From: "Chopra, U.B." <UB.Chopra@transnuclear.com>
To: Joseph Sebrosky <JMS3@nrc.gov>
Date: Mon, Oct 17, 2005 10:03 PM
Subject: RE: Submittal of revision 4 SAR pages for NUHOMS HD storage syste m (7 2-1030)

Joe:

In response to your questions:

1. Agree. Section 1.2.3 is being revised to address your comment.
2. Agree. No new changes are required for Chapter 9.
3. See attached Table "List of SAR Revision 4 Changed pages" with a reason for each change provided.

This Table provides a complete scope of the SAR Rev. 4 changes. It clearly shows that there are no new changes other than those previously discussed with the staff or those which eliminate internal discrepancies within the document or some minor typos.

In addition, there are some minor additional tweaks from the earlier version of the SAR Revision 4 pages sent to you by Peter Shih. See attached file for your review.

If there are any additional questions, please call me at 510-744-6053. If you concur, we will send out a hard copy of the final version of SAR Revision 4 tomorrow.

Thanks.

U. B. Chopra

-----Original Message-----
From: Joseph Sebrosky [mailto:JMS3@nrc.gov]
Sent: Monday, October 17, 2005 9:14 AM
To: Ub.chopra@transnuclear.com
Cc: peter.shih@transnuclear.com; Tara.neider@transnuclear.com
Subject: Re: Submittal of revision 4 SAR pages for NUHOMS HD storage system (7 2-1030)

UB,

I had the following questions regarding the SAR changes that Peter sent me.

1) I'm confused by the change in section 1.2.3. It appears that you removed reference to the CE 14X14 fuel altoghether. I thought you had only intended to call out that the CE 14 X 14 fuel was analyzed only without BPRAs while the other fuel types were analyzed with and without BPRAs

2) What happened to section 9.2? It appears to have been removed at the bottom of page 9-4. Page 9-5 starts with section 9.2.1

3) Do you have a list of changes that were not previously discussed with the staff. For example, I'm not sure the change the resin description in table 3.2 and the changes in 3.5.3.1 to the side drop analysis were

previously discussed with the staff. I might be wrong and an RAI response discusses the issue. If there is anything that has not been previously discussed it would be helpful if I knew.

Thanks,

Joe

>>> "Shih, Peter" <peter.shih@transnuclear.com> 10/17/05 10:25 AM >>>
Dear Sebrosky,

The attached PDF files contain the revision 4 SAR pages for the NUHOMS-HD System. Please give me a call at 410-910-6890 or U. B. Chopra at 510-744-6053 if you need additional information.

Sincerely,

Peter Shih

Transnuclear Inc.

410-910-6890

CC: "Shih, Peter" <peter.shih@transnuclear.com>, "Neider, Tara" <tara.neider@transnuclear.com>

Mail Envelope Properties (435457F0.7F1 : 9 : 55281)

Subject:	RE: Submittal of revision 4 SAR pages for NUHOMS HD storage syste m (7 2-1030)
Creation Date:	Mon, Oct 17, 2005 10:02 PM
From:	"Chopra, U.B." <UB.Chopra@transnuclear.com>
Created By:	UB.Chopra@transnuclear.com

Recipients
nrc.gov
owf4_po.OWFN_DO
JMS3 (Joseph Sebrosky)

transnuclear.com
tara.neider CC (Tara Neider)
peter.shih CC (Peter Shih)

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Files	**Size**	**Date & Time**
MESSAGE	2452	Monday, October 17, 2005 10:02 PM
Revision 4 SAR Pages vs reasons.doc		110592
DOC005.PDF	682814	
Mime.822	922248	

Options

Expiration Date:	None
Priority:	High
Reply Requested:	No
Return Notification:	None
Concealed Subject:	No
Security:	Standard

