March 2015

NAC-LWT

Legal Weight Truck Cask System

LWT-15B HEUNL Changes Initial Submittal

NON-PROPRIETARY VERSION

Docket No. 71-9225

NAC INTERNATIONAL

Atlanta Corporate Headquarters: 3930 East Jones Bridge Road, Norcross, Georgia 30092 USA
Phone 770-447-1144, Fax 770-447-1797, www.nacintl.com

Attachment:
Attachment 1 – NAC International Affidavit Pursuant to 10 CFR 2.390

Enclosures:
Enclosure 1 – No. 71-9225 for NAC-LWT Cask List of SAR Changes NAC-LWT SAR, Revision LWT-15B HEUNL Changes Amendment
Enclosure 2 – No. 71-9225 for NAC-LWT Cask List of Drawing Changes NAC-LWT SAR, Revision LWT-15B HEUNL Changes Amendment
Enclosure 3 – No. 71-9225 for NAC-LWT Cask Proposed Changes for Revision 61 of Certificate of Compliance NAC-LWT SAR, Revision LWT-15B HEUNL Changes Amendment
Enclosure 4 – No. 71-9225 for NAC-LWT Cask List of Calculations NAC-LWT SAR, Revision LWT-15B HEUNL Changes Amendment
Enclosure 5 – No. 71-9225 for NAC-LWT Cask LOEP and SAR Page Changes NAC-LWT SAR, Revision LWT-15B HEUNL Changes Amendment

NAC INTERNATIONAL

ATTACHMENT 1

NAC International Affidavit Pursuant to 10 CFR 2.390

NAC INTERNATIONAL
AFFIDAVIT PURSUANT TO 10 CFR 2.390

George Carver (Affiant), VP Engineering and Licensing, NAC International, hereinafter referred to as NAC, at 3930 East Jones Bridge Road, Norcross, Georgia 30092, being duly sworn, deposes and says that:

1. Affiant has reviewed the information described in Item 2 and is personally familiar with the trade secrets and privileged information contained therein, and is authorized to request its withholding.

2. The information to be withheld includes the following NAC Proprietary Information that is being provided to support the technical review of NAC's Request for a Certificate of Compliance (CoC) (No. 9225) for the NAC-LWT Package.

   - NAC Proprietary Calculation
     - 65008500-2010, Revision 4 and Data Disk 1 of 1
   - NAC-LWT SAR, Revision 15B, - Proprietary Version

   NAC is the owner of the information contained in the above documents. Thus, all of the above identified information is considered NAC Proprietary Information.

3. NAC makes this application for withholding of proprietary information based upon the exemption from disclosure set forth in: the Freedom of Information Act ("FOIA"); 5 USC Sec. 552(b)(4) and the Trade Secrets Act; 18 USC Sec. 1905; and NRC Regulations 10 CFR Part 9.17(a)(4), 2.390(a)(4), and 2.390(b)(1) for "trade secrets and commercial financial information obtained from a person, and privileged or confidential" (Exemption 4). The information for which exemption from disclosure is herein sought is all "confidential commercial information," and some portions may also qualify under the narrower definition of "trade secret," within the meanings assigned to those terms for purposes of FOIA Exemption 4.

4. Examples of categories of information that fit into the definition of proprietary information are:

   a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by competitors of NAC, without license from NAC, constitutes a competitive economic advantage over other companies.

   b. Information that, if used by a competitor, would reduce their expenditure of resources or improve their competitive position in the design, manufacture, shipment, installation, assurance of quality or licensing of a similar product.

   c. Information that reveals cost or price information, production capacities, budget levels or commercial strategies of NAC, its customers, or its suppliers.

d. Information that reveals aspects of past, present or future NAC customer-funded development plans and programs of potential commercial value to NAC.

e. Information that discloses patentable subject matter for which it may be desirable to obtain patent protection.

The information that is sought to be withheld is considered to be proprietary for the reasons set forth in Items 4.a, 4.b, and 4.d.

5. The information to be withheld is being transmitted to the NRC in confidence.

6. The information sought to be withheld, including that compiled from many sources, is of a sort customarily held in confidence by NAC, and is, in fact, so held. This information has, to the best of my knowledge and belief, consistently been held in confidence by NAC. No public disclosure has been made, and it is not available in public sources. All disclosures to third parties, including any required transmittals to the NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements, which provide for maintenance of the information in confidence. Its initial designation as proprietary information and the subsequent steps taken to prevent its unauthorized disclosure are as set forth in Items 7 and 8 following.

7. Initial approval of proprietary treatment of a document/information is made by the Vice President, Engineering, the Project Manager, the Licensing Specialist, or the Director, Licensing – the persons most likely to know the value and sensitivity of the information in relation to industry knowledge. Access to proprietary documents within NAC is limited via "controlled distribution" to individuals on a "need to know" basis. The procedure for external release of NAC proprietary documents typically requires the approval of the Project Manager based on a review of the documents for technical content, competitive effect and accuracy of the proprietary designation. Disclosures of proprietary documents outside of NAC are limited to regulatory agencies, customers and potential customers and their agents, suppliers, licensees and contractors with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

8. NAC has invested a significant amount of time and money in the research, development, engineering and analytical costs to develop the information that is sought to be withheld as proprietary. This information is considered to be proprietary because it contains detailed descriptions of analytical approaches, methodologies, technical data and/or evaluation results not available elsewhere. The precise value of the expertise required to develop the proprietary information is difficult to quantify, but it is clearly substantial.

9. Public disclosure of the information to be withheld is likely to cause substantial harm to the competitive position of NAC, as the owner of the information, and reduce or eliminate the availability of profit-making opportunities. The proprietary information

is part of NAC's comprehensive spent fuel storage and transport technology base, and its commercial value extends beyond the original development cost to include the development of the expertise to determine and apply the appropriate evaluation process. The value of this proprietary information and the competitive advantage that it provides to NAC would be lost if the information were disclosed to the public. Making such information available to other parties, including competitors, without their having to make similar investments of time, labor and money would provide competitors with an unfair advantage and deprive NAC of the opportunity to seek an adequate return on its large investment.

