to the Westinghouse 17 x 17 fuel assemblies (refer to SAR Tables 1.2-2 and 6.2-1). The fuel rod cladding is zirconium alloy, known commercially as M5. The AFA-2G fuel assembly is effectively a standard W 17 x 17 fuel assembly with a maximum enrichment of 3.25 w/o ^{235}U. The AFA-3G fuel assembly is also effectively a standard W 17 x 17 fuel assembly, but is designed for higher burnups and has a maximum enrichment of 4.50 w/o ^{235}U. The design of the AFA-3G fuel assembly allows for replacement of some of the fuel rods with burnable poison rods. An updated shielding analysis has been performed to bound all of the cask contents and the thickness of the ring on the Top Weldment has been increased based on the results of that analysis.

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In addition to the proposed new contents, an alternate o-ring design and several acceptance test changes are proposed for the NAC-STC. For fuel loaded for transport without interim storage, closure and port cover lid configurations are proposed that utilize EPDM/Viton o-rings as an alternate to the already licensed metal o-ring lid configurations. A new containment analysis is presented in SAR Chapter 4 to demonstrate the acceptability of this alternate design and the associated calculated leak rates are incorporated in Chapters 7 and 8, as appropriate. Revisions included in SAR Chapter 8 are: 1) the neutron and gamma shielding material and effectiveness testing sections have been rewritten for clarity; 2) the sampling plan for the neutron absorber material has been revised to incorporate previous NRC comments on other NAC submittals; 3) The thermal acceptance test section has been revised to require a first-article thermal test at each fabrication facility to recognize the uniformity of the fabricated components, based on the use of essentially identical fabrication methods and procedures at the same facility for all of the units fabricated; and 4) the periodic thermal test has been deleted from the maintenance section because it is unnecessary, since the SAR demonstrates that there will be no changes in the physical configuration of the NAC-STC during use for normal conditions of transport.

Implementation of the NAC-STC system is a critical path item for successful initiation of spent fuel transport in China. Therefore, NAC requests that the NRC complete the technical review of this amendment request to support a near-term approval that will support the China spent fuel transport project.

If you have any comments or questions, please contact me at 678-328-1321.

Sincerely,

T.C. Thompson

Thomas C. Thompson
Director, Licensing
Engineering & Design Services

Attachment

Enclosures

cc: Janice Dunn Lee (NRC International Programs Office Director)
Kevin Burke (NRC International Programs Office)

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ATTACHMENT 1

List of Drawing Changes

Revision STC-01A

STC-01A LIST OF DRAWING CHANGES

Drawing 423-800, Revision 8 — Cask Assembly, NAC-STC Cask

- Update drawing borders.
- Add Item 24 to BOM. Qty. Assy 98: 1, Name: Inner Lid; Drawing No., 423-803-98.
- Add Item 25 to BOM. Qty. Assy 98: 1, Name: Outer Lid; Drawing No., 423-805-98.
- Delete Qty. Assy 98 Item 2 and Item 3 in BOM.
- Sheet 1; Update Assembly title: 99 For Alternate Directly Loaded Transport; and: 98 For Storage/Transport.
- Update graphics to show thicker outer ring on the top weldment as shown from Drawing 423-872.

Drawing 423-802, Revision 12 — Cask Body – NAC-STC Cask

- Change Item 6 (inner shell ring): Add Bill of Material "or SA-182 FXM-19".
- Change Item 8 (inner shell): Add to Bill of Materials "or SA-182 F 304".
- Change Item 20 (shear ring): Add to Bill of Materials "or SA-182 F 304".
- Sheet 2, Zone B-5, Outer shell longitudinal weld; **Remove** Delta Note #6 and **Add** "PT".
- Update drawing borders.
- Add Delta Note 28 to read: Install Items 26, 27, 28 and 32 (screw thread inserts), per manufacturers instructions.
- Update Items 13 and 25, Description: from Bisco Prod. To Rogers Corporation.
- Change Item 16, Description: from Bisco Prod. To Unifrax Corp. and material to Fiberfrax 550J, 970J, 880J.
- Revise Note 12 to read: Number and position of girth welds optional. NAC International shall approve alternate weld design to writing prior to fabrication.
- At Delta Note 2 – ADD – "NAC International shall approve alternate materials or procedures prior to fabrication."
- At Delta Note 23 – ADD – "NAC International shall approve alternate materials or procedures prior to fabrication."
- BOM – Item 16, Insulation: Change FIBERFRAX 550J, 970J, 880J to SILICONE FOAM and change UNIFRAX CORP. SEE NOTE 5 to ROGERS CORP. SEE NOTE 5. (<u>Note: Item revised back to original configuration</u>)
- Change Note 5 to read: Fireblock Protective Coating (BISCO FPC) 1/8".
- Incorporate changes recommended by E-mail from Sam Shock to George Jackson dated 12-Nov-01 (Subject: PT requirements on China Licensing Drawings).
- BOM, Item 9, Gamma Shielding: **WAS** "CHEM. LEAD" **IS** "CHEM COPPER GRADE"

Drawing 423-803, Revision 3 — Lid Assembly – Inner, NAC-STC Cask

- Update drawing borders.
- Add Item 15 to BOM. Qty. Assy -99: 1, Name: O-Ring; Matl: EPDM/FKM; Spec.: COML; Description: .275 Dia. E740-75/V0747-75.
- Add Item 16 to BOM. Qty. Assy -99: 1, Name: O-Ring; Matl: EPDM/FKM; Spec." COML; Description: .275 Dia. E740-75/V0747-75.
- Add Item 17 to BOM. Qty. Assy -99: 1, Name: Inner Lid; Drawing No., 423-804-99.
- Add Item 18 to BOM. Qty. Assy -99: 2, Name: Port Coverplate Assy; Drawing No., 423-806-99.
- Delete Qty. Assy -99 Item 1 and Item 2 in BOM.
- Sheet 1; Add Assembly title: -99 for Alternate Directly Loaded Transport; and: -98 For Storage/Transport.
- Add Sheet 2 and move Sections B-B & D-D to show Assy -98 (Storage w/metallic seals) and create Sections B-B & D-D, to show machine grooves for Assy -99 (Transport w/ polymer seals).
- Change Delta Note 13 to read: "... drawing #423-804, sheet 3" (was... sheet 2).
- For Assy -99, add: "For Transport use only", 1.5 inch tall letters with Delta 12 beside the graphics.
- Add Delta Note: "Actual diameter shall fit groove shown in Section E-E, Drawing #423-804, sheet 3. Either material (EPDM or FKM) may be used for Items 15 and 16.
- Add Delta Note: -99 or -98 as per assembly and add callout at Detail E-E.
- Change BOM Items 15 and 16 Material: **WAS**: EPDM/FKM **IS**: EPDM/VITON
- Change Delta Note 13: **WAS**: ... (EPDM/FKM) ... **IS**: ...(EPDM/VITON) ...

Drawing 423-804, Revision 3 — Details – Inner Lid, NAC-STC Cask

- Update drawing borders.
- Add Item 9 to BOM. Qty. Assy -99: 1, Name: Inner Lid; Mat'l: 304 St. Stl.; Spec.: ASME SA336; Description: Forging.
- Add Delta Note 1 to read: Item 8 and counterbore required for storage lid, Item 1, only. Omitted for transport lid, Item 9.
- Delete Qty. Assy -99 Item 1 and Item 8 in BOM.
- Sheet 1; Update Assembly title: -99 For Alternate Directly Loaded Transport; and: -98 For Storage/Transport.
- Move Section E-E to Sheet 3 to show Assy -98 (Storage/Transport w/metallic seals) and create new Alternate Section E-E to show machine grooves for Assy -99 (Alternate Directly Loaded Transport w/polymer seals).

STC-01A List of Drawing Changes

Drawing 423-805, Revision 3 — Lid Assembly, Outer, NAC-STC Cask

- Update drawing borders.
- Add Item 3 to BOM. Qty. Assy 99: 1, Name: O-Ring; Mat'l: EPDM/FKM; Spec.: COML; Description: .275 Dia. E740-75/Vo747-75.
- Add Item 7 to BOM. Qty. Assy 99: 1, Name: Outer Lid; Mat'l: St. Stl.; Spec.: SA705, Type 630; Description: Forging.
- Delete Qty. Assy 99 Item 1 and Item 2 in BOM.
- Sheet 1; Update Assembly title: 99 For Alternate Directly Loaded Transport; and add: Assembly 98 For Storage/Transport.
- Add Sheet 2 and move Detail C-C to show Assy 98 (Storage/Transport w/metallic seals) and create an alternate Detail C-C, to show machine grooves for Assy 99 (Alternate Directly Loaded Transport w/polymer seals).
- Add Delta Note: "Actual diameter to shall fit groove shown in Detail C-C. Either material (EPDM or FKM) may be used for Item 3."
- For Assy-99, add: "For Transport Use Only", 1.5 inch tall letters with Delta Note 6 beside the graphics.
- Change BOM Item 3 Material: **WAS**: EPDM/FKM **IS**: EPDM/VITON
- Change Delta Note 7: **WAS**: . . (EPDM/FKM). . . **IS**: (EPDM/VITON)

Drawing 423-806, Revision 3 — Port Coverplate Assy, Inner Lid, NAC-STC Cask

- Update drawing borders.
- Add Item 7 to BOM. Qty. Assy 99: 1, Name: Port Coverplate; Mat'l: 304 St. Stl.; Spec.: ASME SA240; Description: 1 Plate.
- Add Item 8 to BOM. Qty. Assy 99: 1, Name: O-Ring; Mat'l: EPDM/FKM; Spec.: COML; Description: Parker #2-238 E740-75/V0747-75.
- Add Item 9 to BOM. Qty. Assy 99: 1, Name: O-Ring; Mat'l: EPDM/FKM; Spec.: COML; Description: Parker #2-244 E740-75/V0747-75.
- Delete Qty. Assy 99, Items 1, 4 and 5 in BOM.
- Add Qty. Assy 98, Items 1, 3, 4, 5, 6: 1, and Item 2: 4.
- Update Assembly titles: 99 For Transport; and: 98 For Storage.
- Change Detail J-J to show Assy 98 (Storage/Transport w/metallic seals) and create Detail J-J, to show machine grooves for Assy 99 (Alternate Directly Loaded Transport w/polymer seals).
- Add "Bolt Removed For Clarity" Zone D3, and remove bolt graphics where hole dimensions are shown.
- Add Delta Note 4 to read: "Steel stamp/engrave (0.03 deep) letters, fill with black weather resistant paint. Add graphics across the face of Assy-99 only "For Transport Use Only" ¼" Tall letters.
- Add Delta Note: "Either material (EPDM or FKM) may be used. And add callout to Items 8 and 9.
- Change BOM Items 8 and 9 Material: **WAS**: EPDM/FKM **IS**: EPDM/VITON
- Change Delta Note 5: **WAS**: . . (EPDM/FKM). . . **IS**: (EPDM/VITON)

STC-01A List of Drawing Changes

Drawing 423-812, Revision 2 — Nameplates, NAC-STC Cask

- Update drawing borders.
- Add Delta Note 8 to read: "99 For Directly Loaded Transport Only, 98 For Storage/Transport." Also add delta callout and replace 99 in the drawing number stamped on Item 2 detail.
- Change Item 1 Body Nameplate dimension: **WAS**: 4.5; **IS**: 5.0.
- Change Item 1 Body Nameplate engraved line: **WAS**: USA/9235/B(U)F; **IS**: USA/9235/B(U)F-85.

Drawing 423-872, Revision 5 — Top Weldment, Fuel Basket, PWR, 26

- Item 2, Section A-A; Change ID from 69.1 to 67.4.
- Item 2, Section A-A; Change reference thickness from (.87) to (1.75).
- Item 2, Plane View, add notch at 8 places to maintain full opening at each fuel tube.
- Update drawing border.
- Add Note 2 to read: "Center Items 3 & 4 on web approximately as shown." And omit dimension 1.4, (covered by Note 2).
- Add Delta Note 3: Item 2 (Ring) shall be cut/ground in area of fuel opening such that a full opening and entry bevel are maintained.
- BOM, Item 2, Description **IS)** 1 ¾ Plate **WAS)** Plate. Also Items 1, 3 & 4 Description **IS)** 1 Plate **WAS)** Plate.
- Change Next Assembly number reference in the drawing border: **WAS**: 423-070; **IS**: 423-870.

Drawing 423-875, Revision 3 — Captivated BORAL, NAC-STC Cask

- Update drawing borders.
- Change drawing title to read, "Tube, NAC-STC CASK".
- Add optional tube to flange weld joint detail, per UMS, MPC & CY Fuel Tube drawings.
- Add optional Cladding detail to show 'clipped corners', per UMS, MPC & CY Fuel Tube drawings.
- Add optional BORAL detail, per UMS, MPC & CY Fuel Tube drawings.

Drawing 423-900, Revision 4 — Package Assembly, Transportation, NAC-STC Cask

- BOM Item 2 "Upper Limiter Assy.", Drawing No. was: 423-809-99 is: 423-209.
- BOM Item 3 "Lower Limiter Assy.", Drawing No. was: 423-810-99 is: 423-210.

Drawing 455-801, Revision 2 — Assembly, Transport Cask, NAC-MPC

- Remove proprietary note from title block of Sheet 2.

STC-01A List of Drawing Changes

Drawing 455-870, Revision 4 — Canister Shell, MPC-Yankee

- In Zone C7, dimension is) 23.3 was) 23.1.
- Add 15°±5° x .8 chamfer to the opening of the canister.
- Add tolerance to overall length + .0/-.3.
- Add tolerance +/-5° 3 places on Sheet 1.
- Note 1, delete "45°".

Drawing 455-871, Revision 6 — Details, Canister, MPC-Yankee

- Add component tracking numbers with the following new Delta Note: Steel Stamp ½' high the following sequence located approx. as shown. "MPC-TSC-XXX-YYY" where XXX is indicated on the purchase order for a particular project code and the YYY is a sequential series of numbers starting with 001. Calculated Empty Canister Weight = ZZ,ZZZ LBS." Where ZZ,ZZZ is indicated on the purchase order. Directly below this number is an open area for each customer to add any required identification they choose.
- Change B.O.M. Item 6 description callout IS) SNAP-TITE #SVHN16-16EM WAS) SNAP-TITE #VHN16EM.
- Inside diameter of Item 2 IS) 68.4 WAS) 68.0.
- Add 1" diameter tooling holes to center of both the structural and shield lids.
- Modify structural lid weld prep per sketch.
- Modify Item 8, key, to have only one pair of 45°±5° X .3 chamfers on one short side.
- Add 30°±5° X .5 lead in chamfers on both sides of the key opening in detail F-F.
- Change angle tolerances, Sht 1 and 2, 14 places ARE) X°±5° WERE) X°.
- Add note allowing multiple piece construction for item 1. Specify splice welds.
- Revise Note 5 to allow engraving as well as steel stamping. The first sentence of Note 5 shall read as follows: 5. Steel stamp/engrave ½" high the following sequence located approximately as shown.
- Revise specification for Item 7, Port Cover, WAS) "ASME SA479", IS) "ASMESA479/SA240", and change description, WAS) "6 Dia Bar". IS) "6 Dia Bar/Plate."
- Revise BOM Item 4 as follows: Quantity: 1 Name: Metal Boss Seal Material: St. Stl. Spec: Coml Description: Furon #10061-16-1-0.
- Add BOM Balloon for Item 4 next to BOM Balloon for Item 6 in Section C-C on page 2.
- Item 5, Sheet 2, Zone F3, change depth of thread from 2.50 to 2.25.
- For lid support ring, delete the 0.38" bevel and show the lid support ring as a square bar.
- In Zone C-5, delete Detail B-B.
- In Zone C/D-5/6, delete the dashed circle and the words "See Detail B-B."
- In Zone C-7, add △7 next to △6.

Drawing 455-871, Revision 6 — Details, Canister, MPC-Yankee (continued)

- Add Delta Note 7 to read "Weld preparation shall be determined by the fabricator based upon the weld process used. See Drawing 455-872 for effective throat size of weld."
- On Sheet 2, Detail G-G, reduce the size of the weld prep IS) 45° x .5 Minimum, WAS) 45° x 1.00.
- Revise graphics in the side views for the Shield Lid (Sheet 2, Zone D/6-8) and Shield Lid Assembly (Sheet 2, Zone C-E/3), in the section view in Section E-E (Sheet 2, Zone A/8), and in the plan views for the Shield Lid (Sheet 2, Zone D-F/6-8) and Shield Lid Assembly (Sheet 2, Zone C-E/4-6) to reflect a 0.5" weld prep bevel.
- Revise Delta Note 2 to read "Engrave Delta 0.75-1.0 per side x .03 deep, not to infringe on the weld bevel, and fill with weather resistant black paint."
- On Sheet 1, Zone E/4, revise the diameter of the Backing Ring (Item 2), IS) 68.0, WAS) 68.4.
- On Sheet 2, Zone D/2, revise the diameter of the Structural Lid (Item 5), IS) 68.7 WAS) 69.0.
- On Sheet 2, revise Detail D-D to reflect the reduced diameter of the structural lid, the reduced diameter of the backing ring groove and the reduced diameter of the material below the backing ring groove.
- Revise sheet 1, specification for item 1, lid support ring, WAS) "ASTM A479", IS) "ASTM A479/A240" and change description WAS) "½ X ½ SQ. Bar", IS) "½ X ½ SQ. Bar/Plate."

Drawing 455-872, Revision 9 — Assembly, Transportable Storage Canister (TSC), MPC-Yankee

- Revise the lid support ring weld.
- On Sheet 1, Zone F/5, reduce the size of the shield lid-to-shell bevel weld, IS) (1/2), WAS) (1).
- On Sheet 2, Zone B-C/4-5, revise the graphics in the section view to reflect the reduced size of the shield lid-to-shell weld.
- On Sheet 1, Zone F/5-6, add a symbol for Delta Note 10 in the tail of the bevel weld symbol for the shield lid-to-shell weld.
- On Sheet 1, add Delta Note 10 to read: "The weld depth shall be determined by field measurement if the weld bevel is greater than 1/2".
- Editorial change – BOM Items 10 and 11: Replace "Plug" with "Insert".
- On Sheet 1, Zone F/5, reduce the size of the shield lid-to-shell bevel weld, IS) (1/2), WAS) (1).
- On Sheet 2, Zone B-C/4-5, revise the graphics in the section view to reflect the reduced size of the shield-lid-to-shell bevel weld.
- On Sheet 1, Zone F/5-6, add a symbol for Delta Note 10 in the tail of the bevel weld symbol for the shield lid-to-shell weld.

Drawing 455-872, Revision 9 — Assembly, Transportable Storage Canister (TSC), MPC-Yankee (continued)

- On Sheet 1, add Delta Note 10 to read: "The weld depth shall be determined by field measurement if the weld bevel is greater than 1/2".
- Editorial Change - BOM items 10 & 11: Replace "Plug" with "Insert".
- Add Delta Note 11 as follows: "At the option of the user, Stainless Steel (ASTM/ASME A/SA240, Type 304/304L) Shims of appropriate thickness may be used in the welding of the Shield Lid Assembly (Item 5) to the Shell Weldment (Item 1)."
- Zone F6: Add Delta Note 11 to weld symbol tail of the ½ inch filet weld between Items 1 and 5.
- On Sheet 1, Zone C-5, revise the dimension for the gap between the bottom of the lid support ring (Item 4) and the top of the support ring of the top weldment of the fuel basket assembly (Item 2) IS) .25 MIN GAP WAS) .5 MIN GAP.
- Sheet 1, add new Note 12 to read: If the lid support ring is modified to meet the dimension from the top of the shell to the lid support ring then following details must be met. The flat surface on the top of the lid support ring shall extend a minimum of 0.35 from the inside surface of the canister shell and the average inside diameter of the shield lid support ring, at the top bearing surface, shall be 0.17 less than the average diameter of the shield lid at the base of the bottom chamfer. The gap between the canister shell and lid support ring on the bottom side of the lid support ring shall be less than 0.04. Also add Delta Note 12 callout lid support ring weld callout, Zone F4.
- Revise weld callout Sheet 1, Zone: E-5, IS) 3/16, WAS) 1/4.
- Revise weld callout Sheet 1, Zone: D-5: Remove backing symbol.
- Revise Delta Note 11 to read, "At the option of the user, Stainless Steel (ASTM/ASME A/SA240, Type 304/304L) Shims of appropriate thickness may be used in the welding of the Shield Lid Assembly (Item 5), and the Structural Lid (Item 6), to the Shell Weldment (Item 1)." Also add Delta Note 11 call out to Structural Lid weld symbol in Zone C-6.
- Revise name of Item 8 to be: "Spacer Ring."

Drawing 455-873, Revision 3 — Assembly, Drain Tube, Canister, MPC-Yankee

- Item 2 B.O.M. Spec IS) ASTM A249/A213 WAS) ASTM A249.
- Item 1 B.O.M. Description IS) #SVHN16-16EM WAS) #VHN16EM.

STC-01A LIST OF DRAWING CHANGES

Drawing 455-881, Revision 6 — PWR Fuel Tube, MPC-Yankee

- On Sheet 2, Zone C-F/8, show a cut-out on the two top corners of the cladding as an option. The size of the cut-outs is 45° +/- 5° x .8.
- On Sheet 2, Zone C-F/5, show a cut-out on the two bottom corners of the cladding as an option. The size of the cut-outs is 45° +/- 5° x .5.
- On Sheet 1, revise the graphics for the Tube Assembly and on Sheet 2, revise the graphics for Section D-D to show the optional clipping of the cladding corners.
- On Sheet 2, in Zone C/8, provide a dashed circle around the corner of the cladding referencing Detail G-G. Add Detail G-G.
- On Sheet 1, for Assembly 99, Tube Assembly, revise graphics to show clipped corner for the cladding consistent with Detail G-G, except as noted.
- On Sheet 1, in Zone E/5, provide a dashed circle around the corner of the cladding referencing Detail H-H. Add Detail H-H.
- On Sheet 1, Detail A-A (Alternate Fabrication), delete the "all-around" circle in the weld symbol and revise the note in the tail of the weld symbol to read "Typ 4 sides."
- Add Delta Note: "45° cuts at the corners of the cladding may be made per Detail G-G, prior to welding the tubing (Item 1), or per Detail H-H, after welding to tubing.
- Revise Details G-G and H-H.

Drawing 455-887, Revision 4 — Basket Assembly, 24 GTCC Container, MPC-Yankee

- Remove proprietary note from title block of Sheet 2.
- Revise dimensions to indicate which fuel tubes are welded together.
- Add Note 5 to read: "Required locations of weld between fuel tubes. Fuel tubes may be welded in additional locations at fabricator's discretion to facilitate fabrication."
- Revise the location of the notch in the top support disk shown on Sheet 2 Zone B-6 to be consistent with the location of this notch shown in the plan view for Assembly 99 on Sheet 1.
- Revise the weld symbol for the Item 8, Drain Sleeve, on Sheet 2, Zone F-1: Delete 1/8" size; Revise note in the tail to read, "Seal Weld, Typical Each End."
- Revise Note 4 by adding the underlined text as follows: All welds PT final pass unless otherwise noted. Examine per ASME Section V, Article 6. Acceptance per ASME Section III, Article NG-5350.
- Revise Note 3 by adding the underlined text as follows: When necessary, center the tube array within the support wall weldment using 6: wide shim stock as required. Weld tube array to shim stock using a 1/16 V-groove or 1/16 bevel groove weld. Weld to support wall weldment using weld shown.

Drawing 455-887, Revision 4 — Basket Assembly, 24 GTCC Container, MPC-Yankee (continued)

- On Sheet 2, in Section A-A, revise the size of the 3/8 double fillet welds IS) 1/8 WAS) 3/8.
- On Sheet 2, in Detail C-C, revise the size of the 3/8 bevel and 3.8 fillet welds IS) 1/8 WAS) 3/8.
- On Sheet 1, in Zone C/3, revise the size of the ¼ fillet weld IS) 1/8 WAS) 1/4.
- On Sheet 1, in Zone E/3, revise the size of the ¼ double fillet weld IS) 1/8 WAS) 1/4.
- On Sheet 2, in Zone C/3-4, revise the note in the tail of the V-groove weld symbol by adding the underlined text as follows: 2 seams 180° apart, VT only.
- On Sheet 1, in Zone E/6, revise the concentricity tolerance IS) .15 WAS) .09.
- On Sheet 2, in zone C/4, change reference dimension to hard dimension IS) 8.32±.02 WAS) (8.32).
- On Sheet 2, in zone C/4, revise reference dimension IS) (.19) WAS) (.25).
- On Sheet 2, in Zone C/4, revise inside dimension of tube in two locations from hard dimension to reference dimension IS) (7.94) WAS) 7.82±.02.
- Add BOM Item 9 as follows: Quantity: AR Name: Shim Material: 304 St. Stl. Spec: ASTM A240/A479 Description: 6x6 Plate/Bar, Thickness as required.
- On Sheet 1, Zone C/6, revise dimension for support disk spacing IS) 14.6 WAS) 14.60.
- On Sheet 1, Zone E/2, revise location dimension for bottom pad IS) 19.3 WAS) 19.33.
- On Sheet 1, Zone D-E/3, revise location dimension for bottom pad IS) 19.3 WAS) 19.33.
- On Sheet 1, Zone C/2, revise location dimension for anti-rotational bar IS) 22.3 WAS) 22.29.
- On Sheet 1, Zone C/1, revise location dimension for anti-rotational bar IS) 2.1 WAS) 2.06.
- Revise Section B-B and add Detail E-E.
- Revise the location of the butt weld in Detail E-E (Detail E-E was added by DCR 455-887-2B).
- Sheet 1, Zone E/6: Revise surface profile tolerance: WAS) .06 IS) .15.
- Sheet 1, Item 7: Spec. IS) ASTM A240/A479 WAS) ASTM A240.
- On Sheet 3, Detail C-C, delete the all-around, fillet-weld welding symbol for seal welding the drain sleeve, Item 8, to the bottom support disk, Item 4.
- On Sheet 1, Zone D/6, add an all-around, fillet-weld welding symbol to indicate welding the top of the drain sleeve, Item 8, to the top support disk, Item 4. The tail of the welding symbol shall read "seal weld top only."

Drawing 455-887, Revision 4 — Basket Assembly, 24 GTCC Container, MPC-Yankee (continued)

- On Sheet 1, in the Bill of Materials, for Item 5, Tube, revise the description IS) 3/16 plate WAS) 1/4 plate.
- On Sheet 1, Note 5, revise to read as follows "The ⊗ indicates that a flare-v groove weld must be made between the two adjacent tubes along the overall length of tube. The flare-v groove weld is required to be made along the tube length on one side only of the adjacent tubes. Fuel tubes may be welded in additional locations at fabricator's discretion to facilitate fabrication."
- On Sheet 2, in Zone B/6-7, revise the weld symbol for the tube, Item 5 to show a flush square groove weld instead of a flush V groove weld.
- On Sheet 2, for Item 4, Support Disk, specify a 0.20" radius typical for all corners on the inside surface.
- On Sheet 3, Section B-B (2 locations) specify a 0.20" chamfer typical for all outside corners of the support walls.
- On Sheet 3, in Section B-B and Section B- B (Alternate Fabrication) revise the dimensions as follows:
  - IS) 55.8 ± .15 TYP WAS) 55.85 ± .03 TYP
  - IS) 38.9 ± .1 TYP WAS) 38.97 ± .03 TYP
  - IS) 22.1 ± .1 TYP WAS) 22.09 ± .03 TYP
  - IS) 8.4 ± .1 TYP WAS) 8.44 ± .03 TYP
  - IS) 8.4 ± .1 TYP WAS) 8.44 ± .03 TYP
- On Sheet 3, in Section C-C revise the following dimension: IS) .3 TYP WAS) .25 TYP.
- On Sheet 3, in Detail A-A revise the following dimension: IS) 1.0 WAS) 1.00.
- On Sheet 3, in Detail D-D revise the following dimensions:
  - IS) .5 WAS) .50
  - IS) .5 WAS) .53
  - IS) 1.1 WAS) 1.06
- On Sheet 2, for Item 4, Support Disk, revise the dimensions as follows:
  - IS) 55.9 ± .15 TYP WAS) 55.91 ± .03 TYP
  - IS) 39.0 ± .1 TYP WAS) 39.03 ± .03 TYP
  - IS) 22.1 ± .1 TYP WAS) 22.15 ± .03 TYP
  - IS) 8.4 ± .1 TYP WAS) 8.44 ± .03 TYP
  - IS) 8.4 ± .1 TYP WAS) 8.44 ± .03 TYP
  - IS) 30.0 WAS) 29.96
  - IS) 4.2 WAS) 4.23
- On Sheet 1, add delta note 6 callout to Bill of Materials for Items 1, 2, and 3, Support Wall. Add delta note 6 to read: "Final material thickness to meet ASTM A480 requirements for 2.5 plate, 2.5 +.2, -.01."