List of Revision 4 SAR Changed Pages vs. Reasons for Change

Affected SAR Page Number	Reason for change
1-10	Replace air with nitrogen as a blow down medium
1-11	Add restriction to CE 14x14 about NFAHs not allowed. Make SAR consistent with the proposed Technical Specifications
1-12	(Add the term "Assembly average" enrichment). Make SAR consistent with the proposed Technical Specifications
1-15	Correct Reference 5 to the current revision
2-1	Make SAR consistent with the proposed Technical Specifications
2-2	Make SAR consistent with the proposed Technical Specifications + formatting
2-3	Make SAR consistent with the proposed Technical Specifications + formatting due to pagination
2-13	Replace air with nitrogen as a blow down medium
2-14	Typo + Make SAR consistent with the proposed Technical Specifications
Table 2-1	Make SAR consistent with the proposed Technical Specifications
Table 2-2	Make SAR consistent with the proposed Technical Specifications
Table 2-2 (concluded)	Make SAR consistent with the proposed Technical Specifications. Originally this Table was in a single page. The same content has been shown in two pages
Table 2-3	Make SAR consistent with the proposed Technical Specifications
Figure 2-1	Make SAR consistent with the proposed Technical Specifications
3-ii	Make SAR consistent with the proposed Technical Specifications
3-iii	Response to RAI#2
3-iv	Response to RAI#2
3-7	Text Overflow to next page
3-8	Replace "Exceptions" with "Alternatives" to be consistent with TS and Remove Vyal-b to be consistent with revision 2 shielding analysis
3-10	(Add the term "Assembly average" enrichment). Make SAR consistent with the proposed Technical Specifications
3-13	Make SAR Chapter 3 consistent with shielding analysis (Chapter 5)
3-27	Editorial correction
3-29	Response to RAI#2
3-36	Replace air with nitrogen as a blow down medium
3-54	Response to RAI#2
3-56	Response to RAI#2
3-58	Replace "Exceptions" with "Alternatives" to be consistent with the proposed Technical Specifications
3-59	Replace "Exceptions" with "Alternatives" to be consistent with the proposed Technical Specifications
3-60	Replace "Exceptions" with "Alternatives" to be consistent with the proposed Technical Specifications
Table 3-12	Response to RAI#2
Table 3-13	Response to RAI#2
Figure 3-2	Response to RAI#2
Figure 3-3	Response to RAI#2
Figure 3-3	Response to RAI#2
Figure 3-4	Response to RAI#2
Figure 3-5	Response to RAI#2
Figure 3-6	Response to RAI#2
Figure 3-7	Response to RAI#2
3.9.8-2	Response to Additional NRC Questions following RAI#1
3.9.8-16	Response to Additional NRC Questions following RAI#1
3.9.8-17	Response to Additional NRC Questions following RAI#1

Affected SAR Page Number	Reason for change
3.9.8-18	Response to Additional NRC Questions following RAI#1
3.9.8-19	Response to Additional NRC Questions following RAI#1
Table 3.9.8-1	Response to Additional NRC Questions following RAI#1
Table 3.9.8-2	Response to Additional NRC Questions following RAI#1
Table 3.9.8-3	Response to Additional NRC Questions following RAI#1
Table 3.9.8-4	Response to Additional NRC Questions following RAI#1
Table 3.9.8-5	Response to Additional NRC Questions following RAI#1
Table 3.9.8-6	Response to Additional NRC Questions following RAI#1
Table 3.9.8-7	Response to Additional NRC Questions following RAI#1
Table 3.9.8-8	Response to Additional NRC Questions following RAI#1
3.9.10-15	Correction
4-2	Typo
4-18	Make SAR consistent with the proposed Technical Specifications
4-29	Replace air with nitrogen as a blow down medium
4-30	Add applicable section number
4-31	Text Overflow to next page
4-32	Text Overflow to next page
4-33	Replace air with nitrogen as a blow down medium
5-3	Typo (change ENDF/B-IV to ENDF/B-V)
5-4	Make SAR consistent with the proposed Technical Specifications
5-5	Typo (change ENDF/B-IV to ENDF/B-V)
Table 6-1	Make SAR consistent with the proposed Technical Specifications
Table 6-3	Make SAR consistent with the proposed Technical Specifications
Table 6-4	Make SAR consistent with the proposed Technical Specifications
Table 6-7	Typo + Make SAR consistent with the proposed Technical Specifications
8-1	Replace air with nitrogen as a blow down medium in the first para and add clarification to step 5
8-3	Replace air with nitrogen as a blow down medium
8-4	Replace air with nitrogen as a blow down medium. Also, replace "inert gas" with "helium" in steps 7 and 13
8-5	Typo in step 20 and replace air with nitrogen as a blow down medium in step 23
10-1	Typo
10-8	Change NUHOMS HD to Standardized NUHOMS (Correction). Also add parenthesis to Reference 7 (Typo)
11-9	Restoring the wording back to the version used in SAR Revision 2 submittal
11-26	Make Chapter 11 consistent with thermal analysis (Chapter 4)
Chapter 12 (Entire Chapter)	Latest Proposed Technical Specifications
B12-9	Replace air with nitrogen as a blow down medium
B12-11	Replace air with nitrogen as a blow down medium

Affected SAR Page Number	Reason for change

Insertion of 32PTH DSC into HSM: After final alignment of the transfer cask, HSM-H, and hydraulic ram, the 32PTH DSC is pushed into the HSM-H by the hydraulic ram.

HSM Closure: Install 32PTH DSC axial retainer and install HSM-H door.

1.2.2.3 Identification of Subjects for Safety and Reliability Analysis

1.2.2.3.1 Criticality Prevention

Criticality is controlled by utilizing the fixed borated neutron absorbing material in the 32PTH DSC basket and the pool water boron loading. During storage, with the cavity dry and sealed from the environment, criticality control measures within the installation are not necessary because water cannot enter the canister during storage.