NAC INTERNATIONAL
AFFIDAVIT PURSUANT TO 10 CFR 2.390

STATE OF GEORGIA, COUNTY OF GWINNETT

Mr. George Carver, being duly sworn, deposes and says:

That he has read the foregoing affidavit and the matters stated herein are true and correct to the best of his knowledge, information and belief.

Executed at Norcross, Georgia, this 30th day of March, 2015.

George Carver
VP, Engineering and Licensing
NAC International

Subscribed and sworn before me this 30th day of March, 2015.

Deborah R Chapman
Notary Public

DEBORAH R CHAPMAN NOTARY PUBLIC GWINNETT COUNTY, GEORGIA MY COMMISSION EXPIRES 02-27-2017

Enclosure 1

No. 71-9225 for NAC-LWT Cask

List of SAR Changes

NAC-LWT SAR, Revision LWT-15B

HEUNL Changes Amendment

List of SAR Changes, NAC-LWT SAR, Revision LWT-15B

Note: The List of Effective Pages and the Chapter Tables of Contents, including the List of Figures and the List of Tables, were revised as needed to incorporate the following changes.

Chapter 1

- Page 1-v, Modified List of Drawings for updated revisions to three drawings.

Chapter 2

- Page 2.2.1-2, modified numbers at the bottom of Table 2.2.1-1 for HEUNL.
- Page 2.2.1-4, modified numbers near the bottom of Table 2.2.1-2 for HEUNL.
- Page 2.6.12-125, modified the last paragraph in Section 2.6.12.15.
- Page 2.6.12-128, modified the title of Figure 2.6.12-14 and replaced the figure.
- Page 2.6.12-131, modified the text in the sixth and seventh paragraphs.
- Page 2.6.12-132, modified the text throughout.
- Page 2.6.12-133, modified the text in the first and second paragraphs.
- Page 2.6.12-135, modified the text in the third paragraph, under subheading "Bolt Stresses;" modified the text in the fourth paragraph, under subheading "Thread shear stress."
- Page 2.6.12-136, modified the text in the third paragraph, under subheading "Bolt Stresses;" modified the text in the fourth paragraph, under subheading "Thread shear stress."
- Page 2.6.12-137, modified the text in Section 2.6.12.16, "Conclusion."
- Page 2.7.7-99, modified text near the end of the last paragraph on the page in Section 2.7.7.17.2.
- Pages 2.7.7-100 thru 2.7.7-101, modified the text throughout.
- Page 2.7.7-102, modified the text near the bottom of the page under subheading, "Thread shear stress."

Chapter 3

- No changes

Chapter 4

- No changes

Chapter 5

- No changes

List of SAR Changes, NAC-LWT SAR, Revision LWT-15B

Chapter 6

- No changes

Chapter 6 Appendices

- No changes

Chapter 7

- No changes

Chapter 8

- No changes

Chapter 9

- No changes

Enclosure 2

No. 71-9225 for NAC-LWT Cask

List of Drawing Changes

NAC-LWT SAR, Revision LWT-15B

HEUNL Changes Amendment

List of Drawing Changes, NAC-LWT SAR, Revision LWT-15B

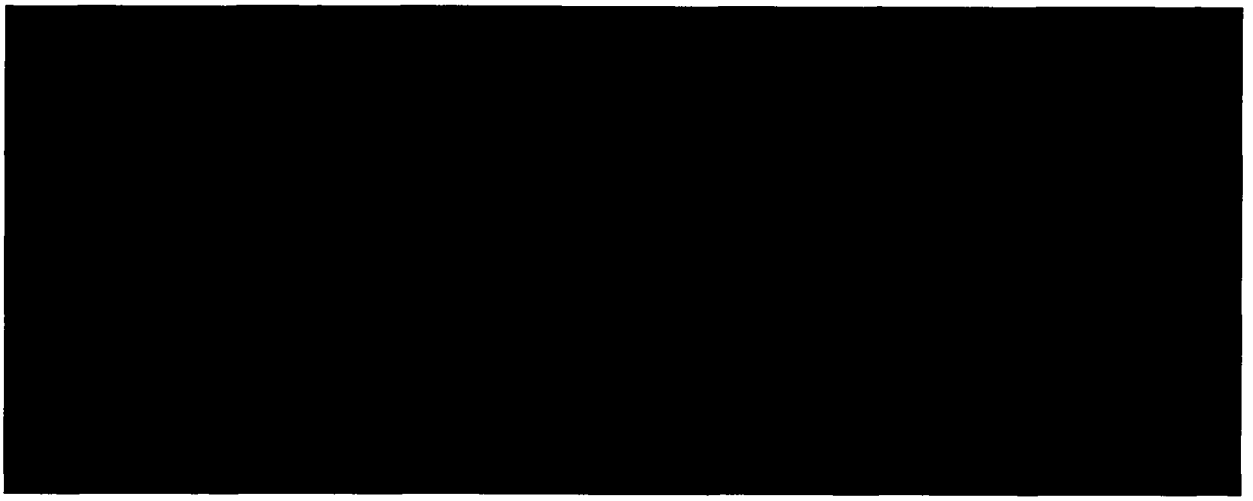
Drawing 315-40-180, Revision 4P

Drawing 315-40-181, Revision 6P

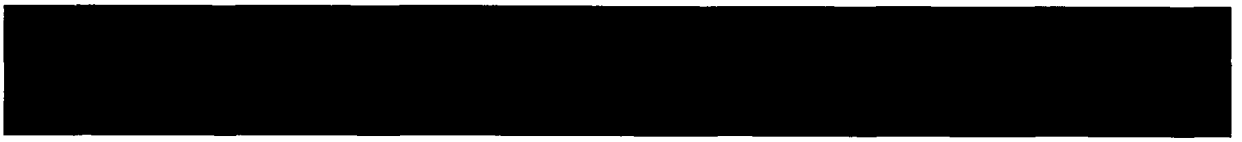
Sheet 1:

Drawing 315-40-182, Revision 3P

Sheet 1:



Add Sheet 2:



Enclosure 3

No. 71-9225 for NAC-LWT Cask

Proposed Changes for Revision 61 of Certificate of Compliance

NAC-LWT SAR, Revision LWT-15B

HEUNL Changes Amendment

Drawings (revised)