STC-01A List of Drawing Changes

Drawing 455-888, Revision 6 — Assembly, Transportable Storage Canister (TSC), 24 GTCC, MPC-Yankee

- Modify the weld note on Detail A-A, to clearly identify the welds on the 2 sides above the support ring and the top of the key.
- Redimension the placement of the shield lid support ring to 8.0 + .0/-.1.
- Structural lid weld, Zone C5 IS) 7/8 WAS) 1.
- Shield lid support ring weld, Zone F4, change to 5/16 effective throat, add a 1/8 fillet on top, remove all around symbol and note "all around, except key slot region" in tail.
- Add 1/8 butt weld to shield lid support ring weld at "key slot region only."
- Add Delta Note for structural lid weld indicating that the welds minimum effective throat is achieved when level with the edge of the canister shell. The lids, due to tolerances, may extend beyond the edge of the canister shell.
- Delete reference dimension "(2.00)" in Zone C-4 on Sheet 2.
- On Sheet 1 in Zone F/4-5, delete the 1/8" butt weld for the key slot region.
- Revise the size of the partial penetration groove weld for the lid support ring (Item 4) to the key (Item 9) in Zone C-D/6 on Sheet 2 IS) (7/16") WAS) (3/8").
- On Sheet 1 in Zone F/4, delete the (5/16) bevel groove and 1/8 fillet welds for the lid support ring-to-shell weld and replace with a (1/8) groove weld. (Note: Weld symbol shall be identical to the weld symbol for TSC as shown on DCR 455-872-8A).
- On Sheet 1, Zone F/5, reduce the size of the shield lid-to-shell bevel weld, IS) (1/2), WAS) (1).
- On Sheet 2, Zone C-D/4-5, revise the graphics in the section view to reflect the reduced size of the shield lid-to-shell bevel weld.
- On Sheet 1, Zone F/5-6, add a symbol for Delta Note 10 in the tail of the bevel weld symbol for the shield lid-to-shell weld.
- On Sheet 1, add Delta Note 10 to read: "The weld depth shall be determined by field measurement if the weld bevel is greater than 1/2".
- Add Delta Note 11 as follows: "At the option of the user, Stainless Steel (ASTM/ASME A/SA240, Type 304/304L) Shims of appropriate thickness may be used in the welding of the Shield Lid Assembly (Item 5) to the Shell Weldment (Item 1)."
- Zone F/5-6: Add Delta Note 11 to weld symbol tail of the ½ inch weld between Items 1 and 5.
- Editorial change – BOM Items 10 and 11: Replace "Plugs" with "Insert."
- Revise Port Cover weld callout Zone E5 **IS**: (3/16) bevel concave **WAS**: (1/4) bevel flush.

Drawing 455-888, Revision 6 — Assembly, Transportable Storage Canister (TSC), 24 GTCC, MPC-Yankee (continued)

- Revise Delta Note 11 to read, "At the option of the user, Stainless Steel (ASTM/ASME A/SA240, Type 304/304L) Shims of appropriate thickness may be used in the welding of the Shield Lid Assembly (Item 5), and the Structural Lid (Item 6), to the Shell Weldment (Item 1)." Also add Delta Note 11 callout to Structural Lid weld symbol in Zone C-6.
- Revise BOM, Item 8, Name: **IS)** Spacer Ring **WAS)** Backing Ring.
- Remove weld backing symbol from weld arrow in Zone C-6.

Drawing 455-894, Revision 2 — Heat Transfer Disk, Fuel Basket, MPC-Yankee

- Change Material Description IS) 6061-T651 WAS) 6061-T6.

November 2001

Revision STC-01A

NAC-STC

NAC Storage Transport Cask

SAFETY ANALYSIS REPORT

Volume 1 of 2

Docket No. 71-9235

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1.0 GENERAL INFORMATION

NAC International Inc. (NAC) has designed a Storable Transport Cask (NAC-STC) for spent nuclear fuel. The United States Nuclear Regulatory Commission (U.S. NRC) licenses the NAC-STC for the transport of spent nuclear fuel. This Safety Analysis Report (SAR) addresses the ability of the NAC-STC to satisfy the U.S. NRC transportation requirements for spent fuel, either directly loaded in the cask (uncanistered) or in a canister, and Greater Than Class C (GTCC) waste in a canister, as prescribed in 10 CFR 71. This chapter presents a general introduction to the cask and a detailed description of its design features. The terminology used throughout this report is summarized in Table 1-1.

The NAC-STC may be shipped by rail, barge, or heavy-haul vehicle. The NAC-STC is assigned a Transport Index of 21 based on the shielding evaluation presented in Section 5.1.4. As shown in Chapter 6, the Transport Index based on nuclear criticality safety is zero, since an infinite number of packages with optimum moderation remain subcritical.

The NAC-STC has been designed to satisfy the international requirements of IAEA Safety Series No. ST-1, in addition to U.S. requirements prescribed in 10 CFR 71.

Table 1-1 Terminology

Cask Model	NAC-STC
NAC-STC Cask	This packaging consists of a spent-fuel storable transport cask body with dual closure lids and energy-absorbing impact limiters.
Packaging	The assembly of components necessary to ensure compliance with the packaging requirements of 10 CFR 71. Within this report, the packaging is denoted as the NAC-STC.
Package	The packaging with its radioactive contents (payload), as presented for transport (10 CFR 71.4). Within this report, the package is denoted as the NAC-STC, the NAC-STC cask or, simply, the cask.
Payload	Twenty-six (26) pressurized water reactor (PWR) fuel assemblies in the directly loaded fuel (uncanistered) configuration or up to thirty-six (36) pressurized water reactor (PWR) fuel assemblies or up to 24 GTCC waste containers in the canistered configuration.
Containment System	The components of the packaging intended to retain the radioactive material during transport.
Cask Body	
- Multiwall Body	Construction of the cask body, which consists of concentric layers of the inner shell, gamma shielding, outer shell and neutron shielding materials.
- Neutron Shield	Consists of the stainless steel shell, gussets, and end plates, copper-stainless steel (Cu/SS) fins, and the solid NS-4-FR neutron shielding material.

Table 1-1 Terminology (continued)

NS-4-FR	A solid, synthetic polymer consisting of a borated hydrogenous material, which results in neutron absorption capabilities similar to borated water.
Lifting Trunnions	Four, high-strength stainless steel components welded to the top forging that are used in pairs for lifting and handling the cask.
Top Forging	
- Interlid Port	A penetration in the top forging that is used as (1) a drain for the interlid region and (2) a pressure test port for the outer lid seal.
- Pressure Port	A penetration in the top forging that houses a pressure transducer, which may be used to monitor the pressure in the interlid region during storage.
- Port Cover Assembly	Includes the port cover body, spacer, retainer, bolts and o-rings.
- Pressure Transducer	An instrument for measurement of pressure in a confined space.
- O-Ring	An o-ring seals the interfaces between separate cask components. O-rings may be elastomer, polymer or metallic.
- PTFE	A blended polytetrafluoroethylene (PTFE) o-ring material used as a sealing component between metallic surfaces.
- EPDM	An ethylene propylene blended polymer o-ring material used as a sealing component between metallic surfaces.
- Viton®	A fluorcarbon rubber o-ring material used as a sealing component between metallic surfaces.

Table 1-1 Terminology (continued)

- Interseal	Refers to the region between pairs of o-rings.
Bottom Inner Forging	The cup-shaped component that forms the bottom of the NAC-STC cavity.
Bottom Outer Forging	The ring-shaped component that forms the bottom outer region of the NAC-STC.
Bottom Plate	The plate welded to the bottom outer forging, which forms the bottom of the cask. The bottom plate encloses the neutron shielding material in the bottom of the cask.
Rotation Trunnion Recesses	Two stainless steel blocks, each provided with a deep machined groove suitable to accept the rear cask support. These recesses are welded onto the outer shell near the bottom of the cask.
Cask Cavity	The volume of space within the containment boundary.
Transportable Storage Canister (Canister)	The stainless steel cylindrical shell, bottom end plate, shield lid, and structural lid that holds the canistered fuel basket or Greater Than Class C Waste.
Canister Spacer	Aluminum honeycomb structures that position the canister in the NAC-STC cavity during transport. The honeycomb material is encased in a shell constructed of 6061-T6 aluminum alloy.

Table 1-1 Terminology (continued)

Fuel Basket	The structure located in the cask cavity or transportable storage canister to support the fuel assemblies.
- Support Disk	A circular stainless steel plate with square holes machined in a symmetrical pattern. The support disk is the primary lateral load-bearing component of the basket. Each square hole in the support disk is a location for a fuel tube.
- Heat Transfer Disk	A circular aluminum plate with square holes machined in a symmetrical pattern. The heat transfer disk enhances heat transfer in the fuel basket. Each square hole in the heat transfer disk is a location for a fuel tube.
- Fuel Tube	A stainless steel tube having a square cross-section. There are two Fuel Tube configurations. The standard Fuel Tube has BORAL neutron poison material on the four exterior surfaces and has different dimensions for the directly loaded and canistered fuel baskets. The enlarged Fuel Tube, used in the canistered fuel basket, has a larger interior cross-section and does not have BORAL on the exterior surfaces.
- Threaded Rod	Aligns and supports the support disks and heat transfer disks in the fuel basket in the cask cavity.
- Spacer Nut	Installed on the threaded rod between the support disks to properly position and provide axial support for the support disks and heat transfer disks in the fuel basket in the cask cavity.
- Tie Rod	Aligns the support disks and heat transfer disks in the fuel basket structure located in the NAC-STC cask cavity or in the transportable storage canister.
- Split Spacer	Installed on the tie rod between the support disks to properly position and provide axial support for the support disks and the heat transfer disks.

Table 1-1 Terminology (continued)

Outer Lid	A secondary containment closure that is bolted to the top forging during transport.
- Outer Lid Bolts	Retain the outer lid.
Inner Lid	The primary containment closure for transport, located directly on top of the cask cavity inside the top forging.
- Drain Port	Located in the inner lid to permit draining of the cask cavity.
- Vent Port	Located in the inner lid to aid in draining and backfilling the cask cavity.
- Port Coverplates	The sealed covers that protect the vent and drain ports.
- Interseal Test Port	The test port between pairs of o-rings that permits testing of the containment seal. The test port is closed by a threaded plug with a metallic o-ring.
- Inner Lid Bolts	Retain the inner lid.
Quick-Disconnect	The quick-disconnect valved nipple used in the vent, drain, interlid, and inner lid interseal test port to close off the port. The drain port quick-disconnect may be valved or unvalved.
Interlid Region	The space between the inner and outer lids.
Transport Configuration	The transport cask configuration using either metallic or non-metallic (EPDM or Viton) o-ring seals in the cask containment boundary.
Storage Configuration	The transport cask configuration using metallic o-ring seals in the cask containment boundary.

Table 1-1 Terminology (continued)

Transport Impact Limiters (Upper and Lower)	Impact limiters designed for use exclusively during transport of the NAC-STC. They protect the cask by limiting impact loads during the 1-foot free drop (normal conditions of transport) and the 30-foot free drop (hypothetical accident conditions).
Greater Than Class C Waste (GTCC)	Irradiated and surface contaminated metal, usually stainless steel, whose disposal is controlled by 10 CFR 61 due to the presence of very long-lived isotopes, including ^{59}Ni, ^{94}Nb and ^{14}C. This waste results from reactor decommissioning.
Yankee Class Fuel	Fuel that includes United Nuclear Type A and Type B, Combustion Engineering Type A and Type B, Exxon-ANF Type A and Type B, Westinghouse Type A and Type B and failed fuel cages that are bound by the above fuel types.
Reconfigured Fuel Assembly	A component having the same external dimension as a standard Yankee Class fuel assembly that ensures geometry control and confinement of Yankee Class fuel having cladding defects. The Reconfigured Fuel Assembly can contain a maximum of 64 full-length fuel rods.

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1.1 Introduction

The NAC-STC is designed to transport spent fuel assemblies or Greater Than Class C (GTCC) waste safely. The fuel assemblies may be sealed in a transportable storage canister (canistered) or placed directly into a fuel basket installed in the cask cavity (uncanistered). In the canistered configuration, the NAC-STC can transport up to 36 Yankee Class fuel assemblies, depending on the mix of assembly types within the canister. The design basis fuels for the directly loaded configuration are the Framatome-Cogema 17 x 17 and Westinghouse 17 x 17 or 15 x 15 PWR fuel assemblies. These fuels bound smaller array Westinghouse and similar Babcock & Wilcox and Combustion Engineering PWR fuel assemblies. Up to 24 containers of GTCC waste may be sealed in a transportable storage canister. The NAC-STC, when loaded, has a maximum design weight of 250,000 pounds. The NAC-STC provides a radioactive material containment boundary for maximum safety during the handling and transport operations required for spent-fuel shipment. The general configuration of the NAC-STC and the major cask dimensions are shown in Figure 1.1-1.

The NAC-STC cask may be transported after loading with or without a period of interim storage. The structural components of the transport containment boundary are the:

(1) Inner shell center section and upper and lower inner shell rings (transition sections);
(2) Bottom inner forging; and,
(3) Top forging.

The closure components of the containment boundary for transport without interim storage after loading are the:

(1) Inner lid and inner lid o-ring;
(2) Vent port coverplate and the coverplate inner o-ring; and,
(3) Drain port coverplate and the coverplate inner o-ring.

As described in the following sections, the o-rings may be either metallic or non-metallic (EPDM or Viton).

The closure components of the containment boundary for transport after an extended period of storage are the:

(1) Inner lid and inner lid outer metallic o-ring;
(2) Inner lid interseal test port threaded plug with metallic o-ring;
(3) Vent port coverplate and the coverplate outer metallic o-ring;

(4) Vent port coverplate interseal test hole threaded plug with metallic o-ring;
(5) Drain port coverplate and the coverplate outer metallic o-ring; and,
(6) Drain port coverplate interseal test hole threaded plug with metallic o-ring.

Metallic o-rings are required for the storage configuration and are qualified for transport prior to shipment in accordance with the operating procedure.

The transportable storage canister provides the secondary containment boundary for transport of fuel within the canister that is classified as damaged, as required by 10 CFR 71.63.

The NAC-STC is designed to meet 10 CFR 71 and IAEA Safety Series No. ST-1 licensing requirements for spent fuel transport packages. The transport licensing requirements include providing safe containment during the handling and transport of spent nuclear fuel. Certain design features of the NAC-STC that have been included for the sole purpose of satisfying storage licensing requirements also provide added safety for transport conditions. The design features of the NAC-STC include: inner and outer lids, redundant seals at each containment boundary penetration, cavity penetrations located in the inner lid, and a puncture-resistant outer shell and outer lid.

This Safety Analysis Report is written for transport cask licensing only. Design features related to storage cask licensing are included for clarity and for the ease of review.

The NAC-STC closure design provides dual lids for transport and storage operations, as well as protection of the vent and drain ports that are located in the inner lid. This design permits performance of a periodic verification leak test on the containment seals prior to transport following extended storage. Both the inner and outer lids are installed during transport and storage.

The inner lid and its o-rings are the major removable components in the primary containment boundary. Two concentric o-rings are used to seal the inner lid to the cask cavity flange. An o-ring test port connects to the annulus between the two o-rings to permit leak testing.

The vent and drain port coverplates, which protect the vent and drain ports located in the inner lid, are also part of the primary containment boundary of the cask. Each coverplate is sealed by two concentric o-rings.

As described in Section 4.1, the inner o-rings of the inner lid and two coverplates are the containment boundary for contents (either directly loaded fuel or a loaded transportable storage canister) that is loaded for transport without interim site storage. The outer o-rings of these components are the containment boundary for directly loaded fuel that is to be transported after an extended period of storage.

The inner lid and coverplate o-rings may be either metallic or non-metallic (EPDM or Viton) as shown in the License Drawings. However, metallic o-rings must be used when the NAC-STC is directly loaded for long-term storage. The metallic o-rings provide long-term sealing capability in an elevated temperature and radiation environment.

The outer lid provides a sealed secondary closure for transport and storage operations using a single o-ring. The o-ring may be either metallic or non-metallic. The outer lid protects the inner lid and the vent and drain ports from external puncture events.

There are two penetrations in the top forging: an interlid port, which serves primarily as a drain for the interlid region, and a pressure port, which may house a transducer that monitors the pressure in the interlid region during storage. During transport, the pressure port is closed by a threaded plug. The pressure port plug is covered by the transport port coverplate. The interlid and pressure port penetrations in the top forging are protected by SA-705, Type 630, 17-4 precipitation-hardened (PH) stainless steel port covers with two piston-type blended polytetrafluoroethylene (PTFE) o-rings.

The body of the NAC-STC is a smooth right-circular cylinder of multiwall construction, consisting of stainless steel inner and outer shells separated by lead gamma radiation shielding, which is poured in place. The center section of the inner shell is fabricated from Type 304 stainless steel. At each end of the inner shell center section, inner shell rings fabricated from Type XM-19 stainless steel provide the transition to the bottom inner forging and the top forging. The outer shell is also fabricated from Type 304 stainless steel. The inner and outer shells are welded to the Type 304 stainless steel top forging, which is a ring that is machined to mate with the inner and outer lids. The inner and outer shells are also welded to the Type 304 stainless steel bottom inner and outer forgings, respectively. The cask bottom consists of the two forgings and a plate with neutron shield material sandwiched between the bottom inner forging and the bottom plate. Neutron shield material is also placed in an annulus that surrounds the cask outer shell along the length of the cask cavity. The neutron shielding material is a solid synthetic polymer (NS-4-FR). The neutron shield annulus is enclosed by a Type 304 stainless steel shell and by end plates that are welded to the outer shell. Two pressure relief valves are provided in the bottom of the neutron shield annulus to relieve pressure in the neutron shield annulus due to a severe thermal accident condition (fire). Neutron shielding is also provided on the top of the cask by a layer of NS-4-FR enclosed in the inner lid.

Redundant lifting capability for the NAC-STC is provided by four lifting trunnions welded to the top forging at 90-degree intervals. Rotation trunnion recesses are located on the outer shell near the bottom of the cask to permit the NAC-STC to be rotated to the horizontal position and to provide longitudinal tiedown restraint in the aft direction. A Type 304 stainless steel shear ring is provided at the top end of the radial neutron shield to supply longitudinal restraint when the cask is positioned horizontally for transport in the front support structure.

For fuel assemblies loaded directly into the NAC-STC, a stainless steel basket locates and supports the 26 PWR fuel assemblies in the cask cavity. The basket design utilizes a series of high-strength stainless steel support disks to support the fuel assemblies in stainless steel tubes, which include BORAL neutron poison sheets (0.02 g/cm^2 ^{10}B minimum). Aluminum heat transfer disks are provided to enhance the thermal performance of the package. The heat transfer disks are also supported by the stainless steel basket.

For the canistered configuration, two aluminum honeycomb spacers, placed one above the canister and one below, locate the canister in the cask cavity so that the location of the Center of Gravity (CG) of the packaging is the same as it is for the uncanistered fuel packaging. The aluminum honeycomb is enclosed in an 6061-T6 aluminum alloy shell. The canister shell, bottom and welded shield and structural lids are fabricated from stainless steel. The canister contains a stainless steel basket that locates and supports up to 36 Yankee Class fuel assemblies.

The canister may contain one or more Reconfigured Fuel Assemblies as shown in Figure 1.2-2. The Reconfigured Fuel Assembly is designed to contain up to 64 Yankee Class fuel rods, or portions, thereof, which are classified as failed, and to maintain the geometric positions of the rods.

The total number of full length rods that can be placed in the Reconfigured Fuel Assembly is less than that in a standard Yankee Class fuel assembly (64 rods versus 256 rods). Consequently, the effects of a Reconfigured Fuel Assembly placed in a canister (e.g., criticality, weight, thermal output, source term) are significantly less than the effects of a design basis (standard) Yankee Class fuel assembly.

The external dimensions and the top end fitting of the Reconfigured Fuel Assembly are the same as those of a standard Yankee Class fuel assembly, allowing it to be handled in the same way as a standard assembly.

The basket for the canistered configuration is similar in design to that used for directly loaded fuel. The NAC-STC may also be used to transport up to 24 containers of GTCC waste in a transportable storage canister.

Impact limiters consisting of a combination of redwood and balsa wood encased in Type 304 stainless steel are provided to limit the g-loads acting on the cask during a drop accident load condition. The g-loads acting on the cask are limited by the crush strength of the redwood and balsa wood contained in the impact limiters.

Any number of NAC-STCs may be shipped at one time, with each cask on its own railcar. The NAC-STC may also be shipped in any number on board ships, barges, or special heavy-haul vehicles.

Figure 1.1-1 Major Cask Dimensions (in inches)

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

1.2 Package Description

This section presents a basic description of the NAC-STC and the contents that may be transported. An operational schematic of the cask is presented in Figure 1.2-1. Detailed dimensional drawings are provided in Section 1.3.2. The design characteristics of the NAC-STC are summarized in Table 1.2-1.

1.2.1 Packaging

1.2.1.1 Gross Weight

The maximum gross transport weight of the NAC-STC spent-fuel shipping cask is calculated to be 248,073 pounds for directly loaded fuel. This weight is calculated based on a fuel assembly weight of 1,500 pounds. When the NAC-STC is loaded on its railcar, the gross weight of the railcar (including cask, impact limiters, supports, and personnel barrier) will satisfy the requirements of the Association of American Railroads. A summary of the component weights, which are detailed in Table 2.2.0-1, is given below:

Component	Directly Loaded Fuel Weight (pounds)	Canistered Fuel Weight (pounds)	Canistered GTCC Waste Weight (pounds)
Cask Body	174,975	174,975	174,975
Basket	16,816	--	--
Impact Limiters	17,282	17,282	17,282
Fuel or GTCC Waste	39,000	30,600	12,340
Canister	--	14,600	14,600
Canister Basket	--	9,530	26,471
Spacers	--	860	860
Total (calculated)	**248,073**	**247,847**	**246,528**
Analysis Weight	**250,000**	**250,000**	**250,000**

1.2.1.2 Material of Construction, Dimensions and Fabrication

The NAC-STC body is of cylindrical, multiwall construction. The materials of construction of the structural components of the cask body are Type 304, Type XM-19, and Type 17-4 PH stainless steel. The primary structural components of the cask are the inner and outer shells. Poured-in-place Chemical Copper Lead fills the annulus between the inner and outer shells and serves as the primary gamma radiation shield. The top forging, which is a ring that forms the upper end of the cask, is welded to the inner and outer shells. The SA-336 Type 304 stainless steel inner lid is recessed in and bolted to the top forging. The SA-705, Type 630, H1150, 17-4 PH stainless steel outer lid is bolted into the end of the top forging. The vent and drain ports are recessed into the inner lid and are each protected by an SA-240, Type 304 stainless steel port coverplate. The interlid port and the pressure port are recessed in the top forging and are protected by SA-705, Type 630, 17-4 PH stainless steel port covers. At the lower end of the cask, the inner and outer shells are welded to the cask bottom, which consists of two forgings and a plate, a cup-shaped bottom inner forging that is the lower end of the cask cavity, a ring-shaped bottom outer forging that forms the exterior of the cask bottom and connects the outer shell to the bottom inner forging, and a bottom plate that is the bottom end of the cask. Neutron radiation shielding is provided by NS-4-FR, a poured-in-place solid synthetic neutron-absorbing polymer, which surrounds the outer shell along the cavity region and is enclosed by a shell and end plates that are welded to the outer shell. A layer of NS-4-FR is enclosed in the inner lid and in the cask bottom to provide neutron shielding at the ends of the cask during cask loading operations. Twenty-four explosively bonded copper and Type 304 stainless steel fins are located in the radial neutron shield to enhance the heat rejection capability of the NAC-STC and to support the neutron shield shell and end plates. The cask is passively cooled.

In the event of an accident during transport where impact force(s) may be applied to the cask, the NAC-STC is protected by energy-absorbing impact limiters that consist of redwood and balsa wood enclosed in a stainless steel shell. The cup-shaped impact limiters fit over each end of the cask and dissipate kinetic energy by crushing the wood at known force values, limiting the g-loads acting on the cask during an impact load condition.

The NAC-STC is provided with four lifting trunnions on the outside of the top forging at 90-degree intervals. The lifting trunnions are fabricated from SA-705, Type 630, 17-4 PH stainless steel. Only two diametrically opposite trunnions are required to lift the NAC-STC. Two additional lifting trunnions are provided for those facilities that require redundant lifting. Two rotation trunnion recesses are located on the outer shell near the bottom of the cask.

The NAC-STC safely transports spent fuel assemblies in two configurations. The fuel may be placed directly in a fuel basket installed in the cask cavity, or the fuel may be sealed in a transportable storage canister that is installed in the cask.

The NAC-STC directly loaded fuel basket has a capacity of 26 PWR fuel assemblies. The fuel basket design uses Type 17-4 PH stainless steel support disks to support the fuel assemblies in Type 304 stainless steel tubes. The support disks are spaced and retained by Type 17-4 PH stainless steel square spacer nuts, which are assembled on six 1.625-inch diameter Type 17-4 PH threaded rods. Type 6061-T651 aluminum alloy heat transfer disks are supported by the stainless steel basket assembly to enhance heat rejection of the package.

The transportable storage canister is constructed of Type 304L stainless steel. The canister is closed with a shielding lid and a separate structural lid, both of which are welded in place. The shielding lid is constructed of Type 304 stainless steel, and the structural lid is constructed of Type 304L stainless steel. The canister contains a basket that provides support and geometry control for up to 36 Yankee Class fuel assemblies, depending on the assembly type. The basket is similar in design to the directly loaded fuel basket.

The materials of construction and detailed component and assembly dimensions for the NAC-STC are shown in the License Drawings. The major components are described in the following sections.

1.2.1.2.1 Cask Body

The outer shell, the center section of the inner shell, the top and bottom forgings, the bottom plate, and the inner lid of the NAC-STC are manufactured from Type 304 stainless steel. Type 304 stainless steel has well-documented mechanical properties and a long history of use in similar applications. It is a commonly welded material and is readily available throughout the world. Type 304 stainless steel possesses good strength and adequate toughness in the operating temperature range of the NAC-STC. The center section of the inner shell is 1.5 inches thick and has an inner diameter of 71.0 inches. Welded to the top and bottom of the inner shell center section are the inner shell rings. The inner shell rings are manufactured from Type XM-19 high-strength stainless steel. The inner shell rings connect the bottom inner forging and the ring-shaped top forging to the center section of the inner shell. The inner shell rings are 2.0 inches thick at the end that is welded to the forgings and have a 3.0-inch-long taper down to a 1.5-inch thickness at the weld joint to the inner shell center section. The top and bottom inner shell rings reduce the stress concentration at the inner shell interface with the top and bottom forgings. Type XM-19 stainless steel has well-documented mechanical properties and is suitable for welding to the Type 304 stainless steel components.

Two forgings and a plate comprise the bottom of the cask body. The separate forgings are necessary to facilitate the pouring of the lead. These forgings are assembled with full-penetration welds and act as a single structural unit when fabrication is complete. The bottom components are differentiated here for clarity as the bottom inner forging, the bottom outer forging, and the bottom plate. The bottom inner forging is cup-shaped. The bottom of the cup is 6.2 inches thick. The side of the cup, which is welded to the bottom inner shell ring, is 2.0 inches thick.

The outer shell is concentric with the inner shell and is 2.65 inches thick. The outer shell is welded to the bottom outer forging, which is ring-shaped. The bottom outer forging is the outer ring portion of the cask bottom and is 3.9 inches thick in the radial direction at the location of the neutron shield material. The bottom outer forging is also welded to the outside diameters of the bottom inner forging and the bottom plate. The bottom plate is a 5.45-inch thick plate. A 2.0-inch thick, 78.9-inch diameter layer of NS-4-FR neutron shielding material is enclosed between the bottom inner forging and the bottom plate. Two rotation trunnion recesses are located approximately 180 degrees apart and are welded to the exterior of the outer shell just above the bottom of the neutron shield. Sixteen 1 - 8 UNC holes, equally spaced on a 76.0-inch diameter, are tapped into the bottom plate for attachment of the bottom transport impact limiter.

The upper inner shell ring and the upper end of the outer shell are welded to the ring-shaped top forging. On the inner diameter of the top forging is a recessed ledge. The inner lid is completely recessed into the top forging and mates with the ledge. The outer lid is bolted into the end of the top forging. Thirty-six outer lid bolts secure the outer lid to the top forging. The inner lid rests on a ledge in the top forging that is the sealing surface for the two o-rings and the land for the 42 inner lid bolts. Two guide pins are installed in two of the inner lid bolt holes during cask loading and unloading operations and, along with alignment marks, assist in aligning and ensuring proper seating of the inner lid. Similar procedures are used to assist in the proper alignment of the outer lid. Four lifting trunnions are welded to the top forging to permit cask lifting and handling with either a redundant or a nonredundant lifting yoke.

Radial gamma radiation shielding for the NAC-STC is provided by the inner shell, the outer shell, and the 3.7-inch thickness of American Society of Testing Materials (ASTM) B29 Chemical Copper Lead located in the annulus between the inner and outer shells. The lead also serves as an elastic support for the outer shell during a puncture event and for the inner shell during a side impact event.

Radial neutron shielding for the NAC-STC is provided by NS-4-FR, which is a solid synthetic polymer originally developed by BISCO Products, Inc. and is now supplied by the Japan Atomic Power Company and its licensees. This solid neutron shielding material is selected to eliminate leakage and maintenance problems and to alleviate other concerns attendant with using a liquid neutron shield. NS-4-FR has a high-hydrogen content to provide for neutron attenuation, is doped with boron to minimize the number of secondary gammas generated, is stable at elevated temperature service, and is fire retardant. A 5.5-inch-thick layer of NS-4-FR is installed in the annulus formed by the outer shell, the 0.236-inch (6 mm)-thick neutron shield shell, and the 0.472-inch (12 mm)-thick neutron shield end plates.

The inner shell, inner shell rings, top forging, bottom inner forging, and the inner lid establish a cask cavity that is 165.0 inches long and 71.0 inches in diameter.

The calculated weight of the cask body is 174,975 pounds. The overall length is 193.0 inches. The maximum outside diameter is 99.0 inches across the corners of the neutron shield shell.

1.2.1.2.2 Inner Lid and Bolts

The inner lid and its o-rings are the principal installed components of the NAC-STC containment boundary. The o-rings may be either metallic or non-metallic (EPDM or Viton), depending on cask use. The inner lid is 9.0 inches thick, 79.0 inches in diameter, and is fabricated from Type 304 stainless steel. The top portion of the inner lid is a 2.0-inch-thick, 67.5-inch-diameter layer of NS-4-FR neutron shielding material enclosed by a 1.0-inch-thick, Type 304 stainless steel coverplate that is welded in place. The 42 inner lid bolts are 1 1/2 - 8 UN socket head cap screws fabricated from SB-637, Grade N07718 nickel alloy steel bolt material. This bolt material has a coefficient of thermal expansion that is very similar to that of the Type 304 stainless steel inner lid and top forging and, thus, alleviates differential thermal expansion effects.

The inner lid is recessed to a depth of 11.8 inches into the top forging to provide clearance for the outer lid. The inner lid bolt holes are located on a ledge machined into the inner lid, so that the bolt heads are below the top surface of the lid. The top surface of the inner lid has threaded holes for the attachment of a lid-lifting device. The bottom of the inner lid is sealed to the top forging of the cask body by two o-rings. The o-rings may be either metallic or non-metallic, depending on the cask use. Metallic o-rings are used for storage and for transport following storage. Either metallic or non-metallic (EPDM or Viton) o-rings may be used for transport without interim storage after loading. The outer metallic o-ring provides the primary containment seal for transport after storage, while the inner o-ring (either metallic or non-metallic) provides the primary containment seal for transport without interim storage after loading. An interseal test port is provided and is equipped with a 1/4-inch quick-disconnect valved nipple to allow leak testing of the inner lid o-rings. The interseal test port plug is part of the containment boundary for transport after a period of storage. As shown on Drawing 423-804, the o-ring grooves on the underside of the inner lid are either square to accommodate metallic o-rings or have a truncated triangular shape to accommodate EPDM or Viton o-rings.

Three ports are recessed into the inner lid: the vent port, the drain port, and the interseal test port. These ports are described in detail in Section 1.2.1.2.4.

1.2.1.2.3 Outer Lid and Bolts

The outer lid, bolts and o-ring, when bolted to the top forging, provide a sealed secondary closure. The outer lid is 5.25 inches thick in the central region, 86.7 inches in diameter, and is fabricated from SA-705, Type 630, H1150, 17-4 PH stainless steel. The 36 outer lid bolts are 1 - 8 UNC socket head cap screws fabricated from SA-564, Type 630, H1150, 17-4 PH stainless steel. The bolt material is identical to that of the outer lid, alleviating differential thermal expansion effects.

The outer lid is bolted to the top forging of the NAC-STC. The lid bolt holes are countersunk into the lid so that the bolt heads are below the top surface of the lid. The bottom surface of the outer lid is sealed to the top forging by one o-ring, which is replaced prior to transport. The o-ring may be either metallic or non-metallic. The interlid port, located in the top forging, is used to test the seal of the o-ring in the outer lid. The top surface of the outer lid has threaded holes for the attachment of a lid-lifting device and for the attachment of the upper transport impact limiter. As shown on Drawing 423-805, the o-ring groove on the underside of the outer lid is either square to accommodate a metallic o-ring or has a truncated triangular shape to accommodate an EPDM or Viton o-ring.

1.2.1.2.4 Ports and Port Covers

The NAC-STC design includes five ports: three in the inner lid and two in the top forging. The vent, drain and interseal test ports are recessed in the inner lid and provide access to the cask containment. Recessed in the top forging are two noncontainment ports, the interlid port for interlid region drainage and outer lid o-ring leak testing, and the pressure port, which is provided for monitoring of the pressure in the interlid region during storage.

The vent port is a 1.0-inch diameter penetration through the inner lid and is closed by a quick-disconnect valved nipple (quick disconnect). The quick disconnect is not considered to be a containment barrier. The vent port is used to access the cask cavity following the fuel loading to drain, dry, leak test and backfill it with inert gas prior to transport. The vent port coverplate uses a two o-ring design, similar to the inner lid. The o-rings may be either metallic or non-metallic, depending on the cask use. Metallic o-rings are used for storage and for transport following storage. Either metallic or non-metallic (EPDM or Viton) o-rings may be used for transport without interim storage after loading. The outer metallic o-ring provides the primary containment seal for transport after storage, while the inner o-ring (either metallic or non-metallic) provides the primary containment seal for transport without interim storage after loading.

The drain port is a 1.0-inch-diameter penetration through the inner lid that is used to fill and drain the cask cavity. The drain port is also closed by a quick disconnect, which is not considered to be a containment barrier. Similar to the vent port, the drain port coverplate uses a two o-ring design. The o-rings may be either metallic or non-metallic, depending on the cask use. Metallic o-rings are used for storage and for transport following storage. Either metallic or non-metallic (EPDM or Viton) o-rings may be used for transport without interim storage after loading. The outer metallic o-ring provides the primary containment seal for transport after storage, while the inner o-ring (either metallic or non-metallic) provides the primary containment seal for transport without interim storage after loading. Alignment marks on the top surface of the inner lid and the top forging assist in aligning the drain port in the lid and the drain tube in the cask cavity. The interseal test port is also closed by a quick disconnect, which is not considered to be a containment barrier. The interseal test port containment is a threaded plug with a metallic o-ring.

The pressure port, located in the top forging, houses the transducer that monitors the pressure in the interlid region during storage. The pressure transducer is removed during transport. The interlid port penetrates the top forging into the region between the inner and the outer lids and serves as a drain for the interlid region and as a port to pressurize the interlid region for seal testing purposes. The interlid port is closed by a quick disconnect. The basic geometry of the interlid and pressure ports and port covers is identical. Each port has a 4.5-inch-diameter opening that is a minimum of 1.1 inches deep. Concentric with the port opening is a 2.93-inch-diameter bore. This bore acts as a lead-in to the 2.875–inch-diameter bore that serves as the sealing surface for the two piston-type blended polytetrafluoroethylene (PTFE) o-rings in the port cover.

Both of the port covers are fabricated from SA-705, Type 630, H1150, 17-4 PH stainless steel. The port covers resemble a cup shape and have the geometrical appearance of a thick round end plate with a cylindrical body. The end plate of the port cover is 4.5 inches in diameter and 1.0 inch thick. The three 3/8 – 16 UNC port cover bolts, which are fabricated from SA-193, Grade B6, Type 410 stainless steel, are countersunk flush with the top of the port cover. There are two piston-type PTFE o-rings on the cylindrical body of the port covers with a seal test port between the o-rings. A retainer is bolted to the open end of the cylindrical body of the port cover to retain the o-rings and the spacer between them after assembly. The port cover design permits the thick end plate to absorb an impact, while any deflection of the end plate results in the o-rings sliding in the bore of the port with the seal maintained.

The basic geometry of the vent port and coverplate, and the drain port and coverplate, are identical to each other. Each port has a 6.53-inch diameter opening in the inner lid that is 1.8 inches deep. Concentric with the port opening is a 2.9-inch deep, 3.25-inch diameter bore that houses the 1.0-inch diameter quick disconnect. As shown in Drawing 423-806, the 1.0-inch thick vent and drain port coverplates are fabricated from SA-240, Type 304 stainless steel. When installed, the port coverplates are recessed 0.8 inch below the top surface of the inner lid. The vent and drain port coverplates are sealed to the inner lid by the metallic o-rings on the bottom face of each port coverplate. The four 1/2 - 13 UNC port coverplate bolts are fabricated from SA-193, Grade B6, Type 410 stainless steel. The bolt holes are countersunk so that the bolt heads are flush with the top of the port coverplate.

1.2.1.2.5 Lifting Trunnions and Rotation Trunnion Recesses

The NAC-STC has four lifting trunnions that are fabricated from SA-705, Type 630, H1150, 17-4 PH stainless steel and are welded into 2.0-inch deep recesses in the top forging at 90-degree intervals around the cask circumference. Only two diametrically opposite lifting trunnions are required to lift the NAC-STC. The basic diameter of the lifting trunnions is 5.5 inches and the load-bearing width is 2.5 inches. The trunnions are machined to create a 0.38-inch thick end flange, which acts as a safety stop to ensure proper engagement and to prevent inadvertent disengagement of the lifting yoke.

There are two rotation trunnion recesses located near the bottom end of the NAC-STC. The rotation trunnion recesses are located approximately 18 inches above the bottom of the cask in line with two of the lifting trunnion, but 3.0 inches offset from the cask centerline to ensure that rotation of the cask occurs in the proper direction. Each recess is fabricated from SA-705, Type 630, 17-4 PH stainless steel and is groove-welded to the bottom outer forging. The recess is 6.0 inches square and 4.13 inches deep, with a full radius at the top of the recess that engages with the rotation support. The neutron shield shell is cut out to accommodate the rotation trunnion recesses.

1.2.1.2.6 Transport Impact Limiters

The NAC-STC is equipped with removable, cup-shaped impact limiters that are bolted over each end of the cask to ensure that the design impact loads for the cask are not exceeded for any of the defined normal operation or accident drop conditions. The NAC-STC transport impact limiters consist of redwood and balsa wood completely enclosed in a stainless steel shell. The upper impact limiter has cutouts in its inside diameter for clearance with the lifting trunnions. The impact limiters absorb the energy of a cask drop by crushing the redwood and balsa wood. The force required to crush the impact limiter is determined by (1) the amount and location of the redwood and of the balsa wood and (2) the grain direction of the redwood and the balsa wood. The upper and lower impact limiters are bolted over each end of the cask body by 16 equally spaced attachment rods and nuts. The impact limiters are 124 inches in outside diameter, 44.0 inches deep, and overlap the ends of the cask by 12.0 inches. The detailed impact limiter design and analysis are presented in Section 2.6.7.4.

1.2.1.2.7 Directly Loaded Fuel Basket

The NAC-STC has three fuel basket configurations and one GTCC waste configuration. The first fuel basket configuration is for directly loaded fuel. The directly loaded basket is described in this section. The remaining configurations are used within the transportable storage canister. The canister fuel basket and the GTCC waste basket are described in Section 1.2.1.2.8. The directly loaded basket and the canister basket are both constructed of stainless steel with aluminum heat transfer disks and are of similar design. The GTCC waste configuration is also used within the transportable storage canister and is constructed of stainless steel.

The NAC-STC design includes a directly loaded PWR fuel basket constructed of stainless steel. The fuel basket design is a right-circular cylinder configuration with standard fuel tubes (Drawing 423-870) laterally supported by a series of support disks, which are retained by square spacer nuts on threaded rods at six locations. The nuts are torqued at installation to provide a solid load path in compression between the support disks. The support disks are 0.5-inch thick, 70.86-inch diameter 17-4 PH stainless steel disks spaced 4.87 inches center-to-center with square holes for the fuel tubes. The top end weldment and the bottom end weldment are fabricated from Type 304 stainless steel, are geometrically similar to the support disks, and are 1.0-inch thick. The threaded rods have a 1-5/8 – 8 UN thread diameter and are fabricated from Type 17-4 PH stainless steel. The nuts are 2.5-inch square bars that are also fabricated from Type 17-4 PH stainless steel. The fuel tubes are fabricated from Type 304 stainless steel and provide support for the encased BORAL sheet on each of the four sides. The BORAL provides criticality control in the basket. No structural credit is assumed for the stainless steel tubes as a contributor to the total structural strength of the basket and support of the fuel assemblies.

The NAC-STC directly loaded fuel basket accommodates 26 PWR fuel assemblies in an aligned configuration in 8.78-inch inside dimension square fuel tubes, which have 0.142-inch thick walls. The fuel tubes are supported in the basket assembly between the top and bottom weldment plates. The hole in the top weldment is 8.75 inches square. The hole in the bottom weldment is 8.65 inch square. The basket design traps the fuel tube between the top and bottom weldment preventing axial movement of the fuel tube. The minimum width of the support disk webs between the fuel tubes is 1.5 inches, but two webs have a width of 3.3 inches.

Twenty Type 6061-T651 aluminum alloy heat transfer disks, 0.625-inches thick, 70.65 inches in diameter, are supported by the threaded rods and spacer nuts, which also support and locate the stainless steel support disks. These aluminum disks are located at the center of the axial spacing between the stainless steel support disks and are sized to eliminate contact with the cask inner shell and basket threaded rods as a result of differential thermal expansion.

The NAC-STC has been designed to facilitate filling with water and subsequent draining. A 1.0-inch rounded notch is located at the bottom of each fuel tube, ensuring that there will be free flow between the inner tube regions and the disk regions. Water will naturally fill and drain between the basket disks and the cask body. Water will also flow between the disks in the gap between each of the tubes and the disk that surrounds it. Each of the disks also has four 1-inch diameter holes to supplement the flow of water between the disks. Also, to facilitate flow to the drain line, the bottom plate is positioned by supports 1.5 inches above the bottom of the cask. These design features have been provided to ensure that there is a free flow of water in the cask basket that results in even filling and draining of the cask.

1.2.1.2.8 Transportable Storage Canister

The transportable storage canister consists of four (4) principle components. These are the canister, canister basket, shield lid and structural lid. The canister consists of an annular right-circular shell closed at one end by a bottom plate. The bottom plate is 1.0-inch thick Type 304L stainless steel. The shell is constructed of 5/8-inch rolled Type 304L stainless steel plate. The edges of the rolled plates are joined with full penetration welds. The bottom plate is attached to the shell by also using a full penetration weld. The canister shell is constructed in accordance with ASME Code Section III, Subsection NB. The inside and outside diameter of the canister are 69.39 inches and 70.64 inches, respectively. The inside depth is 121.5 inches. The overall external length of the canister is 122.5 inches.

After loading, the canister is closed by a shield lid and structural lid, each welded to the canister shell. Both the shield lid and structural lid welds are examined in accordance with the ASME Code Section V.

The shield lid is a 5-inch thick Type 304L stainless steel plate. It is joined to the canister shell using a partial penetration weld. The shield lid contains the drain and fill penetrations and provides gamma radiation protection to operators for the draining, drying and inerting operations attendant to sealing the canister. After the shield lid is welded in place, the shield lid weld is leak tested in accordance with ANSI N14.5-1997 to ensure that the required leaktightness is achieved.

The structural lid is a 3-inch-thick Type 304L stainless steel plate. It is attached to the canister shell with a partial penetration weld. Removable lifting fixtures threaded in the structural lid are used to lift the loaded canister.

1.2.1.2.8.1 Canister Fuel Basket

The canister fuel basket is used to position up to 36 Yankee Class fuel assemblies within the canister and to maintain geometry control of the fuel during all of the transport (and storage) conditions. The canister fuel basket is similar in design to the directly loaded fuel basket. It differs primarily in its principle dimensions. As shown in Table 1.2-2, there are minor weight variations between Yankee Class fuel assembly types. Fuel assembly types may be mixed within the canister basket, provided that the contents weight limit of 30,600 pounds is not exceeded. Mixing fuel types within the weight limit can result in a basket containing 36 fuel assemblies, whereas loading a basket with only Westinghouse fuel would result in the basket containing 34 assemblies.

The fuel basket design is a right-circular cylinder with square fuel tubes laterally supported by a series of support disks, which are retained by split spacers on tie rods at eight locations. The split spacers are installed to provide a solid load path in compression between the support disks. The support disks are 0.5-inch-thick, 68.98-inch-diameter 17-4 PH stainless steel disks spaced 3.91 inches center-to-center with square holes for the fuel tubes. The top end disk (top weldment) and the bottom end disk (bottom weldment) are fabricated from Type 304 stainless steel. They are geometrically similar to the support disks and are 0.5-inch thick. The tie rods have a 1-1/8-inch diameter and are fabricated from Type 304 stainless steel.

Fourteen (14) Type 6061-T651 aluminum alloy heat transfer disks, 0.5-inches thick and 68.87 inches in diameter, are supported by the tie rods and split spacers, which also support and locate the stainless steel support disks. These aluminum disks are located at the center of the axial spacing between the stainless steel support disks and are sized to preclude contact with the cask inner shell and basket tie rods as a result of differential thermal expansion.

There are two basket configurations and two fuel tube configurations. Both fuel tube configurations are fabricated from 18 gauge Type 304 stainless steel sheet. The first, the standard fuel tube configuration (Drawing 455-881, Assembly 99), has a square interior cross-section of 7.8 inches and is encased with BORAL sheets on all four outside surfaces of the fuel tube. The second, the enlarged fuel tube configuration (Drawing 455-881, Assembly 98 "Oversized Tube Assembly"), has a square interior cross-section of 8.0 inches, but does not have exterior BORAL sheets on the sides. These larger cross-section fuel tubes can accommodate fuel assemblies that exhibit slight physical effects (e.g., twist, bow) that could preclude loading in the smaller cross-section standard fuel tubes. The enlarged fuel tubes are restricted to the four corner positions of the basket as shown in Figure 6.3-3. No structural credit is assumed for the stainless steel tubes as a contributor to the total structural strength of the basket and support of the fuel assemblies.

The canister basket configurations accommodate either 36 standard fuel tubes, or 32 standard fuel tubes and four enlarged fuel tubes at the four basket corner positions. To permit full access to the enlarged fuel tubes, the corner positions of the top and bottom weldments used in the enlarged fuel tube basket configuration are also enlarged. Since the enlarged fuel tube and the standard fuel tube with BORAL have approximately the same external dimensions, the support disks and heat transfer disks used in the two basket configurations are identical.

The BORAL encased on the standard fuel tubes assists in providing criticality control in the basket. However, the minimal interaction of fuel in the corner positions with the fuel in the other basket positions eliminates the need for the BORAL in these corner positions. As shown in Section 6.4.3, there is only a minimal change in system reactivity associated with the enlarged fuel tubes. Similarly, the changes in shielding and thermal performance are minimal and not significant. Since the net weight of the enlarged fuel tube is 20 pounds less, the structural evaluation of the standard fuel tube bounds that of the enlarged fuel tube.

The canistered fuel basket accommodates fuel assemblies in an aligned configuration in the square fuel tubes. The fuel tubes are supported in the basket assembly between the top and bottom weldment plates. The hole in the top weldment used with the standard fuel tube is 7.78 inches square, but is 7.97 inches square for the enlarged fuel tube (Drawing 455-881). The hole in the bottom weldment used with the standard fuel tube is 6.0 inches square, and is 6.2 inches square for the enlarged fuel tube (Drawing 455-892). The top of both fuel tube configurations has a flange surface, which extends to 8.7 inches square (Drawing 455-881). The basket design traps the fuel tube between the top and bottom weldments, preventing axial movement of the fuel tubes. The minimum width of the support disk webs between the fuel tubes is 0.75 inches.

The canistered fuel basket has been designed to facilitate filling with water and subsequent draining. A 1.0-inch-diameter rounded notch is located at the bottom of each fuel tube, ensuring that there will be free flow between the inner tube regions and the disk regions. In addition, water will also flow between the disks in the gap between each of the tubes. Each of the disks has three (3) 1.25-inch-diameter holes to facilitate water flow between disks. Also, to facilitate flow to the drain line, the bottom plate is positioned by supports 1.5 inches above the bottom of the cask. These design features have been provided to ensure that there is a free flow of water in the cask basket that results in even filling and draining of the cask.

1.2.1.2.8.2 Canister GTCC Waste Basket

The canister GTCC waste basket positions and supports up to 24 Yankee Class GTCC waste containers. The basket is a modified tube and disk design. The maximum loaded weight of a GTCC waste container is 514 pounds, so the maximum content weight is 12,340 pounds for 24 containers.

The GTCC waste basket is a right-circular cylinder with square tubes laterally supported by a series of eight support disks. The support disks are 1.0-inch-thick, 68.98 inches diameter, Type 304 stainless steel disks that are spaced 15.60 inches center-to-center. The support disks are open in the center region to accommodate the twenty-four 8.32-inch square tubes. The tubes are supported full length by 2.5-inch-thick support walls all around the center region. The support disks are retained in position by welding to the support walls of the basket. The basket accommodates GTCC waste containers in an aligned configuration in 7.82-inch-square inside dimension Type 304 stainless steel tubes, which have 0.25-inch-thick walls.

1.2.1.2.8.3 Canister Transport Spacers

The fuel or GTCC waste canister is located in the NAC-STC cavity by two aluminum honeycomb spacers. One spacer is installed below the canister and one above. The aluminum honeycomb is an engineered material having well-defined load-bearing and crush characteristics established by design and fabrication. The two spacers have different lengths and are not interchangeable. The aluminum honeycomb is encased within a thin 6061-T6 aluminum alloy skin that precludes the entry of incidental water, contamination and foreign materials into the honeycomb structure. The spacers support the canister in all of the normal operations, but may deform during hypothetical accident events.

The bottom spacer is nominally 14 inches high and 69.0 inches in diameter. The top spacer is 28 inches high and 70.6 inches in diameter. Removable lifting lugs are used to install and remove the spacers.

1.2.1.2.8.4 Reconfigured Fuel Assembly

The reconfigured fuel assembly is designed to confine Yankee Class fuel rods, or portions thereof, which are classified as failed fuel, and to maintain the geometric configuration of those fuel rods. The assembly can accept up to 64-full length fuel rods in an eight by eight array of tubes. The assembly is designed to allow the draining of free water and the backfilling of the rods and surrounding region with helium. Since there is no significant remaining "gap activity" in the failed rods, pressure retention is not a concern.

The Reconfigured Fuel Assembly consists of a shell (square tube with end fittings) and a basket assembly that supports the 64 tubes, which hold the failed rods. The shell, basket assembly and tubes are stainless steel. The spent fuel rods are confined in the fuel tubes, which are closed with end plugs. The shell is closed with top and bottom end fittings. The tube end plugs and the shell end fittings have drilled holes to permit draining, drying and helium backfilling.

1.2.1.3 Heat Dissipation

The NAC-STC design basis decay heat dissipation capability is 22.1 kilowatts for directly loaded fuel, 12.5 kilowatts for Yankee Class canistered fuel, and 2.9 kilowatts for Yankee class canistered GTCC waste. The directly loaded basket accommodates 26 PWR fuel assemblies with a maximum decay heat load of 0.85 kilowatts per assembly. The canistered fuel basket accommodates up to 36 assemblies, depending on assembly type. The maximum canistered fuel assembly decay heat load is 0.347 kilowatts per assembly for a canister of 36 assemblies and 0.302 kilowatts per assembly for a canister of 34 assemblies. The canistered fuel basket may also contain one or more Reconfigured Fuel Assemblies with a maximum heat load of 0.102 kW per assembly. The use of aluminum heat transfer disks in the basket and the use of 24 explosively bonded copper/stainless steel fins extending through the NS-4-FR solid neutron shield aid in the heat transfer capability of the NAC-STC. The heat dissipation features of the NAC-STC are entirely passive. No active or support cooling mechanisms are required during transport. A detailed discussion of the thermal characteristics of the NAC-STC is provided in Chapter 3.

1.2.1.4 Coolants

There are no coolants utilized within the NAC-STC. An inert helium gas atmosphere is used to backfill the cask cavity during transport.