CoC Page 4 of 32:

LWT 315-40-180, Rev. 4P	LWT Transport Cask Assembly, HEUNL Contents
LWT 315-40-181, Rev. 6P (Sheets 1 – 2)	Container Assembly, HEUNL
LWT 315-40-182, Rev. 3P (Sheets 1 – 2)	Container Spacer, HEUNL

Enclosure 4

No. 71-9225 for NAC-LWT Cask

List of Calculations

NAC-LWT SAR, Revision LWT-15B

HEUNL Changes Amendment

List of Calculations, NAC-LWT SAR, Revision LWT-15B

Enclosure 4 Contents:

1. Calculation 65008500-2010, "Canister Structural Evaluations for HEUNL in the NAC-LWT", Revision 4

NAC Calculation 65008500-2010, Rev. 4
Withheld In Its Entirety Per 10 CFR 2.390

Enclosure 5

No. 71-9225 for NAC-LWT Cask

LOEP and SAR Page Changes

NAC-LWT SAR, Revision LWT-15B

HEUNL Changes Amendment

March 2015

Revision LWT-15B

NAC-LWT

Legal Weight Truck Cask System

SAFETY ANALYSIS REPORT

Volume 1 of 3

NON-PROPRIETARY VERSION

Docket No. 71-9225

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LIST OF EFFECTIVE PAGES

LIST OF EFFECTIVE PAGES (Continued)

LIST OF EFFECTIVE PAGES (Continued)

LIST OF EFFECTIVE PAGES (Continued)

List of Drawings (continued)

315-40-180		Rev 4P Rev 0NP	LWT Transport Cask Assembly, HEUNL Contents
315-40-181	Sheets 1 - 2	Rev 6P Rev 0NP	Container Assembly, HEUNL
315-40-182	Sheets 1 - 2	Rev 3P Rev 0NP	Container Spacer, HEUNL
315-40-183		Rev 1P Rev 0NP	Container Guide, HEUNL

NAC License Drawings
Withheld In Their Entirety Per 10 CFR 2.390

March 2015

Revision LWT-15B

NAC-LWT

Legal Weight Truck Cask System

SAFETY ANALYSIS REPORT

Volume 2 of 3

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LIST OF EFFECTIVE PAGES

LIST OF EFFECTIVE PAGES (Continued)

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LIST OF EFFECTIVE PAGES (Continued)

List of Figures

List of Figures (continued)

2.2 Weights and Centers of Gravity

2.2.1 Major Component Statistics

The weights of the major components of the NAC-LWT cask and their respective centers of gravity are presented in Table 2.2.1-1. The axial location of the center of gravity is measured from the bottom surface of the cask body. The center of gravity is always on the longitudinal centerline of the cask because the cask is essentially axisymmetric about that axis. The center of gravity location of the fuel is representative of typical fuel configurations.

The weights and centers of gravity of the cask package in eight different shipping configurations are presented in Table 2.2.1-2. In each case, the center of gravity is measured from the bottom surface of the cask body. The term "loaded" refers to the presence of fuel or other radioactive materials in the cask cavity; the term "empty" implies the absence of any fuel or other radioactive materials in the cask cavity. However, the fuel basket does remain in the cask cavity for the "empty" configuration. The weight of a lifting yoke is not included in the tabulated package weights.

All of the values tabulated in Table 2.2.1-1 and Table 2.2.1-2 are calculated to the nearest pound to obtain an accurate cask weight and center of gravity. The cask package weight and center of gravity used in the analyses of this report are the design values - 52,000 pounds and 98.93 inches. A design value of 4,000 pounds is conservatively used for the total weight of the cask contents (including the appropriate basket).

Table 2.2.1-1 Weights of the NAC-LWT Cask Major Components

Component	Weight (pounds)	Axial Center of Gravity Location (inches)
Cask Body	39,906	96.46
Closure Lid and Bolts	941	195.11
Impact Limiters		
Top	1,535	202.98
Bottom	1,320	-3.18
Shield Tank Fluid	3,506	96.26
PWR Fuel Basket and Spacer	874	100.98
PWR High Burnup Rod Payload	1,620	95.33
PWR Fuel Payload (Maximum)	3,126	96.63
BWR Fuel Basket	1,124	97.88
BWR Fuel Payload	1,500	97.88
Metallic Fuel Basket	128	96.40
Metallic Fuel Payload	2,080	96.40
MTR Four Unit Basket	982	96.20
MTR Four Unit Fuel Payload	840[1]	96.20
MTR Four Unit PULSTAR Fuel Payload	2,240[2]	96.20
MTR Five Unit Basket	1,015	96.20
MTR Five Unit Fuel Payload	1,050[1]	96.20
MTR Six Unit Basket	1,002	96.20
MTR Six Unit Fuel Payload	1,260[1]	96.20
GA IFM Basket and Spacer	818	98.06
GA IFM Fuel Payload	148	167.34
TPBAR Basket and Spacer	675	110.40
TPBAR Payload	978[3]	96.00
ANSTO Basket	911	100.95
ANSTO Payload	756	100.95
TPBAR Basket	575	97.43
TPBAR with Rod Transport Canister Payload	1,326[4]	102.26
SLOWPOKE Four Unit Basket	982	96.20
SLOWPOKE Fuel Payload	840[5]	96.20
NRU/NRX Basket & Spacer	845	113.03
NRU/NRX Basket + Spacer + Fuel	1205[6]	116.34
HEUNL Container & Spacer[7]	1,446	104
HEUNL Payload	704	98

[1] For conservatism, a design basis MTR fuel weight of 30 lbs/assy is used in the structural analysis. The maximum MTR element weight is 13.2 lbs for an intact element and 9.7 lbs for the cut elements in the 42-element configuration. The maximum weight for the SLOWPOKE canister is 25 pounds.

[2] For conservatism, a bounding weight of 80 pounds is considered for each of the 28 fuel cells for PULSTAR fuel.

[3] TPBAR payload represents the combined weight of the TPBAR and consolidation canister. A conservative 1.000 lb weight is applied in the structural analysis.