1.2.1.5 Shielding

A 3.7-inch thickness of Chemical Copper Lead and a 4.4-inch total thickness of stainless steel are maintained between the cask contents and the exterior radial surface of the NAC-STC for the attenuation of gamma radiation. Additional radial shielding is provided to reduce the gamma radiation contribution above the radial neutron shield by a 1.75-inch stainless steel ring attached to the top weldment. A thickness of 5.5 inches of solid, borated neutron shielding material (NS-4-FR), which extends beyond the full length of the active fuel region, is provided for radial neutron shielding. The inner and outer lids provide a total thickness of 12.25 inches of stainless steel on the top end of the cask to attenuate gamma radiation from the fuel and assembly hardware. A 2.0-inch-thick disk of solid, borated NS-4-FR is provided in the inner lid for neutron shielding on the top end of the cask. When transporting canistered fuel, the canister shield and structural lids provide an additional total thickness of eight inches of steel that provides significant attenuation of gamma radiation at the top end of the cask. The canister shell also provides an additional 0.62 inches of stainless steel shielding in the top radial direction. The cask provides 11.65 inches of stainless steel gamma radiation shielding material and 2.0 inches of solid, borated NS-4-FR neutron shielding material. The bottom of the canister provides an additional one inch of stainless steel shielding at the bottom in the axial direction of the cask. A detailed description of the NAC-STC shielding design, as well as the shielding analysis, is provided in Chapter 5.

1.2.1.6 Protrusions

There are no outer protrusions on the NAC-STC other than the four external lifting trunnions that are welded to the top forging near the upper end of the cask. The lifting trunnions are within the envelope protected by the impact limiters. The inner lid and all of the port covers are recessed into the cask body and do not protrude above the cask surface. The outer lid forms a smooth surface with its recessed bolts.

1.2.2 Operational Features

The NAC-STC is designed for ease of operation. The cask is designed to be easily loaded, unloaded, and handled at a nuclear facility. The configuration and surface finish of the cask exterior surfaces have been designed to facilitate and minimize cask decontamination efforts. The inner lids of the cask, the outer lids of the cask, and the port covers are all one-piece components designed to reduce handling times and to maintain personnel dose rates as low as reasonably achievable (ALARA). Quick-disconnect fittings are provided in the vent and drain ports, the inner lid interseal test port and in the interlid port for improved handling operations. All operational features are shown on the License Drawings. An operational schematic for the NAC-STC is shown in Figure 1.2-1. Operating procedures are provided in Chapter 7 for both canistered and directly loaded (uncanistered) operations.

1.2.3 Contents of Packaging

Shipments in the NAC-STC shall not exceed the following limits:

1. The maximum content weight of the NAC-STC shall not exceed 56,000 pounds.
2. The limits specified in Table 1.2-2 for the design basis fuels shall not be exceeded.
3. The total decay heat of the cavity contents shall not exceed 22.1 kilowatts for directly loaded fuel and 12.5 kilowatts for canistered fuel.
4. The total weight of the Zircaloy and/or stainless steel clad fuel assemblies in the canistered configuration shall not exceed 30,600 pounds.
5. The total weight of the GTCC waste in the canistered configuration shall not exceed 12,340 pounds.
6. Any number of NAC-STC casks may be shipped at one time on a railcar, a ship, a barge, or a heavy-haul vehicle.
7. Radiation levels shall not exceed the requirements of 10 CFR 71.47, 10 CFR 71.51, and IAEA Safety Standard Series No. ST-1, Common Provision B3.
8. Surface contamination levels shall not exceed the requirements of 10 CFR 71.87(i)(1) and IAEA Safety Standard Series No. ST-1, Common Provision B4.

1.2.3.1 Design Basis Spent Fuel

The NAC-STC is designed to safely transport spent fuel assemblies in two configurations. The fuel assemblies may be directly loaded into a fuel basket installed in the cask cavity (uncanistered) or sealed in a transportable storage canister (canistered). The design basis fuels for the directly loaded configuration are the Framatome-Cogema 17 x 17 and Westinghouse 17 x 17 or 15 x 15 PWR fuel assemblies. These assemblies bound smaller array Westinghouse, and similar Babcock & Wilcox, and Combustion Engineering PWR fuel assemblies. The NAC-STC can transport 26 directly loaded PWR fuel assemblies. In the canistered configuration, the NAC-STC can transport up to 36 Yankee Class fuel assemblies, or up to 24 containers of Greater Than Class C (GTCC) waste. Any spent fuel assembly with fuel rods removed shall have each of the empty fuel rod positions filled with a solid rod fabricated from Zircaloy or stainless steel. Some assemblies may also contain poison shim rods.

The key parameters of the design basis spent fuel assemblies are provided in Table 1.2-2.

1.2.3.2 Greater Than Class C Waste

Greater Than Class C (GTCC) waste is defined in 10 CFR 61.55(a)(3) and (4) by the concentration of long-lived radionuclides, i.e., ^{14}C, ^{59}Ni, and ^{94}Nb, and/or short-lived radionuclides, i.e., ^{3}H, ^{60}Co, and ^{63}Ni. The disposal of GTCC waste is controlled by 10 CFR 61.

GTCC waste consists of radiation activated and surface contaminated steel, and/or plasma cutting debris (dross). Stainless steel core baffle structure, which is located adjacent to the reactor vessel in a high neutron flux field, is the major component of GTCC waste. The core baffle structure is plasma cut underwater into pieces of a size that are loaded into containers that have the same external dimensions as a "Yankee Class" fuel assembly. Dross (fines and debris) is generated by the underwater plasma cutting of the core baffle structure. The dross is solid particulate debris, varying in size from approximately 8 microns to over 850 microns and having a density approximately 24 percent lower than the parent material. The dross material does not generate, nor release, radioactive gases.

Dross material is collected from the spent fuel pool in buckets, in non-metallic sock filters, or by vacuuming and is discharged directly into a GTCC container. No credit is taken for the sock filters in retaining the dross material. The GTCC containers have 80 micron perforated plates that screen the drain holes in the top and bottom end fittings. Based on an experimental study of plasma cutting debris particle size, the 80 micron perforated plates in the GTCC containers retain in excess of 95 percent of the dross material. Up to 24 GTCC containers, having a total weight of 12,340 pounds, can be placed in the GTCC basket/canister. The reference volume for the design basis GTCC is 43,147 inches^3.

The principle isotopic constituents of typical GTCC waste are presented in Table 1.2-3. The radionuclide composition of the waste was determined based on radiochemical assay of samples and dose rate measurements of the waste containers. The isotopes that primarily contribute to the radiological source term are ^{54}Mn, ^{55}Fe, ^{60}Co, and ^{63}Ni. The source terms applied in the evaluation of the GTCC waste are presented in Section 5.2.

Any contents, such as residual water or filter media, that are subject to the production of radiolytically generated combustible gases will be limited so that the quantity of any individual combustible gas will not exceed 4% by volume within any volume of a canister containing GTCC waste. A determination of the combustible gas generation within a sealed canister will be made prior to transport to demonstrate that the 4% limit will not be exceeded from the time the canister is sealed through a period equal to twice the expected shipment duration. Furthermore, the GTCC waste will be evaluated prior to loading to ensure that none of the activated material or filter media contents produce chemical or galvanic corrosion reactions with the stainless steel canister.

Table 1.2-3 provides the detailed inventory of radionuclides in the core baffle and dross material. Activation and surface contamination data is provided for 21 GTCC containers (15 core baffle containers and 6 dross containers). The total activity for these 21 containers is shown to be bounded by the design basis evaluation of 24 containers.

Figure 1.2-1 Operational Schematic for the NAC-STC

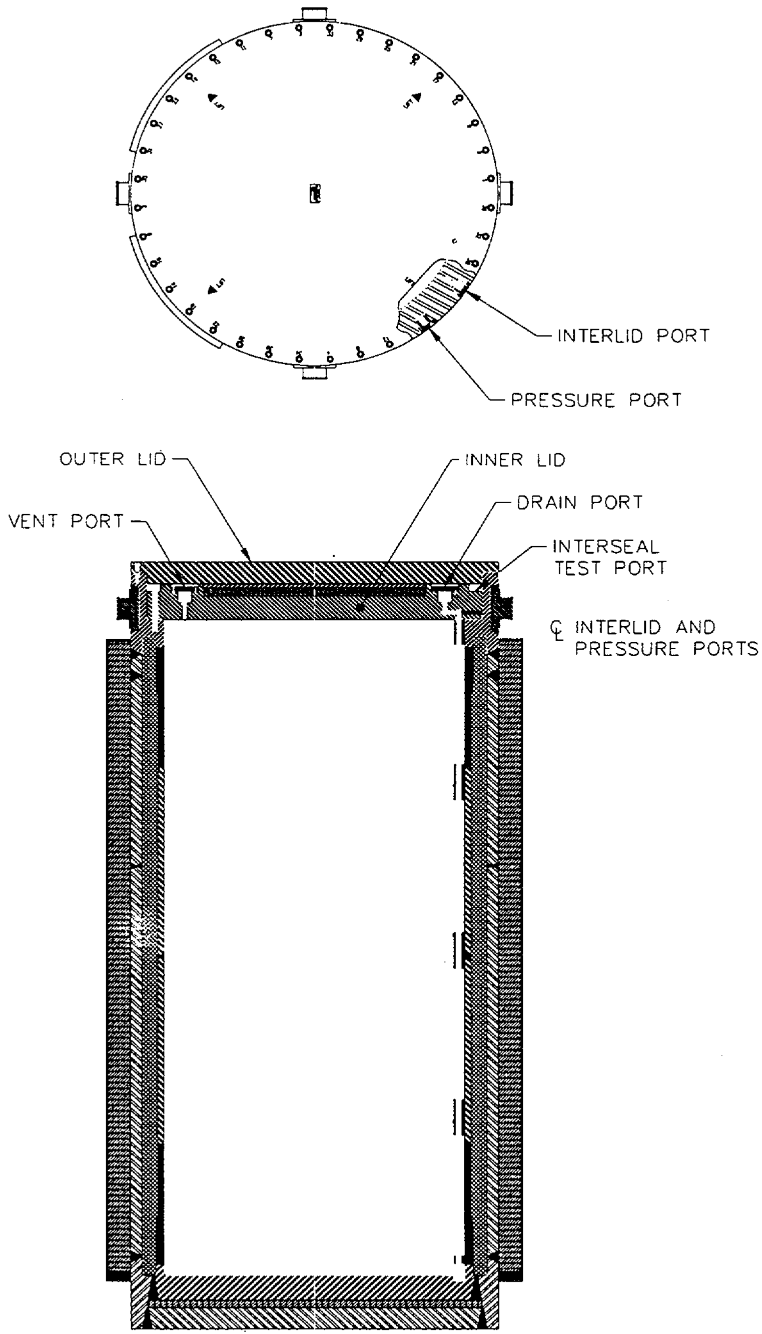

Table 1.2-1 Design Characteristics of the NAC-STC (continued)

Design Characteristic	**Dimension**[1]	**Material**
Inner Shell - Thickness	1.5	Type 304 Stainless Steel
Inner Shell Ring		Type XM-19 Stainless Steel
- Shell Region Thickness	1.5	
- Transition Region Thickness	2.0	
Gamma Shield - Thickness		Chemical Copper Grade Lead
- Shell Region Thickness	4.20	
- Transition Region Thickness	3.70 (min)	
Outer Shell - Thickness	2.65	Type 304 Stainless Steel
Top Forging - Radial Thickness at cavity diameter	7.85	Type 304 Stainless Steel
Bottom Thickness (Total)	13.65	
- Bottom Inner Forging	6.20	Type 304 Stainless Steel
- Bottom Outer Forging (Radial at bottom neutron shield)	3.9	Type 304 Stainless Steel
- Bottom Plate	5.45	Type 304 Stainless Steel
- Neutron Shielding Material	2.00	NS-4-FR, Solid Synthetic Polymer

[1] Dimensions in inches unless otherwise noted.

Table 1.2-1 Design Characteristics of the NAC-STC (continued)

Design Characteristic	Dimension[1]	Material
Neutron Shield - Thickness		
- Neutron Shielding Material	5.50	NS-4-FR, Solid Synthetic Polymer
- Shell	0.25	Type 304 Stainless Steel
- End Plates	0.472	Type 304 Stainless Steel
Lifting Trunnion - Diameter	5.50	Type 17-4 PH Stainless Steel
Rotation Trunnion Recess - Thickness	5.75	Type 17-4 PH Stainless Steel
Inner Lid - Thickness (Total)	9.0	
- Rim and Central Region	6.0	Type 304 Stainless Steel
- Neutron Shielding Material	2.0	NS-4-FR, Solid Synthetic Polymer
- Coverplate	1.0	Type 304 Stainless Steel
- Bolts (42)	1-1/2 - 8 UN	SB-637, GR N07718, Nickel Alloy

[1] Dimension in inches unless otherwise noted.

Table 1.2-1 Design Characteristics of the NAC-STC (continued)

Design Characteristic	Dimension[1]	Material
Outer Lid		
- Body Thickness	5.25	Type 17-4 PH Stainless Steel
- Bolts (36)	1 - 8 UNC	SA-564, Type 630 17-4PH Stainless Steel
Inner Lid Port Coverplates		
- Body Thickness	1.00	Type 304 Stainless Steel
- Bolts (4)	1/2 - 13 UNC	SA-193, Grade B6, Type 410, Stainless Steel
Port Cover		
- Body Thickness	1.01	Type 17-4 PH Stainless Steel
- Bolts (3)	3/8 - 16 UNC	SA-193, GR B6, Type 410 Stainless Steel
Canister Spacers		
- Top Spacer	28.0 x 70.6 (dia)	Aluminum Honeycomb with 6061-T6 Aluminum Outer Shell
- Bottom Spacer	14.0 x 68.9 (dia)	Aluminum Honeycomb with 6061-T6 Aluminum Outer Shell

[1] Dimension in inches unless otherwise noted.

Table 1.2-1 Design Characteristics of the NAC-STC (continued)

Design Characteristics	Dimension[1]	Material
Fuel Basket (Directly Loaded)		
- End Weldments (Plate)	1.0 x 70.86 dia.	Type 304 Stainless Steel
- Support Disks	0.5 x 70.86 dia.	Type 17-4 PH Stainless Steel
- Heat Transfer Disks	0.625 x 70.65 dia.	Type 6061-T651 aluminum alloy
- Fuel Tube (standard)	8.78 x 8.78 (inside dim.) x 0.048 wall	Type 304 Stainless Steel encasing BORAL
- Spacer Nuts	2.5 Square	Type 17-4 PH Stainless Steel
- Threaded Rod (6)	1-5/8 - 8 UN	Type 17-4 PH Stainless Steel
Canister GTCC Basket		
- Support Walls	2.5 x 111.3	Type 304 Stainless Steel
- Support Disks	1.0 x 68.98 dia.	Type 304 Stainless Steel
- Tube	8.32 x 8.32 (inside dim.) x 0.25 wall	Type 304 Stainless Steel

[1] Dimensions in inches unless otherwise noted.

Table 1.2-1 Design Characteristics of the NAC-STC (continued)

Design Characteristics	**Dimension[1]**	**Material**
Canister Fuel Basket		
- End Weldments	0.5 x 68.98 dia.	Type 304 Stainless Steel
- Support Disks	0.5 x 69.15 dia.	Type 17-4 PH Stainless Steel
- Heat Transfer Disks	0.5 x 68.87 dia.	Type 6061-T651 Aluminum Alloy
- Fuel Tube		
- Standard	7.8 x 7.8 (inside dim.) x 0.048 wall	Type 304 Stainless Steel encasing BORAL
-Enlarged	8.0 x 8.0 (inside dim.) x 0.048 wall	Type 304 Stainless Steel without BORAL
- Spacers	2.5 dia.	Type 304 Stainless Steel
- Tie Rods (8)	1-1/8 dia.	Type 304 Stainless Steel
Seals (O-Rings) for Storage Configuration		
- Inner Lid		
- Inner	0.25 dia. x 72.251 dia.	Type 321 Stainless Steel
- Outer	0.25 dia. x 73.497 dia.	Type 321 Stainless Steel
- Port Coverplates		
- Inner	0.125 dia. x 3.875 dia.	Type 321 Stainless Steel
- Outer	0.125 dia. x 4.500 dia.	Type 321 Stainless Steel
- Outer Lid	0.250 dia. x 82.060 dia.	Type 321 Stainless Steel
- Port Covers		
- Primary	0.103 dia. x 2.675 dia.	PTFE
- Secondary	0.103 dia. x 2.675 dia.	PTFE

[1] Dimensions in inches unless otherwise noted.

Table 1.2-1 Design Characteristics of the NAC-STC (continued)

Design Characteristics	Dimension[1]	Material
Seals (O-Rings) for Immediate Transport Configuration		
- Inner Lid		
- Inner	0.25 dia. x 72.251 dia.	EPDM, Viton or Type 321 Stainless Steel
- Outer	0.25 dia. x 73.497 dia.	EPDM, Viton or Type 321 Stainless Steel
- Port Coverplates	0.125 dia. x 3.875 dia.	EPDM, Viton or Type 321 Stainless Steel
- Inner	0.125 dia. x 4.500 dia.	EPDM, Viton or Type 321 Stainless Steel
- Outer	0.250 dia. x 82.060 dia.	EPDM, Viton or Type 321 Stainless Steel
- Outer Lid		
- Port Covers		
- Primary	0.103 dia. x 2.675 dia.	PTFE
- Secondary	0.103 dia. x 2.675 dia.	PTFE

[1] Dimensions in inches unless otherwise noted.

Table 1.2-2 NAC-STC Directly Loaded Fuel Characteristics

Parameter	Westinghouse PWR Fuel 17 x 17	Westinghouse PWR Fuel 15 x 15	Framatome-Cogema 17 x 17	Framatome-Cogema 17 x 17 Ref.[4]
Maximum Number of Assemblies	26	26	26	26
Maximum Assembly Weight, lbs[1]	1467	1440	1463	1472
Maximum Assembly Length, in	160	160	162	162
Active Fuel Length, in	144	144	144	144.25
Fuel Rod Cladding	Zircaloy-4	Zircaloy-4	Zirconium Alloy	Zirconium Alloy
Maximum Uranium, kgU	464	465	467	469
Maximum Initial ^{235}U, wt %	Note 2	Note 2	Note 2	Note 2
Minimum Initial ^{235}U, wt %	Note 3	Note 3	Note 3	Note 3
Maximum Burnup, MWD/MTU	45,000	45,000	45,000	45,000
Maximum Assembly Decay Heat, kW	0.85	0.85	0.85	0.85
Maximum Cask Decay Heat, kW	22.1	22.1	22.1	22.1
Minimum Cool Time, yr	Note 3	Note 3	Note 3	Note 3

1 Actual assembly weights are provided for information only. A conservative weight is used for analysis. These assemblies are the design basis fuel assemblies for the structural, thermal and shielding evaluations. The fuel used for the criticality evaluation is the Westinghouse 17x17OFA. Physical properties for the OFA assembly are provided in Table 6.2-1.
2 Based on criticality analysis. Maximum initial enrichment is variable between 4.2 and 4.5 wt % ^{235}U.
3 Minimum initial enrichment and cool time are based on a fuel loading table, shown in Table 5.4-5.
4 Similar to the Framatome-Cogema 17 x 17, except with expanded fuel characteristics.

Table 1.2-3 NAC-STC Yankee-MPC Canistered Fuel Characteristics

	Yankee Class Fuel[1,4]				
Parameter	**United Nuclear Type A**	**Combustion[2] Type A**	**Westinghouse Type B**	**Exxon Type A**	**Yankee RFA**
Maximum Number of Assemblies	36	36	34	36	36
Maximum Assembly Weight, lbs	850	850	900	850	850
Maximum Assembly Length, in	111.25	111.79	111.25	111.56	111.79
Active Fuel Length, in	91	91	92	91	91
Fuel Rod Cladding	Zircaloy	Zircaloy	Stainless Steel	Zircaloy	Zircaloy
Maximum Uranium, kgU	245.6	239.4	286.9	239.4	70.0
Maximum Initial ^{235}U, wt %	4.0	3.9	4.94	4.0	4.0
Minimum Initial ^{235}U, wt %	4.0	3.7[2]	4.94	3.5	3.5
Maximum Burnup, MWD/MTU	32,000	36,000	32,000	36,000	36,000
Maximum Assembly Decay Heat, kW	0.272	0.347	0.273	0.331	0.097
Maximum Cask Decay Heat, kW	9.8	12.5	9.3	11.9[3]	3.5
Minimum Cool Time, yr	11.0	8.1	19.0	9.0[3]	8.0

1 The Yankee Class Fuel includes United Nuclear Type A and Type B, Combustion Engineering Type A and Type B, Exxon-ANF Type A and Type B and Westinghouse Type A and Type B. The United Nuclear Type A is the most reactive assembly and is used as the design basis fuel for criticality analyses. The Combustion Type A is the design basis fuel for shielding and thermal evaluations. The Westinghouse Type B fuel is the design basis fuel for structural weight considerations. The Yankee Class design basis fuels bound a Yankee Class Reconfigured Fuel Assembly.

2 The NAC-STC can also accommodate canistered Combustion Engineering 3.5 wt % enriched fuel having a minimum cool time of 7 years and a burnup of 32,000 MWD/MTU.

3 The limit corresponds to Exxon assemblies with Zircaloy in-core hardware. Exxon assemblies with steel in-core hardware are limited by a minimum cool time of 16 years and a maximum decay heat of 9.7 kW.

4 The maximum number of mixed Type Yankee Class fuel assemblies is limited to 36 or to 30,600 lbs, total loaded assembly weight.

Table 1.2-4 Isotopic Constituents of GTCC Waste

Isotope	Baffle Activity (Ci)		Average Dross Activity (Ci)		Total Activity (Ci)		Total Activity (Ci)[1]	
	Activation	Surface	Activation	Surface	15 Baffle	6 Dross	Total-21	24 Design Basis
Tritium	4.52E+01	1.68E-04	5.59E+00	2.07E-05	4.52E+01	5.59E+00	5.08E+01	--
Carbon-14	4.90E+01	1.42E-03	6.06E+00	1.76E-04	4.90E+01	6.06E+00	5.50E+01	--
Manganese-54	7.72E+01	1.62E-03	9.57E+00	2.01E-04	7.72E+01	9.57E+00	8.68E+01	1.00E+02
Iron-55	7.07E+04	9.09E-01	8.75E+03	1.13E-01	7.07E+04	8.75E+03	7.94E+04	8.75E+04
Cobalt-60	1.02E+05	2.01E+00	1.26E+04	2.49E-01	1.02E+05	1.26E+04	1.14E+05	1.25E+05
Nickel-63	2.79E+04	6.64E-01	3.45E+03	8.22E-02	2.79E+04	3.45E+03	3.13E+04	3.35E+04
Technetium-99	1.36E-01	1.76E-04	1.68E-02	2.18E-05	1.36E-01	1.69E-02	1.53E-01	--
Cesium-134	0.00	5.32E-03	0.00	6.59E-04	5.32E-03	6.59E-04	5.98E-03	--
Cesium-137	0.00	2.49E-01	0.00	3.09E-02	2.49E-01	3.09E-02	2.80E-01	--
Cerium-144	0.00	1.05E-03	0.00	1.30E-04	1.05E-03	1.30E-04	1.18E-03	--
Plutonium-238	0.00	2.61E-03	0.00	3.23E-04	2.61E-03	3.23E-04	2.93E-03	--
Plutonium-239/240	0.00	6.65E-03	0.00	8.24E-04	6.65E-03	8.24E-04	7.48E-03	--
Plutonium-241	0.00	2.09E-01	0.00	2.59E-02	2.09E-01	2.59E-02	2.35E-01	--
Americium-241	0.00	3.94E-03	0.00	4.88E-04	3.94E-03	4.88E-04	4.43E-03	--
Curium-242	0.00	1.89E-07	0.00	2.35E-08	1.89E-07	2.35E-08	2.13E-07	--
Curium-243/244	0.00	1.48E-03	0.00	1.84E-04	1.48E-03	1.84E-04	1.67E-03	--
Ruthenium-106	0.00	1.82E-03	0.00	2.25E-04	1.82E-03	2.25E-04	2.04E-03	--
Strontium-89	0.00	3.81E-13	0.00	4.72E-14	3.81E-13	4.72E-14	4.29E-13	--
Strontium-90	0.00	2.20E-01	0.00	2.72E-02	2.20E-01	2.72E-02	2.47E-01	--
Iodine-129LLD	0.00	1.12E-04	0.00	1.38E-05	1.12E-04	1.38E-05	1.25E-04	--
Antimony-125	0.00	1.40E-02	0.00	1.73E-03	1.40E-02	1.73E-03	1.57E-02	--
Silver-110m	0.00	1.07E-04	0.00	1.33E-05	1.07E-04	1.33E-05	1.20E-04	--
Cobalt-57	0.00	3.96E-05	0.00	4.90E-06	3.96E-05	4.90E-06	4.45E-05	--
Niobium-94	6.63E-01	0.00	8.21E-02	0.00	6.63E-01	8.21E-02	7.45E-01	--
Nickel-59	1.52E+02	0.00	1.88E+01	0.00	1.52E+02	1.88E+01	1.71E+02	--
Zinc-65	6.78E-01	0.00	8.39E-02	0.00	6.78E-01	8.39E-02	7.62E-01	--

1. Isotopes except Manganese, Iron, Cobalt and Nickel are limited to a total of 500 curies per canister. The total Plutonium content must be less than 20 to exempt the canister from the requirements of 10 CFR 71.63.