[4] TPBAR with Rod Transport Canister payload represents the combined weight of the 25 TPBARs, the PWR /BWR Rod Transport Canister and the PWR insert.

[5] A fuel weight of 30 lbs/assembly is used to compute the weight for this table as compared to the maximum weight for the SLOWPOKE canister of 25 pounds.

[6] Each fuel tube in the NRU/NRX basket is limited to 20 pounds of fuel and aluminum caddy.

[7] Includes 4 HEUNL Containers, Container Guide and Container Spacer.

Table 2.2.1-2 Weights and Center of Gravity Locations for the NAC-LWT Cask Shipping Configurations

Component	Weight (pounds)	Axial Center of Gravity Location (inches)
Package -Loaded for Shipment (PWR) Maximum Payload	51,208	98.96
Package – Loaded for Shipment PWR High Burnup Rods	49,702	99.0
Package - Empty for Shipment (PWR)	48,082	99.12
Package - Loaded for Shipment (BWR)	49,832	99.00
Package - Empty for Shipment (BWR)	48,332	99.07
Package - Loaded for Shipment* (Metallic Fuel)	45,910	98.88
Package - Empty for Shipment* (Metallic Fuel)	43,830	99.09
Package - Loaded for Shipment (PULSTAR Fuel, MTR Four Unit Basket)	50,430	99.1
Package - Loaded for Shipment (MTR Fuel, Four Unit Basket)	49,030	99.1
Package - Empty for Shipment (MTR Fuel, Four Unit Basket)	48,190	98.9
Package - Loaded for Shipment (MTR Fuel, Five Unit Basket)	49,273	99.1
Package - Empty for Shipment (MTR Fuel, Five Unit Basket)	48,223	98.9
Package - Loaded for Shipment (MTR Fuel, Six Unit Basket)	49,470	99.1
Package - Empty for Shipment (MTR Fuel, Six Unit Basket)	48,210	98.9
Package - Loaded for Shipment (GA IFM Fuel and Basket)	48,147	99.3
Package - Empty for Shipment (GA IFM Basket)	48,026	99.3
Package – Loaded for Shipment (TPBARs and Basket)	48,861	99.2
Package – Empty for Shipment (TPBAR Basket)	47, 883	99.2
Package - Loaded for Shipment (ANSTO Fuel and Basket)	48,875	99.2
Package - Empty for Shipment (ANSTO Basket)	48,119	99.1

* Neutron Shield Tank is empty.

Table 2.2.1-2 Weights and Center of Gravity Locations for the NAC-LWT Cask Shipping Configurations (cont'd)

Component	Weight (pounds)	Axial Center of Gravity Location (inches)
Package - Loaded for Shipment TPBARs in the PWR/BWR Rod Transport Canister	49,109	99.2
Package - Empty for Shipment (TPBAR Basket for PWR/BWR Rod Transport Canister)	47,783	99.1
Package - Loaded for Shipment (SLOWPOKE Fuel, Four Unit Basket)[1]	49,030	99.1
Package - Empty for Shipment (SLOWOKE Fuel, Four Unit Basket)	48,190	98.9
Package – Loaded for Shipment (NRU/NRX Basket with Fuel Assemblies)	41,111	97.0
Package – Empty for Shipment (NRU/NRX Basket)	40,751	96.8
Package – Empty for Shipment (HEUNL)	48,656	99.2
Package – Loaded for Shipment (HEUNL)	49,360	99.2
Package - Design for Shipment	52,000	98.93

[1] A fuel weight of 30 lbs/assembly is used to compute the weight for this table as compared to the maximum weight for the SLOWPOKE canister of 25 pounds.

2.6.12.15 HEUNL Container

There will be a total of 4 HEUNL containers in the LWT cask. A support spacer will be located at the bottom of the LWT cask between the bottom container and the bottom forging of the LWT cask. The HEUNL containers and the support ring are structurally evaluated with a combination of standard handbook formulas and finite element models.

The weight of each container is 350 lbs and the weight of the HEUNL fluid was calculated to be 176 lbs which gives a total of 526 lbs. A partially filled container would weigh less but it is conservative to use the weight of a fully filled container.

2.6.12.15.1 Finite Element Models

HEUNL Container FEA Model

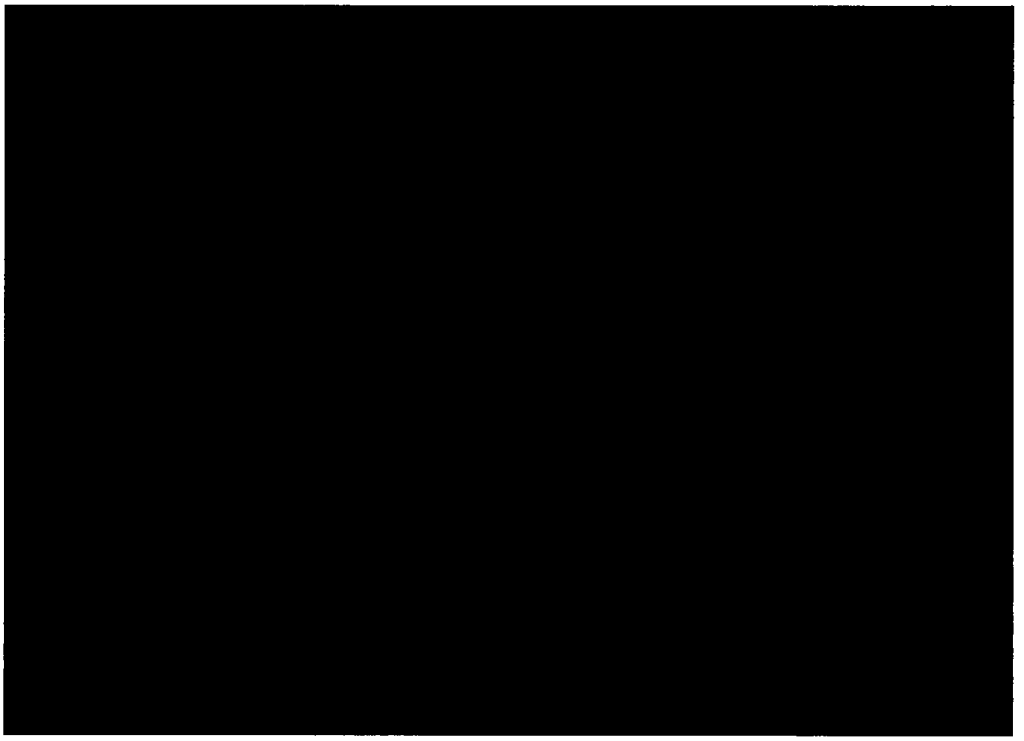
The finite element model (FEA) was constructed of ANSYS SOLID45 3D elements and CONTAC52 gap elements. Both the HEUNL container and contained fluid were modeled. There

are CONTAC52 elements between the outside surface of the fluid region and the inner surface of the container to model the compression only loading by the liquid. For the side drop case, CONTAC52 elements were added to the outer surface of the guide rails to determine the load distribution between the HEUNL container and the inner surface of the LWT cask. The HEUNL container FEA model is shown in the Figure 2.6.12-11 through Figure 2.6.12-13.

Figure 2.6.12-11 HEUNL Container – Outside View

Figure 2.6.12-12 HEUNL Container – Inside View

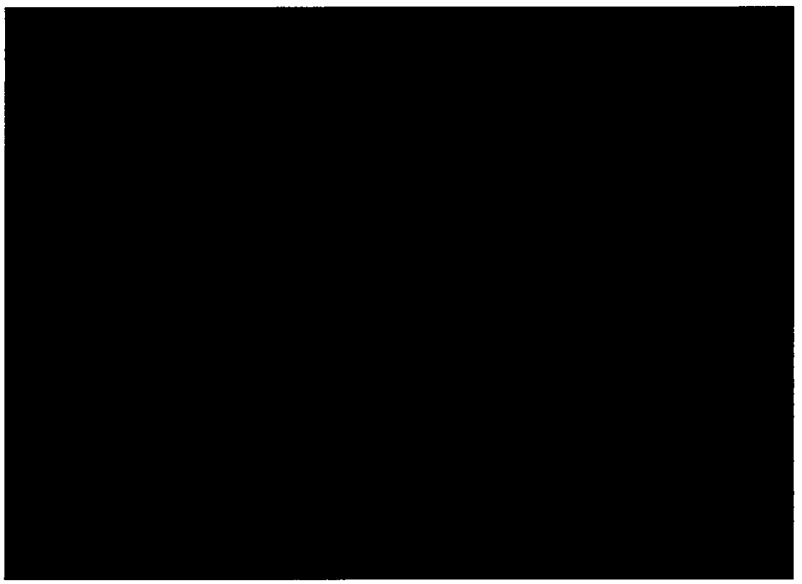
Figure 2.6.12-13 HEUNL Container – Gap Elements Shown



Support Ring Model

The support ring is a flat annular, machined ring. The support ring is constructed from SA-240, Type 304. An axisymmetric FEA model of the support ring was constructed for the bottom drop structural evaluation. Gap elements were placed at the bottom edge of the ring to account for possible lift-off of one edge. The support ring is not loaded significantly by the side drop or the top end drop. The FEA Model is shown in Figure 2.6.12-14. Vertical constraints were applied to the lower end of the gap elements and a pressure load was applied to the model top surface for the inertial load of the containers.

Figure 2.6.12-14 HEUNL Container Support Ring – Axisymmetric Model



Closure Assembly Model

The closure lid is a circular flat plate which is attached to the container head with six ½ inch-13 UNC cap screws. There are two O-rings under the closure lid for sealing purposes. A quarter symmetry model is used for the closure assembly. The closure lid, the O-rings, a portion of the container head and the liquid region are modeled with ANSYS SOLID45, 3D solid elements. The bolts are modeled with ANSYS BEAM4, 3D beam elements. The beam elements representing the bolts are connected to the 3D solid elements with a spider array of rigid, massless beam elements. The FEA model is shown in Figure 2.6.12-15 and 2.6.12-16.

Figure 2.6.12-15 Closure Assembly Model

Sections P6, P7 and P13 are not shown in the figures but are located at the center of the container shell half way between the bottom end cap and the top end cap.

The allowable stress S_m for SA-240, Type 304 at 200 °F is 20 ksi.

Design Pressure Case

As identified in Section 8.1.4.4 the canister is to be hydrostatically tested to 140 +10/-0 psig. This condition is treated as a normal condition, which bounds the maximum pressure expected during normal operational conditions identified in Section 4.5.6. A pressure case of 150 psig was evaluated. For this case a 30° sector of the 180° model was used and the liquid region of material was eliminated.

The maximum membrane stress intensity from the 14 section cuts was 3.24 ksi and the maximum membrane plus bending stress intensity was 4.83 ksi. For the Normal Conditions of Transport, the margin of safety is 4.67 for the membrane stress and 5.21 for the membrane plus bending stress.

1 Foot Side Drop

For the side drop each container rests against the inner shell of the LWT cask. The gap elements on the outside surface of the guide bars have two nodes. The outermost nodes are constrained in the radial, tangential and axial direction. This boundary condition represents the inner surface of the LWT cask as rigid, which is a conservative approach since this produces higher loads on the container guide rails.

For the side drop case an acceleration of 25 g is applied in the lateral (X) direction.

The maximum membrane stress intensity from the 14 section cuts was 2.58 ksi and the maximum membrane plus bending stress intensity was 4.77 ksi. For the Normal Conditions of Transport, the margin of safety is 6.75 for the membrane stress and 5.29 for the membrane plus bending stress. For additional details refer to item 1 in Section 2.6.12.15.5.

The bearing stress between the guide rail and the inner surface of the LWT cask was also computed. Assuming that the entire weight of the filled container is supported by one guide rail, the bearing stress is 0.332 ksi. This gives a margin of safety greater than 10. For additional details refer to item 1 in Section 2.6.12.15.5.

1 Foot Bottom End Drop

For the bottom end drop case an acceleration of 25 g is applied in the vertical (Z) direction. The lowest container rests on the spacer ring, which rests on the bottom forging of the LWT cask. The vertical acceleration accounts for the weight of the lowest container; however, the remaining 3 containers are stacked on the top of the lowest container. To account for the weight of the other

three containers an equivalent pressure load is applied to the top of the FEA model for the bottom container.