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FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

ASSY	ASSY	ASSY
QUANTITY		

DIMENSIONING AND TOLERANCING SHALL BE PER ASME Y14.5-94
UNSPECIFIED DIMENSIONS AND TOLERANCES SHOWN BELOW
DIMENSIONS ARE IN INCHES. FRACTIONAL TOLERANCE: ±1/8

SYM	GEOMETRY	XXX	TOL	XX	TOL
	FLATNESS	UNDER 3	±.003	UNDER 6	±.02
	STRAIGHTNESS	3-12	±.005	6-18	±.03
	ANGULARITY	OVER 12	±.010	OVER 18	±.06
	PERPENDICULARITY	X	±.1	ANGLES ±0.5°	
	PARALLELISM	ALL UNSPECIFIED TOOL RADII .015 - .030			
	CONCENTRICITY	BREAK ALL SHARP CORNERS .015 - .030			
	TRUE POSITION	ALL UNSPECIFIED MACHINED SURFACES SHALL BE ▽ OR BETTER			

NEXT ASSEMBLY 423-900

DRAWING TYPE LICENSE

GROUP	NAME	DATE
PREPARER	[illegible]	11-30-01
CHECKER	R. Walton	11-30-01
PROJECT MANAGER	[illegible]	[illegible]
DIRECTOR DESIGN AND ANALYSIS	[illegible]	11-30-01
DIRECTOR LICENSING	[illegible]	11/30/01
VICE PRESIDENT QUALITY	[illegible] FOR	11/30/01

NAC INTERNATIONAL

CASK ASSEMBLY-
NAC-STC CASK

PROJECT 423	DRAWING 800	REV [illegible]
SCALE 1/6	EST WT NOTED	SH 1 of 2

NAC INTERNATIONAL

CASK ASSEMBLY
NAC-STC CASK

PROJECT 423 | DRAWING 800 | REV 4

SCALE 1/6 | EST WT NOTED | SH 2 OF 2

FIGURE WITHHELD AS SENSITIVE
UNCLASSIFIED INFORMATION

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

ASSY	ASSY	ASSY
QUANTITY		

DIMENSIONING AND TOLERANCING SHALL BE PER ASME Y14.5-94
UNSPECIFIED DIMENSIONS AND TOLERANCES SHOWN BELOW.
DIMENSIONS ARE IN INCHES FRACTIONAL TOLERANCE: ±1/8

SYM	GEOMETRY	.XXX	TOL.	.XX	TOL.
⏥	FLATNESS	UNDER 3	±.003	UNDER 6	±.02
⏤	STRAIGHTNESS	3-12	±.005	6-18	±.03
∠	ANGULARITY	OVER 12	±.010	OVER 18	±.06
⊥	PERPENDICULARITY	.X	±.1	ANGLES ±0.5°	
//	PARALLELISM	ALL UNSPECIFIED TOOL RADII: .015 - .030			
◎	CONCENTRICITY	BREAK ALL SHARP CORNERS .015 - .030			
⊕	TRUE POSITION	ALL UNSPECIFIED MACHINED SURFACES SHALL BE 125 OR BETTER			

NEXT ASSEMBLY: 423-800

DRAWING TYPE: LICENSE

GROUP	NAME	DATE
PREPARER		11-16-01
CHECKER		11-16-01
PROJECT MANAGER		11-16-01
DIRECTOR DESIGN AND ANALYSIS		11-16-01
DIRECTOR, LICENSING		11/16/01
VICE PRESIDENT QUALITY		11/16/01

NAC INTERNATIONAL

CASK BODY--
NAC-STC CASK

PROJECT	DRAWING	REV
423	802	12

SCALE 1/10 | EST WT NOTED | SH 1 OF 6

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

NAC INTERNATIONAL

CASK BODY–
NAC–STC CASK

PROJECT 423		DRAWING 802	REV 12
SCALE 1/6	EST.WT. NOTED	SH 2 OF 6	1:54PM 11-18-2001

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

NAC INTERNATIONAL

CASK BODY-
NAC-STC CASK

PROJECT 423		DRAWING 802	REV 12
SCALE 1/8	EST WT NOTED	SH 3 OF 6	1:53PM 11-16-2001

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

NAC INTERNATIONAL

CASK BODY–
NAC–STC CASK

PROJECT 423		DRAWING 802	REV 12
SCALE 1/6	EST. WT. NOTED	SH 4 OF 6	1:53PM 11-16-2001

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

NAC INTERNATIONAL

CASK BODY–
NAC–STC CASK

PROJECT 423		DRAWING 802	REV 12
SCALE 1/4	EST WT NOTED	SH 5 OF 6	11-16-2001

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

NAC INTERNATIONAL			
CASK BODY- NAC-STC CASK			
PROJECT 423		DRAWING 802	REV 12
SCALE 1/4	EST WT NOTED	SH 6 OF 6	1:55PM 11-16-2001

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

ASSY	ASSY	ASSY
QUANTITY		

DIMENSIONING AND TOLERANCING SHALL BE PER ASME Y14.5-94
UNSPECIFIED DIMENSIONS AND TOLERANCES SHOWN BELOW.
DIMENSIONS ARE IN INCHES. FRACTIONAL TOLERANCE: ±1/8

SYM.	GEOMETRY	.XXX	TOL.	.XX	TOL.
	FLATNESS	UNDER 3	±.003	UNDER 6	±.02
	STRAIGHTNESS	3-12	±.005	6-18	±.03
	ANGULARITY	OVER 12	±.010	OVER 18	±.06
	PERPENDICULARITY	.X	±.1	ANGLES ±0.5°	
	PARALLELISM	ALL UNSPECIFIED TOOL RADII: .015 - .030			
	CONCENTRICITY	BREAK ALL SHARP CORNERS .015 - .030			
	TRUE POSITION	ALL UNSPECIFIED MACHINED SURFACES SHALL BE ▽ OR BETTER			

NEXT ASSEMBLY: 423-800

DRAWING TYPE: LICENSE

GROUP	NAME	DATE
PREPARER	S. Graham	11-15-01
CHECKER	B. Walker	11-16-01
PROJECT MANAGER	[illegible]	11-16-01
DIRECTOR DESIGN AND ANALYSIS	[illegible]	11-16-01
DIRECTOR LICENSING	[illegible]	11/16/01
VICE PRESIDENT, QUALITY	[illegible]	11/16/01

NAC INTERNATIONAL

LID ASSEMBLY-
INNER,
NAC-STC CASK

PROJECT 423	DRAWING 803	REV 3
SCALE 1/6	EST WT NOTED	SH 1 OF 2

2:06PM 11-15-2001

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

NAC INTERNATIONAL

LID ASSEMBLY-
INNER,
NAC-STC CASK

PROJECT 423		DRAWING 803	REV 3
SCALE 1/6	EST. WT NOTED	SH 2 OF 2	2:05PM 11-15-2001

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

97	98	99	ITEM	NAME	MATERIAL	SPEC	DRAWING No.	DESCRIPTION
ASSY	ASSY	ASSY						
QUANTITY								

DIMENSIONING AND TOLERANCING SHALL BE PER ASME Y14.5-94
UNSPECIFIED DIMENSIONS AND TOLERANCES SHOWN BELOW.
DIMENSIONS ARE IN INCHES. FRACTIONAL TOLERANCE: ±1/8

SYM.	GEOMETRY	.XXX	TOL.	.XX	TOL.
		UNDER 3	±.003	UNDER 6	±.02
⏥	FLATNESS	3-12	±.005	6-18	±.03
—	STRAIGHTNESS	OVER 12	±.010	OVER 18	±.06
		.X	±.1	ANGLES ±0.5°	
∠	ANGULARITY	ALL UNSPECIFIED TOOL RADII: .015 - .030			
⊥	PERPENDICULARITY	BREAK ALL SHARP CORNERS .015 - .030			
//	PARALLELISM	ALL UNSPECIFIED MACHINED SURFACES SHALL BE ∀ OR BETTER			
◎	CONCENTRICITY	NEXT ASSEMBLY: 423-803			
⊕	TRUE POSITION	DRAWING TYPE: LICENSE			

GROUP	NAME	DATE
PREPARER	S Graham	9/21/01
CHECKER	[illegible]	9/21/01
PROJECT MANAGER	[illegible] for GMJ	21 SEP 01
DIRECTOR DESIGN AND ANALYSIS	[illegible]	9-21-01
DIRECTOR LICENSING	JSWalker / TCT	9/21/01
VICE PRESIDENT, QUALITY	[illegible]	9/24/01

NAC INTERNATIONAL

DETAILS-
INNER LID,
NAC-STC CASK

PROJECT 423		DRAWING 804	REV 3
SCALE 1/6	EST. WT. NOTED	SH 1 OF 3	9:22AM 9-21-2001

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

NAC INTERNATIONAL

DETAILS–
INNER LID,
NAC–STC CASK

PROJECT 423		DRAWING 804	REV 3
SCALE 1/6	EST.WT. NOTED	SH 2 OF 3	1:38PM 6-16-2001

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

NAC INTERNATIONAL

DETAILS–
INNER LID,
NAC–STC CASK

PROJECT 423		DRAWING 804			REV 3
SCALE 1/2	EST.WT. NOTED	SH 3	OF 3	3:44PM 9-21-2001	

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

ASSY	ASSY	ASSY
QUANTITY		

DIMENSIONING AND TOLERANCING SHALL BE PER ASME Y14.5-94
UNSPECIFIED DIMENSIONS AND TOLERANCES SHOWN BELOW.
DIMENSIONS ARE IN INCHES. FRACTIONAL TOLERANCE: ±1/8

SYM.	GEOMETRY	.XXX	TOL.	.XX	TOL.
	FLATNESS	UNDER 3	±.003	UNDER 6	±.02
	STRAIGHTNESS	3-12	±.005	6-18	±.03
	ANGULARITY	OVER 12	±.010	OVER 18	±.06
	PERPENDICULARITY	.X	±.1	ANGLES ±0.5°	
	PARALLELISM	ALL UNSPECIFIED TOOL RADII: .015 - .030			
	CONCENTRICITY	BREAK ALL SHARP CORNERS .015 - .030			
	TRUE POSITION	ALL UNSPECIFIED MACHINED SURFACES SHALL BE ▽ OR BETTER			

NEXT ASSEMBLY: 423-800
DRAWING TYPE: LICENSE

GROUP	NAME	DATE
PREPARER	S. Graham	11-15-01
CHECKER	[illegible]	11-16-01
PROJECT MANAGER	[illegible]	11-16-01
DIRECTOR DESIGN AND ANALYSIS	[illegible]	11-16-01
DIRECTOR, LICENSING	[illegible]	11/16/01
VICE PRESIDENT QUALITY	[illegible]	11/16/01

NAC INTERNATIONAL

LID ASSEMBLY,
OUTER,
NAC-STC CASK

PROJECT 423	DRAWING 805	REV 3
SCALE 1/6	EST WT NOTED	SH 1 OF 2

3:50PM 11-15-2001

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

NAC INTERNATIONAL

LID ASSEMBLY,
OUTER,
NAC–STC CASK

PROJECT 423		DRAWING 805		REV 3	
SCALE 1/6	EST WT. NOTED	SH 2 OF 2		11-15-2001	

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

ASSY	ASSY	ASSY
QUANTITY		

DIMENSIONING AND TOLERANCING SHALL BE PER ASME Y14.5-94
UNSPECIFIED DIMENSIONS AND TOLERANCES SHOWN BELOW.
DIMENSIONS ARE IN INCHES. FRACTIONAL TOLERANCE: ±1/8

SYM	GEOMETRY	.XXX	TOL.	.XX	TOL.
⏥	FLATNESS	UNDER 3	±.003	UNDER 6	±.02
—	STRAIGHTNESS	3–12	±.005	6–18	±.03
∠	ANGULARITY	OVER 12	±.010	OVER 18	±.06
⊥	PERPENDICULARITY	X	±1	ANGLES ±0.5°	
//	PARALLELISM	ALL UNSPECIFIED TOOL RADII: .015 - .030			
◎	CONCENTRICITY	BREAK ALL SHARP CORNERS .015 - .030			
⌖	TRUE POSITION	ALL UNSPECIFIED MACHINED SURFACES SHALL BE ▽ OR BETTER			

NEXT ASSEMBLY: 423-803

DRAWING TYPE: LICENSE

GROUP	NAME	DATE
PREPARER	S. Graham	11-15-01
CHECKER	[illegible]	11-16-01
PROJECT MANAGER	[illegible]	11-16-01
DIRECTOR DESIGN AND ANALYSIS	[illegible]	11-16-01
DIRECTOR LICENSING	[illegible]	11/16/01
VICE PRESIDENT QUALITY	[illegible]	11/16/01

NAC INTERNATIONAL

PORT COVERPLATE ASSY.
INNER LID,
NAC-STC CASK

PROJECT	DRAWING	REV
423	806	3

SCALE	EST.WT.	SH	
1/1	NOTED	1 OF 1	2:04PM 11-15-2001

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

ASSY	ASSY	ASSY
QUANTITY		

DIMENSIONING AND TOLERANCING SHALL BE PER ASME Y14.5-94
UNSPECIFIED DIMENSIONS AND TOLERANCES SHOWN BELOW.
DIMENSIONS ARE IN INCHES. FRACTIONAL TOLERANCE: ±1/8

SYM.	GEOMETRY	.XXX	TOL.	.XX	TOL.
▱	FLATNESS	UNDER 3	±.003	UNDER 6	±.02
—	STRAIGHTNESS	3-12	±.005	6-18	±.03
∠	ANGULARITY	OVER 12	±.010	OVER 18	±.06
⊥	PERPENDICULARITY	.X	±.1	ANGLES ±0.5°	
//	PARALLELISM	ALL UNSPECIFIED TOOL RADII: .015 - .030			
◎	CONCENTRICITY	BREAK ALL SHARP CORNERS .015 - .030			
⊕	TRUE POSITION	ALL UNSPECIFIED MACHINED SURFACES SHALL BE ▽ OR BETTER			

NEXT ASSEMBLY: 423-802,805,809,810

DRAWING TYPE: LICENSE

GROUP	NAME	DATE
PREPARER	S. Graham	11-15-01
CHECKER	[illegible]	11-16-01
PROJECT MANAGER	[illegible]	11-16-01
DIRECTOR DESIGN AND ANALYSIS	[illegible]	11-16-01
DIRECTOR, LICENSING	[illegible]	11/16/01
VICE PRESIDENT, QUALITY	[illegible]	11/16/01

NAC INTERNATIONAL

NAMEPLATES–
NAC–STC CASK

PROJECT 423	DRAWING 812	REV 2
SCALE FULL	EST.WT.	SH 1 OF 1

2:06PM 11-15-2001

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

ASSY	ASSY	ASSY
QUANTITY		

DIMENSIONING AND TOLERANCING SHALL BE PER ASME Y14.5-94
UNSPECIFIED DIMENSIONS AND TOLERANCES SHOWN BELOW.
DIMENSIONS ARE IN INCHES. FRACTIONAL TOLERANCE: ±1/8

SYM.	GEOMETRY	.XXX	TOL.	.XX	TOL.
	FLATNESS	UNDER 3	±.003	UNDER 6	±.02
	STRAIGHTNESS	3-12	±.005	6-18	±.03
	ANGULARITY	OVER 12	±.010	OVER 18	±.06
	PERPENDICULARITY	.X	±.1	ANGLES ±0.5°	
	PARALLELISM	ALL UNSPECIFIED TOOL RADII: .015 - .030			
	CONCENTRICITY	BREAK ALL SHARP CORNERS .015 - .030			
	TRUE POSITION	ALL UNSPECIFIED MACHINED SURFACES SHALL BE ∀ OR BETTER			

NEXT ASSEMBLY: 423-870

DRAWING TYPE: LICENSE

GROUP	NAME	DATE
PREPARER	S. Graham	11-15-01
CHECKER	B. Walker	11-16-01
PROJECT MANAGER	[illegible]	11-16-01
DIRECTOR DESIGN AND ANALYSIS	[illegible]	11-14-01
DIRECTOR, LICENSING	JC Thompson	11/16/01
VICE PRESIDENT, QUALITY	[illegible]	11/16/01

NAC INTERNATIONAL

TOP WELDMENT,
FUEL BASKET,
PWR, 26 ELEMENT,
NAC-STC CASK

PROJECT 423		DRAWING 872	REV 5
SCALE 1/5	EST WT	SH 1 OF 1	2:06PM 11-15-2001

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

ASSY	ASSY	ASSY
QUANTITY		

DIMENSIONING AND TOLERANCING SHALL BE PER ASME Y14.5-94
UNSPECIFIED DIMENSIONS AND TOLERANCES SHOWN BELOW.
DIMENSIONS ARE IN INCHES. FRACTIONAL TOLERANCE: ±1/8

SYM.	GEOMETRY	.XXX	TOL.	.XX	TOL.
▱	FLATNESS	UNDER 3	±.003	UNDER 6	±.02
—	STRAIGHTNESS	3-12	±.005	6-18	±.03
∠	ANGULARITY	OVER 12	±.010	OVER 18	±.06
⊥	PERPENDICULARITY	.X	±.1	ANGLES ±0.5°	
//	PARALLELISM	ALL UNSPECIFIED TOOL RADII: .015 - .030			
◎	CONCENTRICITY	BREAK ALL SHARP CORNERS .015 - .030			
⊕	TRUE POSITION	ALL UNSPECIFIED MACHINED SURFACES SHALL BE ∀ OR BETTER			

NEXT ASSEMBLY: 423-870

DRAWING TYPE: LICENSE

GROUP	NAME	DATE
PREPARER	S Graham	11-26-01
CHECKER	[illegible]	11-26-01
PROJECT MANAGER	[illegible]	11-26-01
DIRECTOR DESIGN AND ANALYSIS	[illegible]	[illegible]
DIRECTOR, LICENSING	T C Thompson	11/27/01
VICE PRESIDENT QUALITY	[illegible]	11/27/01

NAC INTERNATIONAL

TUBE,
NAC-STC CASK

PROJECT 423	DRAWING 875	REV 3
SCALE 1/1	EST.WT. NOTED	SH 1 OF 2

4:51PM 11-28-2001

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

NAC INTERNATIONAL

TUBE,
NAC–STC CASK

PROJECT 423		DRAWING 875	REV 3
SCALE 1/1	EST.WT. NOTED	SH 2 OF 2	4:51PM 11-28-2001

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

ASSY	ASSY	ASSY	ASSY	ASSY
QUANTITY				

DIMENSIONING AND TOLERANCING SHALL BE PER ANSI Y14.5-82 UNSPECIFIED DIMENSIONS AND TOLERANCES SHOWN BELOW. DIMENSIONS ARE IN INCHES. FRACTIONAL TOLERANCE: ±1/8

SYM	GEOMETRY	.XXX	TOL	.XX	TOL
	FLATNESS	UNDER 3		UNDER 6	±.04
	STRAIGHTNESS	3-12		6-18	±.06
	ANGULARITY	OVER 12		OVER 18	±.09
	PERPENDICULARITY	.X	±.1	ANGLES ±.5°	
	PARALLELISM	ALL UNSPECIFIED TOOL RADII: .01 - .03			
	CONCENTRICITY	BREAK ALL SHARP CORNERS .01 - .03			
	TRUE POSITION	ALL UNSPECIFIED MACHINED SURFACES SHALL BE ▽ OR BETTER			

NEXT ASSEMBLY: 423-901

DRAWING TYPE: LICENSE

GROUP	NAME	DATE
PREPARER	[signature]	10-25-00
CHECKER	R. [signature]	10-25-00
PROJECT MANAGER	[signature]	10-25-00
DIRECTOR DESIGN AND ANALYSIS	[signature]	10-25-00
DIRECTOR LICENSING	[signature]	10/25/00
VICE PRESIDENT, QUALITY	[signature]	10/25/00

NAC INTERNATIONAL

PACKAGE ASSEMBLY
TRANSPORTATION
NAC-STC CASK

PROJECT 423 | DRAWING 900 | REV 4

SCALE 1/10 | EST WT. 250,000LBS | SH 1 OF 1 | 3:30PM 10-25-2000

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

ASSY	ASSY	ASSY	ASSY	ASSY
QUANTITY				

DIMENSIONING AND TOLERANCING SHALL BE PER ANSI Y14.5-82
UNSPECIFIED DIMENSIONS AND TOLERANCES SHOWN BELOW.
DIMENSIONS ARE IN INCHES. FRACTIONAL TOLERANCE: ±1/8

SYM.	GEOMETRY	.XXX	TOL.	.XX	TOL.
	FLATNESS	UNDER 3		UNDER 6	±.04
	STRAIGHTNESS	3-12		6-18	±.06
	ANGULARITY	OVER 12		OVER 18	±.09
	PERPENDICULARITY	.X	±.1	ANGLES ±.5°	
	PARALLELISM	ALL UNSPECIFIED TOOL RADII .01 - .03			
	CONCENTRICITY	BREAK ALL SHARP CORNERS .01 - .03			
	TRUE POSITION	ALL UNSPECIFIED MACHINED SURFACES SHALL BE ∀ OR BETTER			
		NEXT ASSEMBLY:			
		DRAWING TYPE: LICENSE			

GROUP	NAME	DATE
PREPARER	[signature]	10-5-00
CHECKER	[signature]	10-5-00
PROJECT MANAGER	[signature]	10-5-00
DIRECTOR DESIGN AND ANALYSIS	[signature]	10/5/00
DIRECTOR LICENSING	[signature]	10/5/00
VICE PRESIDENT QUALITY	[signature]	10/5/00

NAC INTERNATIONAL

ASSEMBLY,
TRANSPORT CASK,
NAC-MPC

PROJECT 455	DRAWING 801	REV 2
SCALE 1/6	EST WT	SH 1 OF 2 — 12:11PM 10-5-2000

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

NAC INTERNATIONAL			
ASSEMBLY, TRANSPORT CASK, NAC-MPC			
PROJECT 455		DRAWING 801	REV 2
SCALE 1/6	EST. WT	SH 2 OF 2	12:15PM 10-5-2000

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

97	98	99	ITEM	NAME	MATERIAL	SPEC	DRAWING No	DESCRIPTION
ASSY	ASSY	ASSY	–					
QUANTITY								

DIMENSIONING AND TOLERANCING SHALL BE PER ASME Y14.5-94
UNSPECIFIED DIMENSIONS AND TOLERANCES SHOWN BELOW.
DIMENSIONS ARE IN INCHES FRACTIONAL TOLERANCE: ±1/8

SYM	GEOMETRY	.XXX	TOL.	.XX	TOL.
		UNDER 3	±.003	UNDER 6	±.02
⏥	FLATNESS	3-12	±.005	6-18	±.03
—	STRAIGHTNESS	OVER 12	±.010	OVER 18	±.06
		.X	±.1	ANGLES ±0.5°	
∠	ANGULARITY	ALL UNSPECIFIED TOOL RADII .015 - .030			
⊥	PERPENDICULARITY	BREAK ALL SHARP CORNERS .015 - .030			
//	PARALLELISM	ALL UNSPECIFIED MACHINED SURFACES SHALL BE 125 OR BETTER			
◎	CONCENTRICITY	NEXT ASSEMBLY: 455-872			
⌖	TRUE POSITION	DRAWING TYPE LICENSE			

GROUP	NAME	DATE
PREPARER	[illegible]	11/20/01
CHECKER	[illegible]	11-21-01
PROJECT MANAGER	[illegible]	11/21/01
DIRECTOR DESIGN AND ANALYSIS	[illegible]	11-21-01
DIRECTOR LICENSING	[illegible]	11/28/01
VICE PRESIDENT QUALITY	[illegible]	11/28/01

NAC INTERNATIONAL

CANISTER SHELL,
MPC-YANKEE

PROJECT 455		DRAWING 870	REV 4
SCALE 1/8	EST WT	SH 1 OF 1	4:44PM 11-20-2001

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

ASSY	ASSY	ASSY	ASSY	ASSY
QUANTITY				

DIMENSIONING AND TOLERANCING SHALL BE PER ANSI Y14.5-82
UNSPECIFIED DIMENSIONS AND TOLERANCES SHOWN BELOW
DIMENSIONS ARE IN INCHES. FRACTIONAL TOLERANCE: ±1/8

SYM.	GEOMETRY	.XXX	TOL.	.XX	TOL.
⏥	FLATNESS	UNDER 3		UNDER 6	±.04
—	STRAIGHTNESS	3-12		6-18	±.06
∠	ANGULARITY	OVER 12		OVER 18	±.09
⊥	PERPENDICULARITY	.X	±.1	ANGLES ±.5°	
//	PARALLELISM	ALL UNSPECIFIED TOOL RADII: .01 - .03			
◎	CONCENTRICITY	BREAK ALL SHARP CORNERS .01 - .03			
⌖	TRUE POSITION	ALL UNSPECIFIED MACHINED SURFACES SHALL BE ▽ OR BETTER			

NEXT ASSEMBLY: 455-872

DRAWING TYPE: LICENSE

GROUP	NAME	DATE
PREPARER	[illegible]	9/24/01
CHECKER	R. [illegible]	9-25-01
PROJECT MANAGER	[illegible]	9/27/01
DIRECTOR DESIGN AND ANALYSIS	[illegible]	9-27-01
DIRECTOR LICENSING	[illegible]	9/28/01
VICE PRESIDENT QUALITY	[illegible] / RHS	9/28/01

NAC INTERNATIONAL

DETAILS,
CANISTER,
MPC-YANKEE

PROJECT 455	DRAWING 871	REV 6
SCALE 1/8	EST WT	SH 1 OF 2

10:39AM 9-24-2001

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

NAC INTERNATIONAL

DETAILS,
CANISTER,
MPC–YANKEE

PROJECT 455		DRAWING 871	REV 6
SCALE 1/8	EST WT	SH 2 OF 2	10:40AM 9-24-2001

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

ASSY	ASSY	ASSY	ASSY	ASSY
QUANTITY				

DIMENSIONING AND TOLERANCING SHALL BE PER ANSI Y14.5-82
UNSPECIFIED DIMENSIONS AND TOLERANCES SHOWN BELOW.
DIMENSIONS ARE IN INCHES. FRACTIONAL TOLERANCE: ±1/8

SYM	GEOMETRY	.XXX	TOL.	.XX	TOL.
⏥	FLATNESS	UNDER 3		UNDER 6	±.04
—	STRAIGHTNESS	3-12		6-18	±.06
∠	ANGULARITY	OVER 12		OVER 18	±.09
⊥	PERPENDICULARITY	.X	±.1	ANGLES ±.5°	
//	PARALLELISM	ALL UNSPECIFIED TOOL RADII .01 - .03			
◎	CONCENTRICITY	BREAK ALL SHARP CORNERS .01 - .03			
⊕	TRUE POSITION	ALL UNSPECIFIED MACHINED SURFACES SHALL BE 125/OR BETTER			

NEXT ASSEMBLY: 455-800/862
DRAWING TYPE: LICENSE

GROUP	NAME	DATE
PREPARER	[signature]	8/17/01
CHECKER	Graham	8-17-01
PROJECT MANAGER	[signature]	8/17/01
DIRECTOR DESIGN AND ANALYSIS	[signature]	9-20-01
DIRECTOR, LICENSING	[signature] / TCT	9/30/01
VICE PRESIDENT, QUALITY	[signature]	9/10/01

NAC INTERNATIONAL

ASSEMBLY, TRANSPORTABLE STORAGE CANISTER (TSC), MPC-YANKEE

PROJECT 455	DRAWING 872	REV 9
SCALE 1/8	EST WT.	SH 1 OF 2

12:10PM 8-17-2001

A

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

NAC INTERNATIONAL

ASSEMBLY, TRANSPORTABLE STORAGE CANISTER (TSC), MPC-YANKEE

PROJECT 455		DRAWING 872	REV 9
SCALE 1/8	EST WT	SH 2 OF 2	2:15PM 6-11-2001

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

ASSY	ASSY	ASSY	ASSY	ASSY
QUANTITY				

DIMENSIONING AND TOLERANCING SHALL BE PER ANSI Y14.5-82
UNSPECIFIED DIMENSIONS AND TOLERANCES SHOWN BELOW.
DIMENSIONS ARE IN INCHES. FRACTIONAL TOLERANCE: ±1/8

SYM.	GEOMETRY	.XXX	TOL.	.XX	TOL.
⏥	FLATNESS	UNDER 3		UNDER 6	±.04
		3-12		6-18	±.06
—	STRAIGHTNESS	OVER 12		OVER 18	±.09
		.X	±.1	ANGLES ±.5°	
∠	ANGULARITY	ALL UNSPECIFIED TOOL RADII: .01 - .03			
⊥	PERPENDICULARITY	BREAK ALL SHARP CORNERS .01 - .03			
//	PARALLELISM	ALL UNSPECIFIED MACHINED SURFACES SHALL BE ▽ OR BETTER			
◎	CONCENTRICITY	NEXT ASSEMBLY: 455-872			
⌖	TRUE POSITION	DRAWING TYPE: LICENSE			

GROUP	NAME	DATE
PREPARER	R. Walker	3-8-00
CHECKER		3-20-00
PROJECT MANAGER		3-20-00
DIRECTOR DESIGN AND ANALYSIS		3-22-00
DIRECTOR, LICENSING		3/24/00
VICE PRESIDENT QUALITY		4/4/00

NAC INTERNATIONAL

ASSEMBLY,
DRAIN TUBE,
CANISTER
MPC-YANKEE

PROJECT 455		DRAWING 873	REV 3
SCALE FULL	EST WT	SH 1 OF 1	10:59AM 3-3-2000

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

ASSY	ASSY	ASSY	ASSY	ASSY
QUANTITY				

DIMENSIONING AND TOLERANCING SHALL BE PER ANSI Y14.5-82
UNSPECIFIED DIMENSIONS AND TOLERANCES SHOWN BELOW.
DIMENSIONS ARE IN INCHES. FRACTIONAL TOLERANCE: ±1/8

SYM	GEOMETRY	.XXX	TOL.	.XX	TOL.
	FLATNESS	UNDER 3		UNDER 6	±.04
	STRAIGHTNESS	3-12		6-18	±.06
	ANGULARITY	OVER 12		OVER 18	±.09
	PERPENDICULARITY	.X	±.1	ANGLES ± 5°	
	PARALLELISM	ALL UNSPECIFIED TOOL RADII: .01 - .03			
	CONCENTRICITY	BREAK ALL SHARP CORNERS .01 - .03			
	TRUE POSITION	ALL UNSPECIFIED MACHINED SURFACES SHALL BE ∇ OR BETTER			

NEXT ASSEMBLY: 455-895

DRAWING TYPE: LICENSE

GROUP	NAME	DATE
PREPARER		8/24/01
CHECKER		8-24-01
PROJECT MANAGER		
DIRECTOR DESIGN AND ANALYSIS		
DIRECTOR LICENSING		9/11/01
VICE PRESIDENT QUALITY		9/13/01

NAC INTERNATIONAL

PWR FUEL TUBE,
MPC-YANKEE

PROJECT 455	DRAWING 881	REV 6
SCALE 1/1	EST WT NOTED	SH 1 OF 3

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

NAC INTERNATIONAL

PWR FUEL TUBE,
MPC-YANKEE

PROJECT 455		DRAWING 881	REV 6
SCALE 1/1	EST WT NOTED	SH 2 OF 3	

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

NAC INTERNATIONAL

PWR FUEL TUBE,
MPC-YANKEE

PROJECT 455		DRAWING 881	REV 6
SCALE 1/1	EST WT. NOTED	SH 3 OF 3	

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

ASSY	ASSY	ASSY	ASSY	ASSY
QUANTITY				

DIMENSIONING AND TOLERANCING SHALL BE PER ANSI Y14.5-82
UNSPECIFIED DIMENSIONS AND TOLERANCES SHOWN BELOW.
DIMENSIONS ARE IN INCHES. FRACTIONAL TOLERANCE: ±1/8

SYM	GEOMETRY	.XXX	TOL.	.XX	TOL.
	FLATNESS	UNDER 3		UNDER 6	±.04
	STRAIGHTNESS	3-12		6-18	±.06
	ANGULARITY	OVER 12		OVER 18	±.09
	PERPENDICULARITY	X	±1	ANGLES ±.5°	
	PARALLELISM	ALL UNSPECIFIED TOOL RADII: .01 - .03			
	CONCENTRICITY	BREAK ALL SHARP CORNERS .01 - .03			
	TRUE POSITION	ALL UNSPECIFIED MACHINED SURFACES SHALL BE ▽ OR BETTER			

NEXT ASSEMBLY: 455-888
DRAWING TYPE: LICENSE

GROUP	NAME	DATE
PREPARER		10/31/01
CHECKER		10/31/01
PROJECT MANAGER		11/1/01
DIRECTOR DESIGN AND ANALYSIS		11/2/01
DIRECTOR LICENSING		11/2/01
VICE PRESIDENT QUALITY		11/2/01

NAC INTERNATIONAL

BASKET ASSEMBLY,
24 GTCC CONTAINER
MPC-YANKEE

PROJECT 455 | DRAWING 887 | REV 4
SCALE 1/8 | EST WT | SH 1 OF 3

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

NAC INTERNATIONAL

BASKET ASSEMBLY,
24 GTCC CONTAINER,
MPC–YANKEE

PROJECT 455		DRAWING 887	REV 4
SCALE 1/8	EST WT	SH 2 OF 3	4:12PM 10-31-2001

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

NAC INTERNATIONAL

BASKET ASSEMBLY,
24 GTCC CONTAINER,
MPC-YANKEE

PROJECT 455		DRAWING 887	REV 4
SCALE 1/8	EST WT	SH 3 OF 3	10 31 2001

A

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

ASSY	ASSY	ASSY
QUANTITY		

DIMENSIONING AND TOLERANCING SHALL BE PER ASME Y14.5-94
UNSPECIFIED DIMENSIONS AND TOLERANCES SHOWN BELOW.
DIMENSIONS ARE IN INCHES. FRACTIONAL TOLERANCE: ±1/8

SYM	GEOMETRY	.XXX	TOL.	.XX	TOL.
⏥	FLATNESS	UNDER 3	±.003	UNDER 6	±.02
—	STRAIGHTNESS	3-12	±.005	6-18	±.03
∠	ANGULARITY	OVER 12	±.010	OVER 18	±.06
⊥	PERPENDICULARITY	.X	±.1	ANGLES ±0.5°	
//	PARALLELISM	ALL UNSPECIFIED TOOL RADII: .015 - .030			
◎	CONCENTRICITY	BREAK ALL SHARP CORNERS .015 - .030			
⌖	TRUE POSITION	ALL UNSPECIFIED MACHINED SURFACES SHALL BE ▽ OR BETTER			

NEXT ASSEMBLY: 455-800/-862

DRAWING TYPE: LICENSE

GROUP	NAME	DATE
PREPARER	[illegible]	8/31/01
CHECKER	S. Graham	8-31-01
PROJECT MANAGER	[illegible]	8/31/01
DIRECTOR DESIGN AND ANALYSIS	[illegible]	9-10-01
DIRECTOR, LICENSING	TC Thompson	9/11/01
VICE PRESIDENT QUALITY	[illegible] for RHS	9/13/01

NAC INTERNATIONAL

ASSEMBLY, TRANSPORTABLE STORAGE CANISTER (TSC), 24 GTCC CONTAINER, MPC-YANKEE

PROJECT 455	DRAWING 888	REV 6
SCALE 1/8	EST WT	SH 1 OF 2

10:54AM 8-31-2001

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

NAC INTERNATIONAL

ASSEMBLY, TRANSPORTABLE STORAGE CANISTER (TSC), 24 GTCC CONTAINER, MPC-YANKEE

PROJECT 455		DRAWING 888	REV 6
SCALE 1/8	EST WT	SH 2 OF 2	

FIGURE WITHHELD AS SENSITIVE UNCLASSIFIED INFORMATION

ASSY	ASSY	ASSY	ASSY	ASSY
QUANTITY				

DIMENSIONING AND TOLERANCING SHALL BE PER ANSI Y14.5-82 UNSPECIFIED DIMENSIONS AND TOLERANCES SHOWN BELOW. DIMENSIONS ARE IN INCHES. FRACTIONAL TOLERANCE: ±1/8

SYM.	GEOMETRY	.XXX	TOL.	.XX	TOL.
	FLATNESS	UNDER 3		UNDER 6	±.04
	STRAIGHTNESS	3-12		6-18	±.06
	ANGULARITY	OVER 12		OVER 18	±.09
	PERPENDICULARITY	.X	±.1	ANGLES ±.5°	
	PARALLELISM	ALL UNSPECIFIED TOOL RADII: .01 - .03			
	CONCENTRICITY	BREAK ALL SHARP CORNERS .01 - .03			
	TRUE POSITION	ALL UNSPECIFIED MACHINED SURFACES SHALL BE ▽ OR BETTER			

NEXT ASSEMBLY: 455-895

DRAWING TYPE: LICENSE

GROUP	NAME	DATE
PREPARER		3/6/01
CHECKER	R. Walker	3-6-01
PROJECT MANAGER		3-6-01
DIRECTOR DESIGN AND ANALYSIS		3-6-01
DIRECTOR LICENSING		3/6/01
VICE PRESIDENT QUALITY		3/6/01

NAC INTERNATIONAL

HEAT TRANSFER DISK,
FUEL BASKET,
MPC-YANKEE

PROJECT 455	DRAWING 894	REV 2
SCALE 1/5	EST WT 57 LBS	SH 1 OF 1

10:25AM 3-6-2001

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2.1 Structural Design

2.1.1 Discussion

The NAC-STC is a cylindrical, multiwall cask designed to safely transport up to 26 design basis PWR fuel assemblies, or up to 36 Yankee Class fuel assemblies, or 24 containers of Greater Than Class C waste. As described in Section 2.6.14, Reconfigured Fuel Assemblies containing failed fuel rods may be substituted for standard Yankee Class fuel assemblies in a canister containing spent fuel. The primary components of the NAC-STC are: (1) the cask body—inner shell, outer shell, lead shell, and bottom; (2) the inner lid, bolts, and o-rings; (3) the outer lid, bolts, and o-ring; (4) the port covers, port coverplates, bolts, and o-rings; (5) the neutron shield; (6) the trunnions; (7) the transport impact limiters—upper and lower; and (8) the fuel basket. The NAC-STC primary containment boundary for storage and transport after storage consists of: (1) inner shell center section and upper and lower inner shell rings (transition sections); (2) bottom inner forging; (3) top forging; (4) inner lid and inner lid outer metallic o-ring; (5) inner lid interseal test port and its threaded plug with metallic o-ring; (6) vent port coverplate and vent port coverplate outer metallic o-ring; (7) vent port coverplate interseal test threaded plug with metallic o-ring; (8) drain port coverplate and drain port coverplate outer metallic o-ring; and (9) drain port coverplate interseal test threaded plug with metallic o-ring. The primary containment boundary for transport immediately after loading consists of: (1) inner shell center section and upper and lower inner shell rings (transition sections); (2) bottom inner forging; (3) top forging; (4) inner lid and inner o-ring; (5) vent port coverplate and vent port coverplate inner o-ring; and (6) drain port coverplate and drain port coverplate inner o-ring. For transport without interim storage after loading, either metallic or non-metallic (EPDM or Viton) o-rings may be used in the containment boundary. A detailed discussion of the containment boundary is presented in Chapter 4. As described in Section 7.1.3, for loading of the NAC-STC for immediate shipment, the containment boundary for the inner lid and drain port coverplate are the inner metallic o-rings, rather than the outer o-rings and interseal test plugs. The geometry and the materials of fabrication of the cask components are described in Section 1.2.1 and are shown on the license drawings presented in Section 1.3.2.

The NAC-STC is designed to satisfy the requirements of 10 CFR 71 for the transport of radioactive materials (and the requirements of 10 CFR 72 for the storage of radioactive materials) and the requirements of IAEA Safety Series No. ST-1. The cask body holds and protects the cask cavity contents for the normal conditions of transport, as well as for the hypothetical accident conditions. The lead located between the inner and outer shells provides the primary gamma radiation shielding for the cask in the radial direction. The cask bottom connects the inner and outer shells, providing for the bottom end closure, as well as both gamma and neutron radiation shielding in the axial direction.

The inner lid, bolts, and o-rings are the primary closure components of the NAC-STC for transport conditions. The outer lid and o-ring provide a secondary closure boundary.

The vent port and the drain port are located in the inner lid and are each protected by a port coverplate. The primary containment boundary at the vent port and at the drain port is the port coverplate and its o-rings. The o-ring is located in the bottom surface of the port coverplate. A second o-ring is also located in the bottom surface of the port coverplate, inside of, and concentric with, the primary containment, outer o-ring.

The forty-two 1 1/2 - 8 UN inner lid bolts are preloaded by an installation torque to restrain rotation of the edge of the inner lid and to maintain a containment seal for the critical load condition. This condition is a uniformly distributed pressure resulting from the impact of the basket and cavity contents on the inner surface during a top end or top corner impact. The critical design load condition for the inner lid bolts, as listed in Table 2.7.1.6.2, Section 2.7.1.6, is a 55 g top corner impact (10 CFR 71 Hypothetical Accident Condition). The critical design load condition for the inner lid is the top end impact, Section 2716.

The outer lid is bolted to the top forging by the thirty-six 1 - 8 UNC outer lid bolts, which are installed to a specified torque. The torque provides a total bolt preload that exceeds the maximum applied bolt load for the critical load condition, preventing any lid and o-ring movement that might result in a loss of secondary seal integrity. The critical design load condition for the outer lid bolts, as listed in Table 2.7.1.6-4, Section 2.7.1.6, is a 49.7 g side impact (10 CFR 71 Hypothetical Accident Condition). The critical design load condition for the outer lid is the pin puncture accident condition. The NAC-STC outer lid bolts are loaded by the interlid region pressure, the o-ring compression force, and by either the impact limiter crush force during a top end or top corner impact, or by a concentrated center load during a pin puncture impact. The outer lid seal is provided by an o-ring, which is tested by pressurizing the interlid region.

In addition to the main closure, the secondary closure boundary of the NAC-STC also includes the two ports located in the top forging—the interlid port and the pressure port. Each of these ports is protected and sealed by a recessed, bolted port cover with two piston-type (bore seal)

PTFE o-rings. The port covers are installed with new o-rings just prior to transport (a slightly different port cover is installed during storage operation). The seal at each port cover is verified by pressure-testing the annulus between the two PTFE o-rings.

The neutron shielding material, NS-4-FR, is a solid synthetic polymer that absorbs the neutron radiation emitted by the cask contents. In addition to the radial neutron shielding along the cask length, neutron shielding is provided in the axial direction at each end of the cask by circular layers of NS-4-FR enclosed in the inner lid and in the cask bottom.

Four external trunnions are welded to the top forging of the NAC-STC at 90-degree intervals around the circumference of the cask. These trunnions are provided for lifting and handling the cask. Either a redundant (four trunnions) or a nonredundant (two trunnions) lifting system may be used. However, each pair of opposing trunnions are conservatively designed to satisfy the heavy lifting requirements of NUREG-0612 for a nonredundant lift, as well as the requirements of 10 CFR 71.45(a) and paragraph 506 of IAEA Safety Series No. ST-1. Two rotation trunnion recesses are welded to the bottom outer forging near the bottom of the cask. The neutron shield is cut out to accommodate the placement of the rotation trunnion recesses, which are used to attach the bottom of the cask to the transport vehicle and to rotate the cask from the vertical lifting position to the horizontal position and vice-versa.

The redwood/balsa wood transport impact limiters for the NAC-STC limit the impact loads that may act on the cask during the normal conditions of transport 1-foot free drop or the hypothetical accident 30-foot free drop. The impact limiters absorb the energy of a cask drop impact through the crushing of the redwood and balsa wood.

The NAC-STC fuel basket is constructed of stainless steel and has a capacity of 26 PWR fuel assemblies. The fuel basket has a cylindrical shape with a series of support disks that provide lateral support for the square, stainless steel fuel tubes, which encase BORAL poison plates on each of the four sides. The support disks are separated and supported at 4.87-inch intervals by a threaded rod and spacer nuts at six locations. Aluminum heat transfer fins are located in the central region of the fuel basket and are supported by the six threaded rods and spacer nuts. The stainless steel support disks have adequate strength at the basket temperatures that occur during the transport and/or storage of 26 design-basis PWR fuel assemblies.

Specifically for the Yankee class fuel, a transportable storage canister (TSC) serves as the enclosure of the spent fuel assemblies. This TSC has a capacity of up to 36 Yankee Class spent fuel elements. The TSC consists of a cylindrical shell with a welded bottom plate, a fuel basket, a shield lid and a structural lid.

When transporting failed fuel assemblies or Reconfigured Fuel Assemblies, the transportable storage canister qualifies as the separate inner container required by 10 CFR 71.63(b). The canister is evaluated for normal conditions of transport in Sections 2.6.13 and for hypothetical accident conditions in Section 2.7.11 in the transport configuration.

One TSC is designed and fabricated to accommodate 24 containers of Greater Than Class C (GTCC) waste that do not exceed the Yankee class fuel assembly dimensions:

- GTCC Tube Section - 7.82 inches (±0.1 inch) by 7.82 inches (±0.1 inch)
- Length - 109.8 inches (± 0.5 inch)

2.1.2 Design Criteria

2.1.2.1 Discussion

The load conditions that must be considered for the design of a spent-fuel transport cask are defined in 10 CFR 71 and in Regulatory Guide 7.8. Additionally, the NAC-STC is designed for the load conditions defined in 10 CFR 72 for dry storage casks. The stresses in the containment vessel, the noncontainment structure, and the closure bolts of the NAC-STC satisfy the stress limits defined in "Design Criteria for the Structural Analysis of Shipping Cask Containment Vessels," Regulatory Guide 7.6. These limits are essentially the same as those in the "ASME Boiler and Pressure Vessel Code," Section III, Division 1, Subsection NB for Class 1 Components.

The NAC-STC is analyzed as a pressure vessel whose containment boundary is not breached during any loading condition. The cask design provides well-defined load paths that are analyzed using straight-forward, proven structural analysis methods. The structural analysis of the NAC-STC is a linear elastic analysis. In those cases where loadings are open to analytical interpretation, bounding load condition analyses are performed to bracket the actual load condition.

Each normal condition of transport and each hypothetical accident condition will have a combination of various loading types. These load type combinations will define the total load criteria for each condition. The loading types that must be considered will include thermal, external and/or internal pressure, bolt preload, inertia, and cask drop impacts. The NAC-STC is analyzed for normal conditions of transport in Section 2.6 and for hypothetical accident conditions in Section 2.7.

The total stresses in the cask components are calculated as the combination of stresses that result from each of the various load types (thermal, pressure, mechanical) that are part of a given load condition. For those load conditions and components that are analyzed using classical hand-calculational methods, the total stress components are obtained by summation of the individual stress components for each type of load that is a part of the load condition. This summation is appropriate because the individual and total stress components are linear, elastic stresses.

2.1.2.2 Allowable Stress Limits - Ductile Failure

2.1.2.2.1 Containment Structures

Regulatory Guide 7.6 and "ASME Boiler and Pressure Vessel Code," Section III, Subsection NB are used to establish the allowable stress limits for the NAC-STC primary containment boundary for both normal conditions of transport and hypothetical accident conditions. Material property data used in calculating the allowable stress limits corresponds to the design stress intensities (S_m), yield strengths (S_y), and ultimate strengths (S_u), presented in Section 2.3. The NAC-STC primary containment boundary for storage and transport after storage includes: 1) the 6.2-inch thick cup-shaped bottom inner forging (Type 304 stainless steel); 2) the 71.0-inch inside diameter, 1.50-inch thick inner shell (Type XM-19 and Type 304 stainless steel), to which the bottom inner forging is welded; 3) the top forging (Type 304 stainless steel), to which the upper end of the inner shell is welded; 4) the 9.0-inch thick inner lid (Type 304 stainless steel) and its outer metallic o-ring (as well as its interseal test port, threaded plug and metallic o-ring), and 5) the vent and drain port coverplates, outer metallic o-rings and the port coverplate interseal test threaded plugs and metallic o-rings. When loaded for immediate shipment, the containment boundary includes the inner o-rings of the inner lid, vent port and drain port cover plate, rather than the outer o-ring and interseal test ports. The inner lid is installed and retained using 42 bolts (SB-637, Grade N07718 nickel alloy steel).

A summary of the allowable stress criteria used for containment structures and bolting materials is presented in Table 2.1.2-1. These criteria are consistent with Regulatory Guide 7.6 and applicable parts of Subsection NB-3000 and Appendix F of the "ASME Boiler and Pressure Vessel Code." Analysis section locations on the cask are identified in Section 2.10.2.4.2 to aid in the evaluations of the various load conditions.

For the canistered fuel configuration, the NAC-STC primary containment boundary is unchanged. However, the TSC is designed as a confinement/containment boundary to satisfy 10 CFR 72 spent fuel storage requirements and provides a second containment boundary for the transport of Reconfigured Fuel Assemblies in accordance with the requirements of 10 CFR 71.63. A summary of the allowable stress criteria used for containment structures and bolting materials, including the Yankee class fuel canister is presented in Table 2.1.2-1.

2.2 Weights and Centers of Gravity

The calculated weights of the major components of the NAC-STC are tabulated in Table 2.2.0-1. The table also presents a summary of the weights and center of gravity locations of the NAC-STC for the three cask configurations most likely to occur--empty, under-the-hook loaded with fuel, and loaded with fuel/ready for transport. In Table 2.2.0-1, the term "empty" implies the absence of any fuel or water in the cask cavity, although the basket does remain in the cask cavity. The term "loaded with fuel" refers to the cask loaded with 26 design basis fuel assemblies in the basket. "Under-the-hook loaded with fuel" describes the loaded NAC-STC with water in the cavity, without the outer lid in place, and with the yoke. "Loaded with fuel/ready for transport" describes the loaded NAC-STC with helium in the cavity and the upper and lower impact limiters installed on the cask. The axial locations of the centers of gravity are measured from the bottom outer surface of the cask body. The centers of gravity are on the axial centerline of the cask because it is essentially symmetric about that axis.

The design weight of the NAC-STC "loaded with fuel/ready for transport" is 250,000 pounds. This design weight is used in all normal transport, hypothetical accident, and lifting/handling analyses.

The calculated weights of the major components of the canistered fuel and GTCC waste configurations of the NAC-STC are tabulated in Tables 2.2.0-2 and 2.2.0-3, respectively. The tables also present a summary of the weights and center of gravity locations of the NAC-STC for the three cask configurations most likely to occur – empty, under the hook loaded with fuel, and loaded with fuel/ready for transport. In Tables 2.2.0-2 and 2.2.0-3, the term "empty" implies the absence of a canister, fuel or water in the cask cavity, although the spacers do remain in the cask cavity. The term "loaded with fuel" refers to the loaded canister in the cask, with the noted number of design basis fuel assemblies in the basket. "Under-the-hook loaded with fuel" describes the loaded NAC-STC with the outer lid in place, and with the yoke. "Loaded with fuel/ready for transport" describes the loaded NAC-STC with helium in the cavity and the upper and lower impact limiters installed on the cask. The axial locations of the centers of gravity are measured from the bottom outer surface of the cask body. The centers of gravity are on the axial centerline of the cask because it is essentially symmetric about that axis. Table 2.2.0-3 provides similar information for the GTCC configuration. The design weight of the NAC-STC "loaded with fuel/ready for transport" is 250,000 pounds. This design weight is used in all normal transport, hypothetical accident, and lifting/handling analyses.

Table 2.2.0-1 NAC-STC Weights and Centers of Gravity

Component	**Weight (lbs)**	**Center of Gravity*(in)**
Body Assembly	156,210	
Outer Lid	8,105	
Outer Lid Bolts	36	
Inner Lid	10,360	
Inner Lid Bolts and Port Covers	264	
TOTAL	174,975	96.20
Fuel (26 PWR Assemblies @ 1,500 lbs)	39,000	93.25
Fuel Basket	16,816	97.5
Water In Cavity	16,430	96.15
Yoke	2,150	NA
Transport Impact Limiters		
Top	8,641	202.40
Bottom	8,641	-11.70
TOTAL WEIGHT		
Empty	191,791	96.30
Under-the-Hook, with Fuel and Water	241,230	91.70
Loaded with Fuel/Ready for Transport	248,073	95.80
Design - Loaded with Fuel/ Ready for Transport	250,000	96.01

* Measured from bottom outer surface of cask body.

Table 2.2.0-2 NAC-STC Weights and Centers of Gravity for Canistered Fuel

Component	Weight (lbs)	Center of Gravity* (in)
Body Assembly	156,210	
Outer Lid	8,105	
Outer Lid Bolts	36	
Inner Lid	10,360	
Inner Lid Bolts and Port Covers	264	
TOTAL	174,975	96.20
Fuel (34 W PWR Assemblies @ 900 lbs)	30,600	NA
or (36 CE or UN Assemblies @ 850 lbs)	30,600	NA
Fuel Basket	9,530	NA
Canister w/Lids	14,600	NA
Spacers		
Top	510	NA
Bottom	350	NA
TOTAL WEIGHT OF CONTENTS (Canistered Fuel Basket Configuration)	55,590	NA
Yoke	2,150	NA
Transport Impact Limiters		
Top	8,641	202.40
Bottom	8,641	-11.70
TOTAL WEIGHT OF NAC-STC		
Empty with Spacers	175,835	NA
Under-the-Hook, Dry with Fuel	232,715	NA
Loaded with Fuel/Ready for Transport	247,847	96.01
Design - Loaded with Fuel/ Ready for Transport	250,000	96.01

* Measured from bottom outer surface of cask body.

Table 2.2.0-3 NAC-STC Weights and Centers of Gravity for Canistered GTCC Waste

Component	Weight (lbs)	Center of Gravity* (in)
Body Assembly	156,210	
Outer Lid	8,105	
Outer Lid Bolts	36	
Inner Lid	10,360	
Inner Lid Bolts and Port Covers	264	
TOTAL	174,975	96.20
GTCC Waste (24 Tubes Full @ 514 lbs)	12,340	NA
Basket - GTCC Waste	26,471	
Canister w/Lids	14,600	NA
Spacers		
Top	510	NA
Bottom	350	NA
TOTAL WEIGHT OF CONTENTS (Canistered Fuel Basket Configuration)	54,271	NA
Yoke	2,150	NA
Transport Impact Limiters		
Top	8,641	202.40
Bottom	8,641	-11.70
TOTAL WEIGHT		
Empty with spacers	175,835	NA
Under-the-Hook. Dry with GTCC Waste	231,396	NA
Loaded with GTCC Waste, Ready for Transport	246,528	NA
Design - Loaded with Fuel or GTCC Waste, Ready for Transport	250,000	96.01

* Measured from bottom outer surface of cask body.

2.3 Mechanical Properties of Materials

2.3.1 Discussion

The structural analyses of the NAC-STC for the normal conditions of transport and the hypothetical accident load conditions use the mechanical properties of the component materials at the appropriate temperature. The mechanical properties at the applicable temperature are also used in calculating the allowable stresses in each component analysis.

The NAC-STC is fabricated from several different materials. Most of the cask body—the center section of the inner shell, the outer shell, the cask bottom, the top forging, and the neutron shield shell—is Type 304 stainless steel. The 31-inch long inner shell rings at each end of the inner shell are Type XM-19 high-strength stainless steel. The remainder of the cask body consists of chemical copper grade lead gamma radiation shielding and borated NS-4-FR solid neutron radiation shielding (The radial neutron shield region also contains explosively-bonded copper/Type 304 stainless steel heat transfer "fins."). The inner lid is Type 304 stainless steel. The outer lid, the outer lid bolts, the port covers, the lifting trunnions, and the rotation trunnion recesses are SA-705 or SA-564, Type 630, H1150 17-4 PH stainless steel. The inner lid bolts are SB-637, Grade N07718 nickel alloy bolting material. The bolts for the port covers and port coverplates are SA-193, Grade B6 (Type 410) stainless steel. The fuel basket is an assembly of SA-693 or SA-564, Type 630, H1150 17-4 PH stainless steel support disks, threaded rods and spacer nuts, Type 304 stainless steel top and bottom end plates, and fuel tubes. Fuel basket heat transfer disks are Type 6061-T6 aluminum alloy. The impact limiters are redwood/balsa wood encased in thin stainless steel shells. For the canistered configuration of the NAC-STC, the canister and its structural lid are Type 304L stainless steel. The remaining components of the canister and baskets (fuel and GTCC waste) are Type 304 stainless steel with the exception of the support disks, which are 17-4 PH stainless steel, and the heat transfer disks, which are 6061-T6 aluminum alloy. The top and bottom cavity spacers are 5056 aluminum honeycomb encased in thin 6061-T6 aluminum alloy shells.

The "ASME Boiler and Pressure Vessel Code," Section III, Appendix I, and Standard Handbook for Mechanical Engineers (Baumeister) are the sources of the mechanical properties of Type 304 stainless steel; Type XM-19 stainless steel; SA-705 and SA-564, Type 630, H1150 17-4 PH stainless steel; SB-637, Grade N07718 nickel alloy steel bolting material; SA-193, Grade B6 (Type 410) stainless steel, and Type 6061-T6 aluminum alloy. The effects of temperature variations on the mechanical properties are included. The coefficients of thermal expansion presented in this section represent the mean value for the temperature range from 70°F to the indicated temperature.

2.3.2 Austenitic Stainless Steels

The primary structural components of the NAC-STC body, excluding: (1) the inner shell rings (transition sections of the inner shell); (2) the outer lid; (3) the lifting trunnions; and (4) the rotation trunnion recesses, are fabricated from Type 304 stainless steel. In addition to the cask body components fabricated from Type 304 stainless steel, the fuel tubes and fuel basket top and bottom weldment plates are fabricated from the same material. This material is selected because it is strong, ductile, and highly resistant to corrosion and brittle fracture. Type XM-19 stainless steel is selected for the inner shell rings at the ends of the inner shell because the high strength of Type XM-19 stainless steel provides additional resistance to shear buckling in those sections of the inner shell.