The maximum membrane stress intensity from the 14 section cuts was 4.44 ksi and the maximum membrane plus bending stress intensity was 6.52 ksi. Comparing this to the allowable stress gives a margin of safety of 3.50 for the membrane stress and 3.60 for the membrane plus bending stress. For additional details refer to item 1 in Section 2.6.12.15.5.

The bearing stress between the lowest container and the top surface of the support spacer was computed. The bearing stress is 5.82 ksi. This gives a margin of safety against the yield strength of 3.30. The bearing stress between the bottom of the support ring and the bottom of the LWT cask was also checked. This bearing stress is 2.0 ksi, which gives a margin of safety greater than 10. For additional details refer to item 1 in Section 2.6.12.15.5.

The container wall was also evaluated for potential buckling with a standard closed form solution. The calculated critical buckling stress calculated was 131 ksi. Compared to the calculated compressive stress in the container wall of 5.96 ksi, the margin of safety is greater than 10. For additional details refer to item 1 in Section 2.6.12.15.5.

The revised support ring FEA model was utilized to evaluate this case. The maximum membrane stress intensity calculated was 6.70 ksi and the maximum membrane plus bending stress intensity was 17.57 ksi. Comparing this to the allowable stress gives a margin of safety of 4.99 for the membrane stress and 0.71 for the membrane plus bending stress. For additional details refer to item 1 in Section 2.6.12.15.5.

1 Foot Top End Drop

For the top end drop case an acceleration of 25 g is applied in the vertical (-Z) direction. The topmost container rests on the closure lid of the LWT cask. The vertical acceleration accounts for the weight of the lowest container; however, the remaining 3 containers are stacked on the top of the lowest container. To account for the weight of the other three containers, an equivalent pressure load is applied to the bottom of the FEA model of the top container.

The maximum membrane stress intensity from the 14 section cuts is 5.01 ksi and the maximum membrane plus bending stress intensity is 5.96 ksi. Comparing this to the allowable stress gives a margin of safety of 2.99 for the membrane stress and 4.03 for the membrane plus bending stress. For additional details refer to item 1 in Section 2.6.12.15.5.

The bearing stress between the topmost container and the bottom surface of the LWT cask closure lid was also checked. The bearing stress is 1.76 ksi, which gives a margin of safety greater than 10. For additional details refer to item 1 in Section 2.6.12.15.5.

The container wall was evaluated for potential buckling with a standard closed form solution. The calculated critical buckling stress calculated was 131 ksi. The calculated compressive stress in the container wall is 5.96 ksi; therefore, the margin of safety is greater than 10. For additional details refer to item 1 in Section 2.6.12.15.5.

Pressure Case Combined with Drop Cases

The maximum stress intensities for the pressure case are added absolutely to the maximum stress intensities for the drop cases to get the combined stress intensity. The maximum combined membrane stress intensity is 7.13 ksi and the maximum combined membrane plus bending stress intensity is 9.74 ksi. Comparing this to the allowable stress gives a margin of safety of 1.81 for the membrane stress and 2.08 for the membrane plus bending stress. For additional details refer to item 1 in Section 2.6.12.15.5.

Liquid Sloshing

[redacted]

Thermal Stresses

Since the heat load for each HEUNL container is less than 5 Watts, there will not be any significant thermally induced stresses for the Normal Condition of Transport.

Extreme Cold Ambient Conditions (-40 °F)

[redacted]

2.6.12.15.3 Closure Assembly Model

The closure assembly model is evaluated for the conditions of bolt preload, normal pressure loading and cold conditions. The bolt preload requirement was determined by the maximum load required to resist the blow-off load for maximum pressure or the maximum load required to compress the O-rings to the point of metal-to-metal contact between the closure lid and the top of the container. The compression load required to compress the seals was larger than that required to resist the blow-off load. The bolt preload requirement was determined to be 18,000 lbs or 3,000 lbs per bolt.

The bolt preload for the FEA model was achieved by specifying as an initial strain for the beam elements representing the bolts.

Normal Condition Pressure Case

The stresses are linearized through the closure lid at two locations; 1) the center of the lid and 2) at the location of the maximum stress which is from the bottom of the counter-bore to the bottom of the lid. These paths are shown in Figure 2.6.12-20.

Figure 2.6.12-20 Stress Linearization Paths in Closure Lid

The normal condition pressure of 100 psi was applied to the lower surface of the closure lid from the center out to the inner diameter of the inner O-ring. The maximum stress occurs at the counter-bore for the cap screws in the lid. The linearized stresses at the two locations were checked. The maximum membrane stress was 12.2 ksi and the maximum membrane plus bending stress was 18.46 ksi. Comparing these stresses to the allowable stress gives a margin of safety of 0.64 for membrane stress and 0.63 for membrane plus bending.

The contact pressure on the inner seal is checked to ensure that full contact between the closure lid and the inner seal is maintained. This validates the assumption that the pressure load only extends to the inner radius of the inner seal.

The maximum axial bolt load calculated for the 100 psi case was 3,162 lbs. Using the thread tensile area, the bolt tensile stress calculated was 22.98 ksi. The maximum bolt moment calculated was 133.6 in-lbs. This produces a bending stress of 18.52 ksi. The combined axial plus bending stress is 41.5 ksi.

Bolt Stresses

Using an allowable stress of $(S_m)_{BM}$ = 36.85 ksi for SA 705, Type 630 (17-4 PH) at 150 °F gives a margin of safety of 2.21 for the axial stress and 1.66 for axial plus bending stress.

Thread shear stress

The shear stress for the internal threads in the container is limiting since the bolt is SA 705, Type 630 and the container is SA 240, Type 304. The internal thread shear stress for a bolt load of 3,162 lbs is 3.48 ksi. Using the allowable for shear stress gives a margin of safety of 2.45.

For additional details refer to item 1 in Section 2.6.12.15.5.