The mechanical properties of SA-240 (plate), Type 304 stainless steel are tabulated in Table 2.3.2-1. The mechanical properties of SA-336 (forging), Type 304 stainless steel are tabulated in Table 2.3.2-2. The mechanical properties of SA-240 (plate), Type XM-19 stainless steel are tabulated in Table 2.3.2-3.

The primary structural components of the Yankee class canisters and baskets, excluding the support disks and heat transfer disks, are fabricated from Type 304 and Type 304L stainless steels. This material is selected because it is strong, ductile, and highly resistant to corrosion and brittle fractures. The associated mechanical properties of the Type 304 and 304L stainless steels are tabulated in Tables 2.3.2-1, 2.3.2.-2 and 2.3.2-4.

Table 2.3.2-1 Mechanical Properties of SA 240, Type 304 Stainless Steel

	Temperature (°F)							
Property (units)[8]	**-40**	**-20**	**+70**	**+200**	**+300**	**+400**	**+500**	**+750**
Ultimate Strength[1] (ksi)	75.0	75.0	75.0	71.0	66.0	64.4	63.5	63.1
Yield Strength[2] (ksi)	30.0	30.0	30.0	25.0	22.5	20.7	19.4	17.3
Design Stress Intensity[3] (ksi)	20.0	20.0	20.0	20.0	20.0	18.7	17.5	15.6
Modulus of Elasticity[4] (ksi)	28.7E+3	28.7E+3	28.3E+3	27.6E+3	27.0E+3	26.5E+3	25.8E+3	24.4E+3
Alternating Stress[5] @ 10 cycles (ksi)	718.0	718.0	708.0	690.5	675.5	663.0	645.5	610.4
Alternating Stress[5] @ 10^6 cycles (ksi)	28.7	28.7	28.3	27.6	27.0	26.5	25.8	24.4
Coefficient of Thermal Expansion[6] (in/in/°F)	8.13E-6	8.19E-6	8.46E-6	8.79E-6	9.00E-6	9.19E-6	9.37E-6	9.76E-6
Poisson's Ratio[7]	0.31							
Density (lbm/in^3)	497 lbm/ft^3 (0.288 lbm/in^3)							

1 "ASME Boiler and Pressure Vessel Code," Section III, Division 1, Appendix I, Table I-3.2.
2 "ASME Boiler and Pressure Vessel Code," Section III, Division 1, Appendix I, Table I-2.2.
3 "ASME Boiler and Pressure Vessel Code," Section III, Division 1, Appendix I, Table I-1.2.
4 "ASME Boiler and Pressure Vessel Code," Section III, Division 1, Appendix I, Table I-6.0.
5 "ASME Boiler and Pressure Vessel Code," Section III, Division 1, Appendix I, Table I-9.1.
6 "ASME Boiler and Pressure Vessel Code," Section III, Division 1, Appendix I, Table I-5.0.
7 "ASME Boiler and Pressure Vessel Code," Section II, Part D, Table NF-1.
8 SA-182, Type 304 stainless steel may be substituted for SA-240 Type 304 stainless steel provided that the SA-182 material yield and ultimate strengths are equal to or greater than those of the SA-240 material. The SA-182 forging material and the SA-240 plate material are both Type 304 austenitic stainless steels. Austenitic stainless steels do not experience a ductile-to-brittle transition for the range of temperatures considered in this Safety Analysis Report. Therefore, fracture toughness is not a concern.

Table 2.3.2-2 Mechanical Properties of SA 336, Type 304 Stainless Steel

Property (units)	Temperature (°F)							
	-40	-20	+70	+200	+300	+400	+500	+750
Ultimate Strength[1] (ksi)	70.0	70.0	70.0	66.2.0	61.5	60.0	59.3	58.9
Yield Strength[2] (ksi)	30.0	30.0	30.0	25.0	22.5	20.7	19.4	17.3
Design Stress Intensity[3] (ksi)	20.0	20.0	20.0	20.0	20.0	18.7	17.5	15.6
Modulus of Elasticity[4] (ksi)	28.7E+3	28.7E+3	28.3E+3	27.6E+3	27.0E+3	26.5E+3	25.8E+3	24.4E+3
Alternating Stress[5] @ 10 cycles (ksi)	718.0	718.0	708.0	690.5	675.5	663.0	645.5	610.4
Alternating Stress[5] @ 10^6 cycles (ksi)	28.7	28.7	28.3	27.6	27.0	26.5	25.8	24.4
Coefficient of Thermal Expansion[6] (in/in/°F)	8.13E-6	8.19E-6	8.46E-6	8.79E-6	9.00E-6	9.19E-6	9.37E-6	9.76E-6
Poisson's Ratio[7]	0.31							
Density[8] (lbm/in^3)	497 lbm/ft^3 (0.288 lbm/in^3)							

[1] "ASME Boiler and Pressure Vessel Code," Section III, Division 1, Appendix I, Table I-3.2.
[2] "ASME Boiler and Pressure Vessel Code," Section III, Division 1, Appendix I, Table I-2.2.
[3] "ASME Boiler and Pressure Vessel Code," Section III, Division 1, Appendix I, Table I-1.2.
[4] "ASME Boiler and Pressure Vessel Code," Section III, Division 1, Appendix I, Table I-6.0.
[5] "ASME Boiler and Pressure Vessel Code," Section III, Division 1, Appendix I, Table I-9.1.
[6] "ASME Boiler and Pressure Vessel Code," Section III, Division 1, Appendix I, Table I-5.0.
[7] "ASME Boiler and Pressure Vessel Code," Section II, Part D, Table NF-1.
[8] "Nuclear Materials Handbook," Volume 1, Design Data, Property Code 3304.

Table 2.3.2-3 Mechanical Properties of Type XM-19 Stainless Steel

Property (units)[9]	Temperature (°F)							
	-40	-20	+70	+200	+300	+400	+500	+750
Ultimate Strength[1] (ksi)	100.0	100.0	100.0	99.5	94.3	90.7	89.1	85.7
Yield Strength[2] (ksi)	55.0	55.0	55.0	47.0	43.4	40.8	38.8	35.8
Design Stress Intensity[3] (ksi)	33.3	33.3	33.3	33.2	31.4	30.2	29.7	28.5
Modulus of Elasticity[4] (ksi)	28.3E+3	28.3E+3	28.3E+3	27.0E+3	27.0E+3	26.5E+3	25.8E+3	24.4E+3
Alternating Stress[5] @ 10 cycles (ksi)	708.0	708.0	708.0	690.5	675.5	663.0	645.5	610.4
Alternating Stress[5] @ 10^6 cycles (ksi)	28.3	28.3	28.3	27.6	27.0	26.5	25.8	24.4
Coefficient of Thermal Expansion[6] (in/in/°F)	8.13E-6	8.19E-6	8.46E-6	8.79E-6	9.00E-6	9.19E-6	9.37E-6	9.76E-6
Poisson's Ratio[7]	0.31							
Density[8] (lbm/in^3)	497 lbm/ft^3 (0.288 lbm/in^3)							

1 "ASME Boiler and Pressure Vessel Code," Section III, Division 1, Appendix I, Table I-3.1.
2 "ASME Boiler and Pressure Vessel Code," Section III, Division 1, Appendix I, Table I-2.1.
3 "ASME Boiler and Pressure Vessel Code," Section III, Division 1, Appendix I, Table I-1.1.
4 "ASME Boiler and Pressure Vessel Code," Section III, Division 1, Appendix I, Table I-6.0.
5 "ASME Boiler and Pressure Vessel Code," Section III, Division 1, Appendix I, Table I-9.1.
6 "ASME Boiler and Pressure Vessel Code," Section III, Division 1, Appendix I, Table I-5.0.
7 "ASME Boiler and Pressure Vessel Code," Section II, Part D, Table NF-1.
8 "Nuclear Materials Handbook," Volume 1, Design Data, Property Code 3304.
9 SA-182, FXM-19 stainless steel may be substituted for SA-240 XM-19 stainless steel provided that the SA-182 material yield and ultimate strengths are equal to or greater than those of the SA-240 material. The SA-182 forging material and the SA-240 plate material are both XM-19 austenitic stainless steels. Austenitic stainless steels do not experience a ductile-to-brittle transition for the range of temperatures considered in this Safety Analysis Report. Therefore, fracture toughness is not a concern.

2.3.6 Shielding Material

Gamma radiation shielding for the NAC-STC is provided by the steel cask body and lids and by lead in the cask wall. The primary radial gamma radiation shielding for the cask is provided by a cylinder of chemical copper grade lead, which fills the annulus between the inner shell and the outer shell. There is no concern that the lead will experience large deformation or volume change, since it is completely enclosed and is essentially incompressible.

Neutron radiation shielding for the NAC-STC is provided by a solid synthetic polymer, NS-4-FR, located in each end of the cask and around the outside of the outer shell. The solid neutron shield material eliminates leakage and maintenance concerns associated with liquid neutron shields. The NS-4-FR neutron shielding function requires no strength and none is assumed for the structural evaluations.

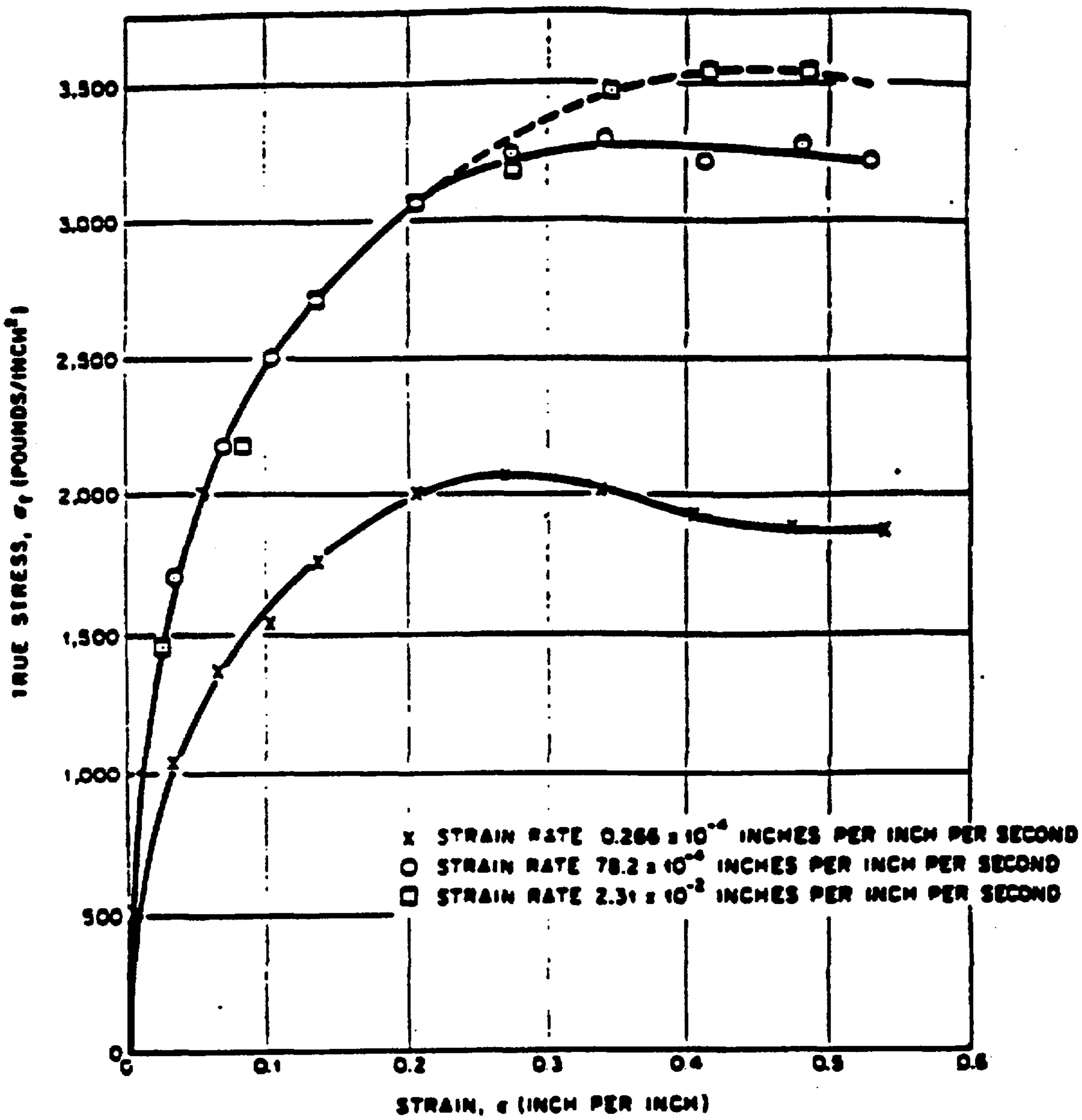
2.3.6.1 Chemical Copper Grade Lead

The coefficient of thermal expansion for lead is of particular significance because it is approximately twice that of stainless steel. The static mechanical properties of Chemical Copper Grade Lead are tabulated in Table 2.3.6-1, and the stress-strain curve for Chemical Copper Grade Lead is presented in Figure 2.3.6-1.

2.3.6.2 NS-4-FR

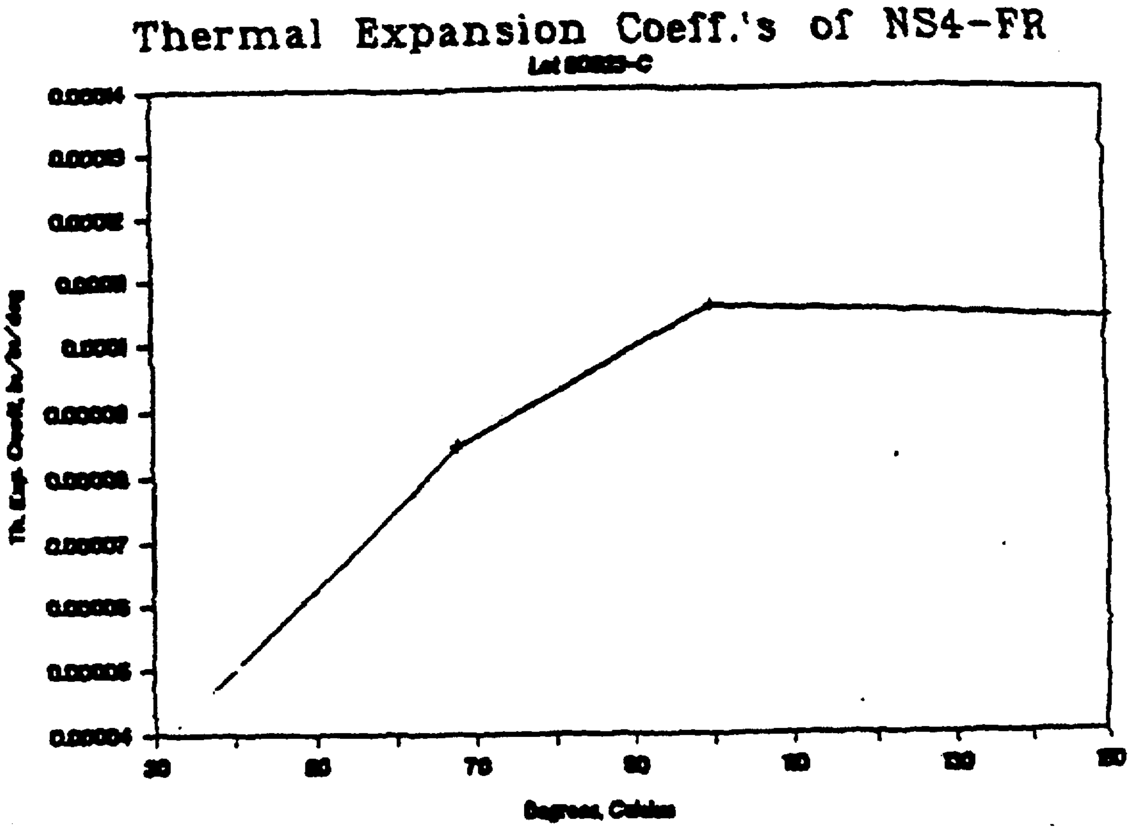
The NS-4-FR neutron shielding material was developed by BISCO Products, Inc. and is now supplied by the Japan Atomic Power Company (JAPC). The mechanical properties of NS-4-FR are tabulated in Table 2.3.6-2. The thermal expansion coefficient is shown in Figure 2.3.6-2.

Figure 2.3.6-1 Quasi-Static True Stress-Strain Curves for Chemical Copper Grade Lead in Compression



Reference: Evans

Figure 2.3.6-2 Neutron Shield Thermal Expansion Coefficient



1 BISCO Products Data

Table 2.3.6-1 Static Mechanical Properties of Chemical Copper Grade Lead

Property (units)	Temperature (°F)					
	-40	**-20**	**+70**	**+200**	**+300**	**+600**
Ultimate Strength[1,2] (ksi)	700	680	640	490	380	20
Modulus of Elasticity[3] (ksi)	2.45E+3	2.42E+3	2.28E+3	2.06E+3	1.94E+3	1.5E+3
Coefficient of Thermal Expansion[3] (in/in/°F)	15.6E-6	15.7E-6	16.1E-6	16.6E-6	17.2E-6	20.2E-6
Poisson's Ratio	0.40					
Density (lbm/in^3)	708 lbm/ft^3 (0.41 lbm/in^3)					

1 Tietz
2 Gallagher
3 NUREG/CR-0481, pages 42, 56 and 66.
4 Baumeister, page 6-10.

Table 2.4-1 Summary of NAC-STC Materials Categories and Operating Environments

ITEM	MATERIAL	ENVIRONMENT
Stainless Steels/Alloys	304, 304L, XM-19, 17-4PH, Ni Alloy, 410	Sealed Internal Open Internal/ External
Nonferrous Metals	ASTM B152 Cu, 6061-T6 Aluminum	Sealed Internal Open Internal/External
Shielding Materials	NS-4-FR, Chemical Copper Grade Lead	Enclosed
Criticality Control Materials	Boroncarbide Aluminum 1100	Enclosed
Energy Absorbing Materials	Balsa Wood, Redwood	Enclosed
Cellular Foam/Insulation	Silicone (HT-810 & 800), Silicone Caulk (Dow Corning)	Enclosed
Lubricants & Greases	Never-Seeze® Neolube® High Vacuum Grease® by Dow Corning	Sealed Internal Open Internal
Seals & Gaskets	Silicone Rubber, PTFE, Viton®	Sealed Internal Open Internal/ External

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$$R_B = 5.0 + 0.375 + (0.5)(1.748 \sin 30°)$$
$$= 5.812$$

$$R_{ave} = 5.881 \text{ inches}$$

The ultimate shear strength of the weld/forging interface is:

$$F_u = (A_w)(0.42S_u)$$
$$= 2{,}335{,}539 \text{ lb}$$

where:

$$S_u = \text{ultimate strength of the forging}$$
$$= 63{,}800 \text{ psi}$$

$$A_w = (2p)(5.881)(2.028) + (p)(5.375^2 - 5.0^2)$$
$$= 87.16 \text{ in}^2$$

The maximum ultimate shear capacities are summarized below:

	Capacity
Lifting Trunnion Shaft	1,347,095 lb
Weld/trunnion interface	2,111,150 lb
Weld/forging interface	2,335,539 lb

Thus, the lifting trunnion shank will fail in shear before the weld or the forging, ensuring that failure caused by excessive overload on the lifting trunnions will not impair the ability of the cask to meet the other requirements of 10 CFR 71.

2.5.1.2 Lid Lifting Device

The inner lid and the outer lid of the NAC-STC will each be lifted using a wire-rope sling that is load-rated for not less than the weight of each individual lid. The sling will be attached to each of the lids using hoist-eyes that are threaded into four equidistant holes in the lids. These holes will be clearly marked by engraved black painted letters on the top surface of each lid. The four slings will attach to a strongback at two points, centered 22.5 inches apart, two slings at each point.

2.5.1.2.1 Outer Lid Lifting

The outer lid lifting system uses four 1-8 UNC threaded holes located on a 76.00 inch bolt circle. The four holes are equally spaced. Helical thread inserts are used to increase the wear endurance. The outer lid material is SA-705, Type 630, H1150, 17-4 PH stainless steel.

For purposes of this calculation, the outer lid weight (W_o) is 8,120 pounds. This weight is conservative with respect to the actual weight shown in Table 2.2.0-1.

From the requirements of 10 CFR 71.45(a), a load factor of 3 is used in the stress qualification of a lifting device:

$$P_y = (3.0)(W_o) = 24{,}360 \text{ lb}$$

The inclined angle (a_o) of the sling for an outer lid lifting condition is illustrated in Figure 2.5.1-3. The sling length is 68.0 inches. The vertical distance from the hoist eye to the strongback is 60.48 inches, for the outer lid.

$$\sin a_o = 60.48/68.00$$
$$a_o = 62.80 \text{ degrees}$$

The lifting force F_n, and its components F_x and F_y, on each sling, are calculated as:

$$F_y = P_y/4 = 6090 \text{ lb}$$
$$F_n = F_y/\sin a_o = 6847 \text{ lb}$$
$$F_x = (F_n)(\cos a_o) = 3130 \text{ lb}$$

(Outer Lid Thread Engagement Evaluation)

The outer lid material is SA-705 Type 630 forging material. Allowable shear stress = $0.577\ S_y$ = 56.0 ksi at 200°F, (Table 2.3.3-1). Shear area per length of engagement for a 1 1/8 – 8 UNC internal thread for use with a 1-8 UNC helical coil insert is determined as:

$$A_s = 3.1416\ N\ D_{smin}\ [1/(2N) + 0.57735\ (D_{smin} - E_{nmax})]$$
$$= 2.67\ in^2$$

(FED-STD-H28/2A, page 5)

where:

N = 8 threads per inch
D_{smin} = 1.1014 in (min. major diameter of external thread)
E_{nmax} = 1.0421 in (max. pitch diameter of internal thread)

The actual thread length is 1.54 inches, but the effective thread engagement length is conservatively take to be 1.25 inches. Therefore, the resultant shear stress and margin of safety for the outer lid is:

$$\tau = (F_y/(A_s)(\text{Effective Length}) = 6090/(2.67)(1.25) = 1825\ psi$$
$$M.S. = (0.577\ S_y/\tau) - 1 = (56{,}000/1825) - 1 = +\ \text{Large}$$

2.5.1.2.2 Inner Lid Lifting

The inner lid lifting system uses the same approach as the outer lid lifting system. The analysis considers four 1-8 UNC threaded holes located on a 70.41 inch bolt circle. The four holes are equally spaced. Helical thread inserts are used to increase the wear endurance. The inner lid material is Type 304 stainless steel ASME SA-336.

For purposes of this calculation, the inner lid weight (W_i) is 10,690 pounds. This weight is conservative with respect to the actual weight shown in Table 2.2.0-1.

From the requirements of 10 CFR 71.45(a), a load factor of 3 is used in the stress qualifications of a lifting device:

$$P_y = (3.0)(Wi)$$
$$= 32{,}070 \text{ lb}$$

The inclined angle (α_i) of the sling for an inner lid lifting condition is illustrated in Figure 2.5.1-4. The sling length is 68.0 inches. The vertical distance from the hoist eye to the strongback is 61.79 inches, for the inner lid.

$$\sin \alpha i = 61.79/68.00$$
$$\alpha i = 65.32 \text{ degrees}$$

The lifting force, F_n, and its components F_x and F_y, on each sling, are calcuated as:

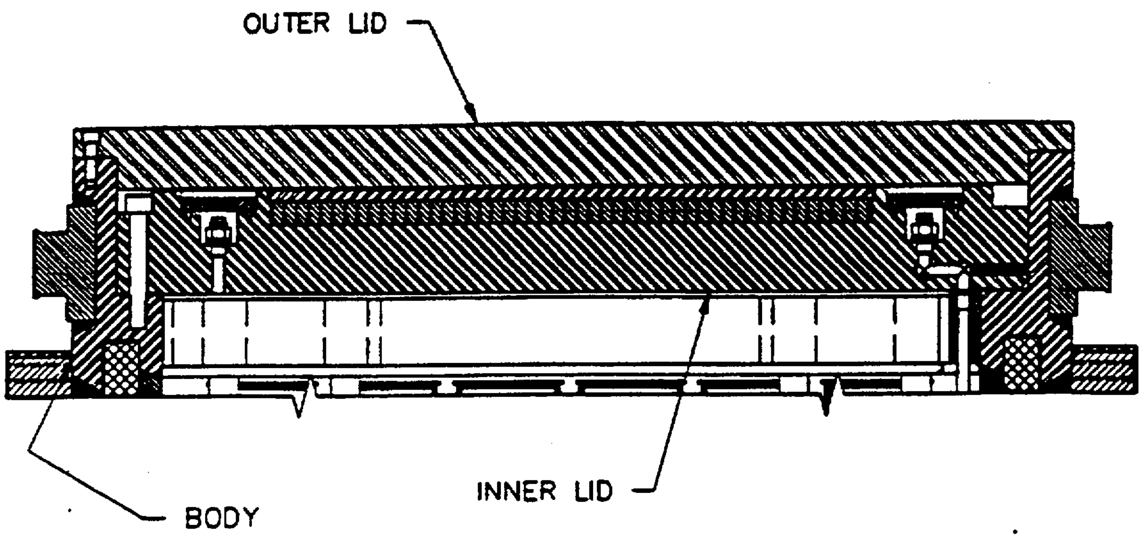
$$Fy = P_y/4 = 8017.5 \text{ lb}$$
$$Fn = F_y/\sin \alpha i = 8823.5 \text{ lb}$$
$$Fx = (F_n)(\cos \alpha i) = 3685 \text{ lb}$$

Hoist Eye Specifications – American Drill Brushing Company, Part 23106 or equivalent)

Thread: 1-8 UNC-2A x 1.54 long
Material: SA-540, Grade B22 Low Alloy Steel
S_y = $3S_m$ = 100.2 ksi at 200°F
A_t = 0.606 in^2
I = 0.0252 in^4
c = 0.4233 in

2.6.7.5 Closure Analysis - Normal Conditions of Transport

The main closure of the NAC-STC is effected by an assembly of a bolted inner lid and a bolted outer lid. The Type 304 stainless steel inner lid is bolted to the top forging by forty-two 1 1/2 - 8 UN bolts fabricated from SB-637, Grade N07718 nickel alloy bolting material and is sealed by two o-rings. The SA-705, Type 630, 17-4 PH stainless steel outer lid is bolted to the end of the top forging by thirty-six 1 - 8 UNC bolts fabricated from SA-564, Type 630, 17-4 PH stainless steel, and is sealed to the top forging by one o-ring.



Closure Assembly of NAC-STC Body and Lids

2.6.7.5.1 Closure Geometry

The main body of the inner lid is 9.0 inches thick and 79.0 inches in diameter. A 3.0-inch thick, 2.75-inch wide integral outer rim on the top of the inner lid encloses a 2.0-inch thick layer of NS-4-FR neutron shielding material and a 1.0-inch thick, Type 304 stainless steel coverplate. The inner lid provides the primary containment for the NAC-STC main closure.

The outer lid is a plate consisting of a 5.25-inch thick central body having a 79.08-inch diameter and a 2.50-inch thick integral outer flange having an outside diameter of 86.70 inches. There is a 0.06-inch gap between the inner lid and the outer lid.

2.6.7.5.2 Closure Analysis Considerations

The closure assembly analysis must demonstrate that the lids and bolts satisfy two criteria: (1) calculated maximum stresses must be less than the allowable stress limit (the material yield strength is conservatively selected) and (2) lid deformation and/or rotation at the o-ring locations must be less than the elastic rebound of the o-rings.

Finite element evaluations of the closure are performed using the ANSYS computer program and a two-dimensional axisymmetric model. The critical design load conditions for the NAC-STC closure are three 10 CFR 71 accident loading conditions: (1) impact limiter crush pressure on the outer lid; (2) pin puncture on the outer lid; and (3) impact of the cavity contents on the inner lid. These accident condition analyses are presented in Section 2.7.1.6. The lids and bolts are evaluated at a temperature of 200°F and 270°F, respectively. The impact stresses in the closure components for the normal conditions of transport 1-foot drop are calculated by ratioing the impact stresses calculated in Section 2.7.1.6 according to the g-loads documented in Table 2.6.7.4-3.

The package geometry, package weight, and contents weight are the parameters that control the closure design. This fact is demonstrated to be true by the analysis results in Tables 2.6.7.5-1, -2, -3, and -4, as well as Tables 2.7.1.6-2, -3, -4, and -5. The tables show that the inner lid and bolts (the containment boundary) are critical for end or "near end" impact load conditions and the outer lid bolts are critical for side or "near side" impact load conditions. The closure evaluation presented in this section is for the package (loaded NAC-STC cask with impact limiters as described on the drawings in Section 1.3.2) with a total weight of 250,000 pounds and a cavity contents weight of 56,000 pounds. This evaluation envelopes all of the NAC-STC cask configurations, i.e., the directly loaded fuel configuration, the canistered fuel configuration, and the canistered GTCC waste configuration. The package geometry is identical for all of the configurations, as is the package center of gravity location. The differences in the contents weight and the associated package weight for each of the contents configurations—56,000 pounds and 249,700 pounds for directly loaded fuel, 55,590 pounds and 249,290 pounds for the canistered fuel, and 54,271 pounds and 247,971 pounds for the canistered GTCC waste—have no significant effect on the closure design or performance. Therefore, the closure analyses in this section and in Sections 2.7.1.6, 2.7.3.4, and 2.10.8 are applicable for the directly loaded and the canistered configurations of the NAC-STC.

2.6.7.5.3 Closure Analysis Results

2.6.7.5.3.1 Description

The critical normal conditions of transport loading for the inner lid is the 1-foot top end drop. Since the 45.1 psig maximum internal operating pressure (Section 4.2.2.1) produces a minimal portion of the inner lid stress, approximately 1,500 psi (Table 2.10.4-1, Sections U, V, W, and X), the maximum inner lid primary membrane plus bending stress for the 1-foot top end drop is calculated by ratioing from the 30-foot top end drop result shown in Table 2.7.1.6-1 (Load Condition 1):

$$S_{IL} = (18{,}088)(19.6/56.1) = 6320 \text{ psi}$$

For the inner lid primary membrane plus primary bending stress ($P_m + P_b$) the allowable stress limit is 1.5 S_m, which for Type 304 stainless steel is 30.0 ksi at 200°F.

Then,

$$\text{M.S.} = \frac{1.5S_m}{S_{IL}} - 1 = \underline{+\text{Large}}$$

The critical normal conditions of transport loading for the outer lid is also the 1-foot top end drop. The outer lid is loaded on its outer surface by the crush pressure of the upper impact limiter. The maximum outer lid primary membrane plus bending stress for the 1-foot top end drop is calculated by ratioing from the 30-foot top end drop result shown in Table 2.7.1.6-1 (Load Condition 1):

$$S_{OL} = (19{,}647)(19.6/56.1) = 6864 \text{ psi}$$

For the outer lid primary membrane plus bending stress ($P_m + P_b$), the allowable stress limit is 1.5 S_m, which for Type 17-4 PH, H1150 stainless steel is 67.5 ksi at 200°F.

Then,

$$\text{M.S.} = \frac{1.5S_m}{S_{OL}} - 1 = \underline{+\text{Large}}$$

2.6.7.5.4 Lid Bolt Analysis - Normal Conditions of Transport

The NAC-STC inner and outer lid bolts are preloaded at installation to ensure that the sealing function of the o-rings located in the inner and in the outer lids are maintained. The lid bolts are installed with a torque that is calculated to produce a total tensile load that is not less than the total load on the lid; that is, the sum of: (1) internal pressure force on the lid; (2) o-ring compression force; (3) inertial weight of the lid (calculated weight multiplied by the impact load factor); and (4) inertial weight of any other components that can contact the lid (calculated weight multiplied by the impact load factor). Since the total bolt preload exceeds the total load on the lid, there is no movement of the lid relative to its mating component and the status of the seal at the o-ring(s) is maintained.

2.6.7.5.4.1 Inner Lid Bolts

The inner lid of the NAC-STC is bolted to the top forging of the cask body by forty-two 1 1/2 - 8 UN bolts that are fabricated from SB-637, Grade N07718 nickel alloy bolting material.

Since the coefficient of thermal expansion for the SB-637, Grade N07718 nickel alloy bolting material is lower than that of the Type 304 stainless steel inner lid, the inner lid expands faster than the bolts during normal transport heat-up, and the bolt preload increases. The differential thermal expansion between the inner lid and the bolts results in an increase in the bolt tensile stress of 9,128 psi is calculated below.

The required preload on the inner lid bolts considers the following factors: (1) an internal pressure force on the inner lid of 45.3 psig (60 psia); (2) the o-ring compression force due to the two metallic o-rings for the inner lid (which bounds the compression force for the non-metallic [EPDM and Viton] o-rings); (3) the inertial weight of the inner lid, basket, and fuel due to the 30-foot accident drop conditions; and (4) the differential thermal expansion between the inner lid material and the bolt. Based on the above considerations, an installation torque of 2540 ± 200 foot-pounds is conservatively selected for the inner lid bolts. The maximum torque value, 2,740 foot-pounds, develops a tensile force of 115,734 pounds based on the following relationship:

$$T = \left[\left(\frac{d_m}{2d}\right)\left(\frac{\tan\psi + \mu\sec\alpha}{1-\mu\tan\psi\sec\alpha}\right) + 0.625\mu\right](F)(d) \qquad \text{(Roehrich)}$$

Component	Ultimate Load Capacity (lbs)
Inner Lid Bolt	260,652
Bolt Thread	534,844
Insert I.D. Thread	833,430
Insert O.D. Thread	666,840
Top Forging Thread	283,868

M.S. = (283,868/260,652)- 1 = +0.09

Since the minimum Tensile Load Capacity of the threaded joint exceeds the maximum Tensile Load Capacity of the inner lid bolt, the design requirements are satisfied. The inner lid bolt threaded-joint design is satisfactory.

Using consistently conservative assumptions, the NAC-STC inner lid is shown to satisfy the performance and structural integrity requirements of 10 CFR 71.71(c)(7) for normal conditions of transport.

2.6.7.5.4.2 Outer Lid Bolts

The outer lid of the NAC-STC is bolted to the end of the top forging by thirty-six 1 - 8 UNC bolts that are fabricated from SA-564, Type 630, H1150, 17-4 PH stainless steel, which has mechanical properties that are identical to those of the material of the outer lid (SA-705, Type 630, H1150, 17-4 PH stainless steel). Thus, there is negligible differential thermal expansion between the outer lid bolts and the outer lid, since they are at essentially the same temperature and have the same mechanical properties.

The required preload on the outer lid bolts considers the following factors: (1) a conservative interlid pressure force on the outer lid of 7.35 psig (1.5 atm absolute) to provide operational flexibility; (2) the o-ring compression force due to the metallic o-ring located between the cask forging and the outer lid (which bounds the compression force for the non-metallic [EPDM and Viton] o-rings); and (3) the inertial weight of the outer lid and impact limiter, due to the 30-foot accident drop conditions, considering the impact limiter together with the outer lid for the 30-foot accident drop condition envelopes the transport conditions when the influence of the impact limiter is actually transmitted to the outer lid bolts. Based on these loading conditions for the outer lid bolts, an installation torque of 550 ± 50 foot-pounds is conservatively selected for the outer lid bolts. The maximum torque value, 600 foot-pounds, develops a tensile force of 37,171 pounds based on the following relationship:

$$T = \left[\left(\frac{d_m}{2d}\right)\left(\frac{\tan\psi + \mu\sec\alpha}{1-\mu\tan\psi\sec\partial}\right) + 0.625\mu\right](F_{bp})(d) \qquad \text{(Roehrich)}$$

where:

T = applied torque in inch-pounds
F_{bp} = preload force in pounds
d = bolt diameter = 1.00 in
d_m = mean diameter of thread = 0.9134 in
α = one-half the thread angle = 30°
μ = coefficient of friction = 0.15

$\tan\psi = 1 / (\pi\, d_m\, N)$

N = 8 threads per inch

Therefore, the bolt preload, F_{bp}, due to a 600 foot-pound torque for each outer lid bolt, is determined as:

$T = (0.1937)F_{bp}d$
$F_{bp} = (600)(12)/(0.1937)(1.0)$
$F_{bp} = 37{,}171$ lbs

The average tensile stress in the outer lid bolt is:

$S_t = F_{bp} / A_t$

$= 61{,}338$ psi

2.6.12.6 Stress Evaluation of Threaded Rods and Spacer Nuts for a 1-Foot End Drop Load Condition (Directly Loaded Fuel Configuration)

The deceleration for the NAC-STC for the normal conditions of transport 1-foot end drop is 19.6 g. During the 1-foot end drop, the threaded rods and spacer nuts in the directly loaded fuel configuration fuel basket are loaded with the weight of the 31 support disks, 20 aluminum heat transfer disks, one end plate and weights of the threaded rods and spacer nuts. These loads are calculated as follows:

Design weight of basket	=	17,000 lb
Less weight of bottom plate	=	-671 lb
Less weight of fuel tubes	=	-3,666 lb
1g load on the tie rods and spacer nuts	=	12,663 lb
Accident load on tie rods and spacer nuts	=	(12,663)(19.6)
	=	248,195 lb

The effective area of one threaded rod and spacer nut at each of the six locations supporting the weight of the support disks is equivalent to the gross area of the square spacer nut and is calculated as:

$$A = (2.5)(2.5)$$

$$= 6.25 \text{ in}^2$$

The average compressive stress in the threaded rods and spacer nuts is:

$$S_c = \frac{248{,}195}{(6)(6.25)}$$

$$= 6{,}619 \text{ psi}$$

The allowable stress of the 17-4 PH stainless steel under normal conditions of transport is S_m.

Then, the margin of safety is:

$$\text{M.S.} = \frac{S_m}{S_c} - 1 = +\text{Large}$$

where

S_m = 43.8 ksi (17-4 PH stainless steel at 405°F)

Therefore, the threaded rods and spacer nuts in the directly loaded fuel configuration of the fuel basket are structurally adequate for a 19.6 g end impact under normal conditions of transport.

The uniformly distributed internal pressure exerted by the spacer, the fuel assemblies and the basket on the inner lid is:

$$p = \frac{(56{,}350)(5.3)}{\frac{\pi}{4}(71)^2}$$

$$= 75.7 \text{ psi}$$

The finite element model with boundary conditions is shown in Figure 2.7.1.6-2.

2.7.1.6.2.3 Loading Condition 3: 30-Foot Top Corner Drop

During a 30-foot top corner drop, the cask (with its attached transport impact limiters) falls through a distance of 30 feet onto a flat, unyielding horizontal surface. As the corner of the impact limiter contacts the flat, unyielding surface, the cask body impacts on the inside diameter of the impact limiter and the cask cavity contents (spacer, basket and fuel assemblies) impact on the inside surface of the inner lid. The design deceleration of 55 g (actual impact load = 44.2 g, Table 2.6.7.4-2) acting on the cavity contents produces a pressure on the inner surface of the inner lid of:

$$p = \frac{56{,}350 \times 55}{(\pi)(35.50)^2}$$

$$= 785 \text{ psi}$$

Adding the contents pressure to the design internal pressure of 45 psig brings the total pressure on the inner lid to 830 psi. The bearing pressure of the impact limiter on the external surface of the outer lid and the outer lid are conservatively neglected. 847 psi internal pressure, representing 56.1 g is conservatively applied to the inner lid. The finite element model with boundary conditions is shown in Figure 2.7.1.6-3.

The 30-foot top corner drop for the directly loaded fuel configuration bounds the canistered fuel design, as the total contents weight is equal to, or less than, that of the directly loaded fuel configuration under all accident scenarios. Additionally, the canistered fuel configuration includes aluminum honeycomb spacers in the cask that provide additional fuel basket deceleration at impact.

2.7.1.6.3 Analysis Results

Based on the discussion presented for the canistered fuel configuration in Section 2.7.1.6.2, the results presented in this subsection for the NAC-STC directly loaded fuel configuration bound the canistered fuel configuration.

Table 2.7.1.6-1 provides a summary of the resulting stresses and deformations for the inner and outer lids as determined by the ANSYS finite element analyses for the three loading conditions defined in Section 2.7.1.6.2. Both the stress and the deformation/rotation limit criteria are satisfied for the inner and the outer lids.

The maximum calculated stress in the outer lid is 52,042 psi, which results in a minimum margin of safety of +0.87 when evaluated with respect to material yield strength for load condition 2, pin puncture on the outer lid. Note that this evaluation is very conservative and that when the outer lid stress results are compared to non-containment structural criteria for the maximum primary membrane stress of 24 ksi with allowable of $0.7S_u$ and the maximum primary membrane plus bending stress of 52 ksi with allowable of S_u, the respective margins of safety are 2.94 and 1.59. The maximum out-of-plane rotational movement of the outer lid is 0.001 inch for load condition 1, impact limiter crush pressure on the outer lid. This elastic deformation is less than the elastic rebound of the Type 321 stainless steel o-ring material (0.005 inches) and is less than the rebound of the EPDM or Viton o-rings (0.03 inches); therefore, the seal is maintained.

The maximum calculated von Mises stress in the inner lid is 22,284 psi, which results in a minimum margin of safety of +0.12 when evaluated with respect to the material yield strength for load condition 1, neglecting impact limiter crush pressure on the outer lid. Note that this evaluation is very conservative and that when the inner lid stress results are compared to containment structural criteria for the maximum primary membrane stress of 2 ksi with allowable 2.4 S_m and the maximum primary membrane plus bending stress of 18 ksi with allowable of S_u, the respective margins of safety are +24.0 and +2.66. The maximum out-of-plane rotational movement of the inner lid is 0.0053 inch for load condition 3, impact of the cavity contents on the inner lid. This rotational movement of 0.0053 inches is calculated for a loading condition that is 27 percent larger than the conservatively postulated loading from the corner drop

2.7.2.2.6 Analysis Results

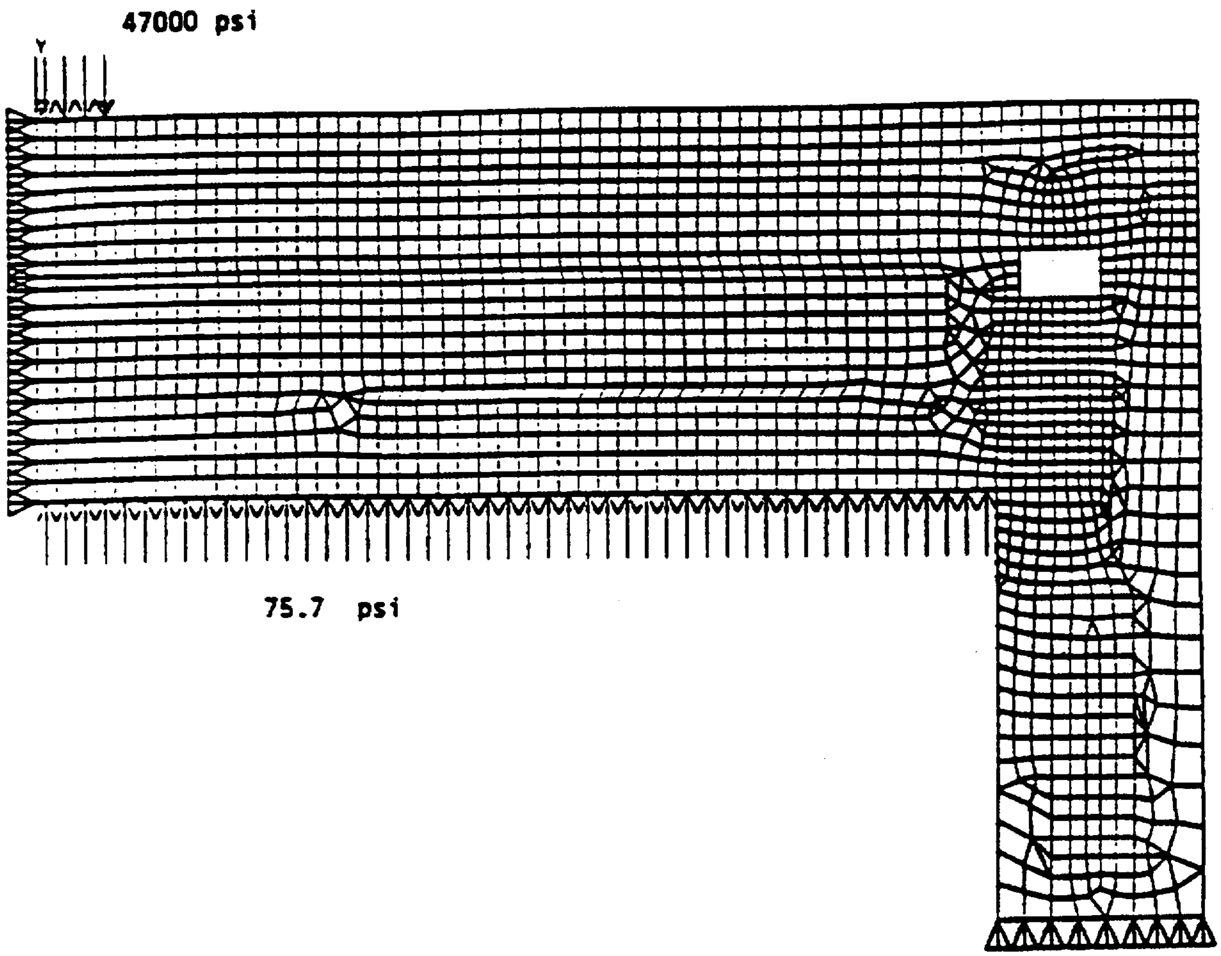
The ANSYS finite element analysis of the NAC-STC closure lids for the pin puncture loading produced the results as summarized in this section.

The maximum primary membrane plus bending calculated stress in the outer lid is 52,000 psi. The ultimate strength of the 17-4 PH stainless steel is 135 ksi at 200°F, providing a margin of safety of +1.59. The maximum gap at the location of the outer o-ring on the outer lid as a result of the out-of-plane rotation of the outer lid is 0.00016 inch. This elastic, short-duration deformation is less than the elastic rebound of the metallic o-ring material (0.005 inches) and is less than the elastic rebound of the non-metallic EPDM or Viton o-rings (0.03 inches); therefore, the seal is maintained.

The maximum primary membrane plus bending calculated stress in the inner lid is 12,000 psi. The ultimate strength of the Type 304 stainless steel is 66.2 ksi at 200°F, providing a margin of safety of +4.52. The maximum gap at the location of the o-rings on the inner lid as a result of the out-of-plane rotation of the edge of the inner lid is 0.00162 inch. This short duration, elastic deformation is less than the elastic rebound of the metallic o-ring material (0.005 inch) and is less than the elastic rebound of the non-metallic EPDM or Viton o-rings (0.03 inches); therefore, the seal is maintained.

The positive margins of safety on the stresses and the small displacements of the lids at the o-ring locations satisfy both stress and displacement/ rotation limit criteria for the lids. Therefore, the NAC-STC satisfies the requirements of 10 CFR 71 for consideration of puncture at the cask closure lids.

Figure 2.7.2.2-1 Finite Element Model - Lid Assembly - Pin Puncture



Minimum margin of safety for shear is

$$M.S. = \frac{(2)(0.42S_u)}{SI} - 1$$

$$= \frac{(2)(0.42)(126.7)}{50.58} - 1 = +1.1$$

Therefore, the structural adequacy of the NAC-STC fuel basket support disk design for the normal conditions of transport 30-foot side drop and 30-foot end drop is demonstrated.

2.7.8.1.3 Supplemental Data - Support Disk Analysis

2.7.8.1.3.1 Calculation of Pressure Loading

The impact pressure loading on the 26 PWR fuel assembly basket in the side drop condition is calculated based on a fuel assembly weight of 1,525 lbs. This weight is conservative with respect to the maximum weight of 1,500 lbs, shown in Table 2.2.0-1.

The weight per unit length (W/L) of the fuel assembly is:

L = Length of fuel = 159.20 in
W = Weight of one fuel assembly = 1,525 lb
W/L = Unit weight = 1525/159.20 = 9.579 lb/in

The weight (W_c) of the tube per linear inch is:

W_{tube} = 141 lb
L_{tube} = 154.7 in

$$W_c = \frac{141}{154.7}$$

$$\doteq 0.911 \text{ lb/in}$$

The fuel assembly plus fuel tube weight per linear inch is:

9.579 + 0.911 = 10.490 lb/in

Distributing the combined weight as a pressure load considering a 4.88-inch spacing between two adjacent support disks and a 55-g load factor:

$$P = \frac{(10.490)(4.88)(55)}{(9.234)(0.5)} = 609.8 \text{ psi}$$

For the 0-degree drop use:

$$P_x = 609.8 \text{ psi}$$

For a 90-degree drop use:

$$P_y = 609.8 \text{ psi}$$

For a q-degree drop use:

$$P_x = (609.8)(\text{Cos } q)$$

$$P_y = (609.8)(\text{Sin } q)$$

2.7.8.1.3.2 Calculation of Lump Masses of the Aluminum Heat Transfer Disk and the Six Threaded Rods and Spacers

The masses of the aluminum heat transfer disk and the six threaded rods and spacer nuts are lumped into the finite element model at the threaded rod locations on the support disk for both the 18.1 g and 55 g side drop analyses. The lump masses applied to the model through ANSYS pointwise generalized mass element (STIF21) is 0.0613 pounds mass.

2.7.8.1.3.3 Verification of Impact Load Applied on the ANSYS Model

The total impact pressure applied on the model is verified by comparing the reaction forces from the ANSYS results versus the hand-calculated method. The 90-degree side drop evaluation is used as an example.

2.7.8.2 Stress Evaluation of Threaded Rods and Spacer Nuts - Accident Condition

In accordance with 10 CFR 71.73(c)(1), a spent-fuel shipping cask is subject to a free drop from a height of 30 feet onto a flat, unyielding surface. The design deceleration for the NAC-STC for the hypothetical accident 30-foot end drop is 56.1 g (Table 2.6.7.4-2).

For a bottom end drop, the threaded rods and spacer nuts are loaded with the weight of the 31 support disks, the top plate, the 20 aluminum heat transfer disks, and the weights of the threaded rods and spacer nuts. These loads are calculated as follows:

Design weight of basket	=	17,000 lb
Less weight of bottom plate	=	-671 lb
Less weight of fuel tubes	=	-3,666 lb
1g load on the tie rods and spacer nuts	=	12,663 lb
Accident load on tie rods and spacer nuts	=	(12,663)(56.1)
	=	710,394 lb

The effective area of one threaded rod and spacer nut at each of the six locations supporting the weight of the support disks is equivalent to the gross area of the square spacer nut and is calculated as:

$$A = (2.5)(2.5)$$

$$= 6.25 \text{ in}^2$$

The average compressive stress in the threaded rods and spacer nuts is:

$$S_c = \frac{710,394}{(6)(6.25)}$$

$$= 18,944 \text{ psi}$$

Then, the margin of safety is:

$$M.S. = \frac{0.7\,S_u}{S_c} - 1 = +3.86$$

where

S_u = 131.43 ksi (17-4 PH stainless steel at 405°F)

Therefore, the threaded rods and spacer nuts are structurally adequate for a 56.1 g end impact.

2.7.8.3.2 Assessment of Buckling of the 17-4 PH Threaded Rods

2.7.8.3.2.1 Maximum Compressive Load

The maximum compressive load applied to the threaded rods are during the 30 foot (9 meter) end drop, which corresponds to a maximum deceleration of 56.1 g's.

During the end impact, the weight of the support disks, aluminum heat transfer disks, are transferred to the threaded rods. The forces due to the weight of the fuel assemblies is transmitted directly to the end plate of the cask cavity.

The threaded rods transferring the load can be represented as a direct stress (i.e., uniaxial stress). This characterization categorizes the rod as a linear support (Section NF-3300).

To address the accident condition, Section NF-3340 can be applied which uses limit analyses to establish allowable loads acting on the support disks. Since out of plane loading is not present, the governing conditions are detailed in equation (5) of Section NF-3342.2, which specifies the allowable compressive force (P_{cr}).

$$P_{cr} = 1.7 \, A \, F_a$$

The maximum force ($P_{max} \leq P_{cr}$) transmitted to a threaded rod is based on the weight of the basket less the weight of the fuel tubes and the bottom weldment (The bottom weldment weighs 671 pounds, while the fuel tubes weigh 3,666 pounds). The total weight transmitted by the six rods is 12,663 pounds.

The design of the basket is not sufficiently symmetrical to distribute the loading to the threaded rods in an equal fashion. To determine the distribution of the loads to the threaded rods in an end drop orientation, a finite element model of a single support disk was generated. The model of the entire disk shown in Figure 2.7.8.3-1, uses the ANSYS plate element (STIF63). The material properties for 17-4 PH employed in the model corresponds to the maximum basket temperature at 500°F. While the temperature does vary throughout the basket, the effect on the variation of the modulus of elasticity and the corresponding effect on the load distribution to the rods is considered to be insignificant.

The support of the threaded rod is simulated by restraining the out of plane degree of freedom at the centerline of the location of the threaded rod connection with the support disk. A 1g load was applied to the elements comprising the support disk. The nodal reactions were used to determine the load distribution to the threaded rods. The four threaded rods at location A in Figure 2.7.8.3-1 have the same reaction value and carry 74.5% of the weight of the support disk, 18.6% per rod. The remaining two threaded rods, which are also of equal value carry 25.5% of the weight of the disk, 12.8% per rod. The limiting load for the threaded rod is 18.6% of the weight of the support disk.

The maximum load to be considered for the threaded rod is 12,663 pounds amplified by 56.1 g and factored by 0.186, or P_{max} = 132.13 kips.

The axial compressive stress permitted in the threaded rod, F_a, is computed in the same manner as in Section 2.7.8.3.1. In the section of the threaded rod experiencing the maximum compressive load, the span is considered as a simple span configuration and the length corresponds to the centerline to centerline distance between the support disks. The simple span condition requires the effective length factor, K, to equal 1.0 (AISC Steel Construction Code, Eighth Edition). Using the minor diameter to compute the radius of gyration, $Kl/r = 13.279 < C_c$. Using C_c = 75.70, F_a is determined to be 52.87 ksi and P_{cr} is 152.79 kips.

The margin of safety for equation (5) of NF-3342.2 is:

$$M.S. = (154.58/132.13) - 1 = \underline{+0.17}$$

2.7.8.3.2.2 Maximum Combined Axial and Bending Loads

In drop orientations other than the end drop, the aluminum heat transfer disks, which are supported by the threaded rods, will exert a lateral component on the threaded rods. This will induce bending moment into the threaded rod. It is assumed that the entire weight of one aluminum heat transfer disk will be carried by a single threaded rod carrying the maximum compressive load. This is conservative since the location of the closest aluminum fin to the