Cold Conditions

[redacted]

Since the pressure in the container for cold conditions is 38.2 psig (52.9 psia), it is assumed that this pressure exists underneath the closure lid also. The 100 psig normal condition pressure load is applied from the center of the lid out to the inner radius of the inner seal.

The maximum stress occurs at the counter-bore for the cap screws in the lid. The linearized stresses at the two locations were checked. The maximum membrane plus bending stress was 28.86 ksi. Since this is a displacement controlled load, the allowable stress for membrane plus bending is $3S_m$. For SA 240, Type 304 at -40 °F, S_m is 20 ksi. Therefore the margin of safety is 1.08 based on the linearized membrane plus bending stress.

The contact pressure on the inner seal is checked to ensure that full contact between the closure lid and the inner seal is maintained. This validates the assumption that the pressure load only extends to the inner radius of the inner seal.

The maximum axial bolt load calculated for the cold condition case was 5,921 lbs. Using the thread tensile area, the bolt tensile stress calculated was 43.03 ksi. The maximum bolt moment calculated was 470.9 in-lbs. This produces a bending stress of 65.27 ksi. The combined axial plus bending stress is 108.3 ksi.

Bolt Stresses

Using an allowable stress of $(S_m)_{BM}$ = 38.3 ksi for SA 705, Type 630 (17-4 PH) for less than 100°F gives a margin of safety of 0.78 for the axial stress and 0.06 for axial plus bending stress.

Thread shear stress

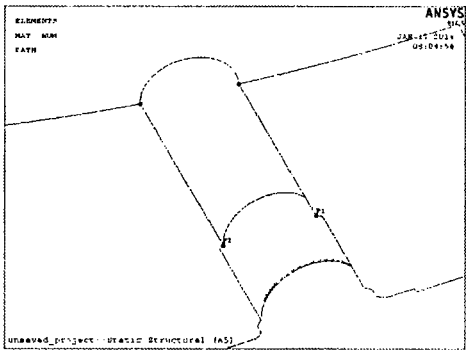
The shear stress for the internal threads in the container is limiting since the bolt is SA 705, Type 630 and the container is SA 240, Type 304. The internal thread shear stress for the bolt load of 5,921 lbs is 6.52 ksi. Using the allowable for shear stress gives a margin of safety of 0.84.

For additional details refer to item 1 in Section 2.6.12.15.5.

2.6.12.15.4 Fill/Drain Port Model

To evaluate the stresses due to cold conditions, two paths are defined along the inner radius of the port passage. These paths are shown in Figure 2.6.12-21.

Figure 2.6.12-21 Stress Linearization Paths in Fill/Drain Ports



The maximum linearized stresses at these two locations are 16.78 ksi for membrane stress and 20.16 ksi for membrane plus bending stress. Since this is a displacement controlled load, the allowable stress for membrane plus bending is $3S_m$. For SA 240, Type 304 at -40 °F, S_m is 20 ksi. Therefore the margin of safety for the membrane plus bending stress is 1.98.

For additional details refer to item 1 in Section 2.6.12.15.5.

2.6.12.15.5 HEUNL Structural Calculations

1. 65008500-2010 "Canister Structural Evaluations for HEUNL in the NAC-LWT"

2.6.12.16 Conclusion

Loads generated during normal operations conditions for each basket assembly design result in total equivalent stresses, which each basket body can adequately sustain. Analyses show that all basket-bearing stresses during a side drop are much less than the material yield strength. Column analyses demonstrate that each basket assembly is self-supporting during an end drop. The minimum Margin of Safety, for all basket designs, is +0.10 as reported in Section 2.6.12.7.4 for the TRIGA basket; +0.003 as shown in Table 2.6.12-2 for the DIDO basket; +0.10 as reported in Section 2.6.12.9.2 for the GA fuel basket; +0.26 as reported in Section 2.6.12.11.1 for the ANSTO basket, +7.78 as reported in Section 2.6.12.13 for the SLOWPOKE fuel canister assembly; and +0.16 as reported in Section 2.6.12.14 for the NRU/NRX basket. The HEUNL canister has a minimum margin of safety of +0.06 as reported in Section 2.6.12.15.3. Therefore, it can be concluded that all basket designs have sufficient structural integrity for adequate service during normal conditions of transport.

2.7.7.17.1 Finite Element Models

Drop Cases Model

The finite element model (FEA) used to evaluate the accident drop cases is the same as that used for the normal conditions drop cases. This model was described in detail in Section 2.6.12.15.1. Refer to that section for a complete description.

Internal Pressure Case Model

For the fire transient, a significant internal pressure would occur. For the internal pressure case, a 30° sector of the 180° FEA model used for the drop cases was developed. Since the HEUNL container has 6 guide rails spaced 60° apart, a 30° sector is sufficient for the pressure case. The internal elements representing the HEUNL fluid was removed. This model is shown in the Figure 2.7.7-8.

Figure 2.7.7-8 Internal Pressure Case – 30° Sector Model

2.7.7.17.2 HEUNL Container 30 Foot Drop Case

The HEUNL container is evaluated for both end drops (top and bottom drops) and a side drop. An equivalent acceleration of 61 g is used to evaluate the 30 foot drops.

For each drop case, the container and the support ring FEA models are utilized. The linearized stresses are checked at 14 section locations for the container model. The sections used were shown in Figures 2.6.12-15 and 2.6.12-16, previously.

The allowable stresses are based on either S_m, which is 20.0 ksi, or S_u, which is 66.2 ksi for SA 240, Type 304 at 300 °F. The allowable stress for membrane is either 2.4 S_m or 0.7 S_u, whichever is smaller, and the allowable stress for membrane + bending is either 3.6 S_m or 1.0 S_u, whichever is smaller. For SA-240, Type 304, the lower allowable stresses are 0.7 S_u and 1.0 S_u. The pressure inside the canister is the 100 psig normal condition pressure during the accident drop.

30 Foot Side Drop

For the side drop each container rests against the inner shell of the of the LWT cask. The gap elements on the outside surface of the guide bars have two nodes. The outermost nodes are constrained in the radial, tangential and axial direction. This boundary condition represents the inner surface of the LWT cask as rigid, which is a conservative approach since this produces higher loads on the container guide rails.

For the side drop case an acceleration of 61 g is applied in the lateral (X) direction.

For the 30-foot side drop loading, the maximum membrane stress intensity from the 14 section cuts was 4.73 ksi and the maximum membrane plus bending stress intensity was 8.68 ksi. To determine the stress intensity combined with the 100 psig pressure, the maximum membrane stress intensity of 3.24 ksi and the maximum membrane plus bending stress intensity of 4.83 ksi of the 150 psig pressure case are conservatively added to internal loading stress intensities to generate a combined value of 7.97 ksi for membrane and 13.51 ksi for membrane plus bending. This gives a margin of safety of 4.81 for the membrane stress intensity and 3.9 for the membrane plus bending stress intensity. For additional details, refer to item 1 in Section 2.7.7.17.4.

30 Foot Bottom End Drop

For the bottom end drop case, an acceleration of 61 g is applied in the vertical (Z) direction. The lowest container rests on the bottom forging of the LWT cask. The vertical acceleration accounts for the weight of the lowest container; however, the remaining 3 containers are stacked on the top of the lowest container. To account for the weight of the other three containers an equivalent pressure load is applied to the top of the FEA model of the bottom container.

The maximum membrane stress intensity from the 14 section cuts was 10.80 ksi and the maximum membrane plus bending stress intensity was 14.70 ksi. To determine the stress intensity combined with the 100 psig pressure, the maximum membrane stress intensity of 3.24 ksi and the maximum membrane plus bending stress intensity of 4.83 ksi of the 150 psig pressure case are conservatively added to inertial loading stress intensities to generate a combined value of 14.04 ksi for membrane and 19.53 ksi for membrane plus bending. This gives a margin of safety of 2.3 for the membrane stress and 2.39 for the membrane plus bending stress intensity. For additional details, refer to item 1 in Section 2.7.7.17.4.

The container wall was also evaluated for potential buckling with a standard closed form solution. The calculated critical buckling stress calculated was 119 ksi. Compared to the calculated compressive stress in the container wall of 14.54 ksi, the margin of safety is 7.18. For additional details, refer to item 1 in Section 2.7.7.17.4.

The revised support ring FEA model was utilized to evaluate this case. The maximum membrane stress intensity calculated was 16.36 ksi and the maximum membrane plus bending stress intensity was 42.8 ksi. Comparing this to the allowable stress gives a margin of safety of 1.83 for the membrane stress and 0.55 for the membrane plus bending stress. For additional details, refer to item 1 in Section 2.7.7.17.4.

30 Foot Top End Drop

For the top end drop case an acceleration of 61 g is applied in the vertical (-Z) direction. The topmost container rests on the closure lid of the LWT cask. The vertical acceleration accounts for the weight of the lowest container; however, the remaining 3 containers are stacked on the top of the lowest container. To account for the weight of the other three containers, an equivalent pressure load is applied to the bottom of the FEA model of the top container. Again the total reaction load was checked to ensure that the weight of all 4 containers was accounted for.

The maximum membrane stress intensity from the 14 section cuts was 12.23 ksi and the maximum membrane plus bending stress intensity was 14.57 ksi. To determine the stress intensity combined with the 100 psig pressure, the maximum membrane stress intensity of 3.24 ksi and the maximum membrane plus bending stress intensity of 4.83 ksi of the 150 psig pressure case are conservatively added to inertial loading stress intensities to generate a combined value of 15.47 ksi for membrane and 19.4 ksi for membrane plus bending. This gives a margin of safety of 2.0 for the membrane stress and 2.41 for the membrane plus bending stress. For additional details, refer to item 1 in Section 2.7.7.17.4.

The container wall was evaluated for potential buckling with a standard closed form solution. The calculated critical buckling stress calculated was 119 ksi. The calculated compressive stress in the container wall is 14.54 ksi; therefore, the margin of safety is 7.18. For additional details, refer to item 1 in Section 2.7.7.17.4.

Internal Pressure Case

[redacted]

Thermal Expansion

[redacted]

[redacted]

2.7.7.17.3 Closure Assembly Model

Accident Condition Pressure Case

The stresses are linearized through the closure lid at two locations; 1) the center of the lid and 2) at the location of the maximum stress which is from the bottom of the counter-bore to the bottom of the lid. These paths are shown in Figure 2.6.12-20.

The accident condition pressure of 200 psi was applied to the lower surface of the closure lid from the center out to the inner diameter of the inner O-ring. The maximum stress occurs at the counter-bore for the cap screws in the lid. The linearized stresses at the two locations were checked. The maximum membrane stress was 13.67 ksi and the maximum membrane plus bending stress was 20.87 ksi. Comparing these stresses to the allowable stress gives a margin of safety of 2.39 for membrane stress and 2.17 for membrane plus bending.

The contact pressure on the inner seal is checked to ensure that full contact between the closure lid and the inner seal is maintained. This validates the assumption that the pressure load only extends to the inner radius of the inner seal.

The maximum axial bolt load calculated for the 200 psi case was 3,573 lbs. Using the thread tensile area, the bolt tensile stress calculated was 25.97 ksi. The maximum bolt moment calculated was 167.9 in-lbs. This produces a bending stress of 23.27 ksi. The combined axial plus bending stress is 49.24 ksi.

Bolt Stresses

Using an allowable stress of S_y = 93.0 ksi and S_u = 135.0 ksi for SA 705, Type 630 (17-4 PH) at 200 °F gives a margin of safety of 2.58 for the axial stress and 1.74 for axial plus bending stress.

Thread shear stress

The shear stress for the internal threads in the container is limiting since the bolt is SA 705, Type 630 and the container is SA 240, Type 304. The internal thread shear stress for a bolt load of 3,573 lbs is 3.94 ksi. Using the allowable for shear stress gives a margin of safety of 6.06.

For additional details refer to item 1 in Section 2.7.7.17.4.

2.7.7.17.4 HEUNL Structural Calculations

1. 65008500-2010, "Canister Structural Evaluation for HEUNL in the NAC-LWT"

March 2015

Revision LWT-15B

NAC-LWT

Legal Weight Truck Cask System

SAFETY ANALYSIS REPORT

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