1.2.2.3.2 Chemical Safety

There are no chemical safety hazards associated with operations of the NUHOMS® HD System. The coating materials used in the design of the 32PTH DSC are chosen to minimize hydrogen generation. Hydrogen monitoring is required during sealing operations to ensure hydrogen concentration levels remain within acceptable limits.

1.2.2.3.3 Operation Shutdown Modes

The NUHOMS® HD System is a totally passive system so that consideration of operation shutdown modes is unnecessary.

1.2.2.3.4 Instrumentation

The NUHOMS® HD System is a totally passive system. No safety-related instrumentation is necessary. The maximum temperatures and pressures are conservatively bounded by analyses. Therefore, there is no need for monitoring the internal cavity of the 32PTH DSC for pressure or temperature during normal operations. The 32PTH DSC is conservatively designed to perform its confinement function during all worst case normal, off-normal, and accident conditions.

1.2.2.3.5 Maintenance and Surveillance

All maintenance and surveillance tasks are described in Chapter 9

1.2.3 32PTH DSC Contents

The 32PTH DSC is designed to store up to 32 intact PWR Westinghouse 15x15 (WE 15x15), Westinghouse 17x17 (WE 17x17), Framatome ANP Advanced MK BW 17x17 (Fr 17x17) and/or Combustion Engineering 14x14 (CE 14X14) fuel assemblies, ~~with or without~~ NFAHs likeVibration Suppressor Inserts (VSI), Burnable Poison Rod Assemblies (BPRAs), or Thimble Plug Assemblies (TPAs). ~~NFAHs are not allowed for the~~ CE 14x14 fuel assemblies. The 32PTH DSC is also designed for storage of up to 16 damaged fuel assemblies, and remaining intact assemblies, utilizing top and bottom end caps. A description of the fuel assemblies including the damaged fuel assemblies is provided in Chapter 2.

are allowed for these fuel assemblies except for

1.2 Supplemental Data

1.2.1 References

1. Title 10, Code of Federal Regulations, Part 72, "Licensing Requirements for the Storage of Spent Fuel in an Independent Spent Fuel Storage Installation".

2. U.S. Nuclear Regulatory Commission, Regulatory Guide 3.61, Standard Format and Content for a Topical Safety Analysis Report for a Spent Fuel Dry Storage Cask, February 1989.

3. U.S. Nuclear Regulatory Commission, "Standard Review Plan for Dry Cask Storage Systems," NUREG 1536, U.S. NRC, January 1997.

4. NRC Certificate of Compliance 72-1004, NUHOMS® General License Spent Fuel Storage System, Amendment No. 7, March, 2004.

5. ~~TN West~~, Final Safety Analysis Report for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel, Revision ~~7~~ 8, ~~November 2003~~ June 2004, File NUH003.0103, USNRC Docket No. 72-1004.

6. Title 10, Code of Federal Regulations, Part 50, "Domestic Licensing of Production and Utilization Facilities".

7. Application for Amendment No. 8 of the NUHOMS® Certificate of Compliance 72-1004, Revision 0, September 2003.

1.2.2 Drawings

- 32PTH DSC: 10494-72-(1 to 12), Rev 1 (PROPRIETARY)
- OS187H: 10494-72-(15 to 17), Rev 1 (PROPRIETARY)
  10494-72-18, Rev 0 (PROPRIETARY)
  10494-72-(19 to 21), Rev 1(PROPRIETARY)
- HSM-H: 10494-72-(101 to 103 & (105 to 107) Rev. 0 (PROPRIETARY)
  10494-72-(100, 104, & 108), Rev 1 (PROPRIETARY)
- Damaged Fuel End Caps: 10494-72-30, Rev 0 (PROPRIETARY)

2. PRINCIPAL DESIGN CRITERIA

2.1 Spent Fuel to be Stored

The NUHOMS® HD System components have currently been designed for the storage of 32 intact and or up to 16 damaged with remaining intact, Westinghouse 15x15 (WE 15x15), Westinghouse 17x17 (WE 17x17), Framatome ANP Advanced 17x17 MK BW (FR 17x17), and/or Combustion Engineering 14x14 (CE 14x14) PWR fuel assemblies. Equivalent reload fuel assemblies that are enveloped by the fuel assembly design characteristics listed in Table 2-1 for a given assembly class are also acceptable Additional payloads may be defined in future amendments to this application.

The thermal and radiological characteristics for the PWR spent fuel were generated using the SCALE computer code package [1]. The physical characteristics for the PWR fuel assembly types are shown in Table 2-1. Free volume in the 32PTH DSC cavity is addressed in Chapter 4. Specific gamma and neutron source spectra are given in Chapter 5.

Although analyses in this SAR are performed only for the design basis fuel, any other intact or damaged PWR fuel which falls within the geometric, thermal, and nuclear limits established for the design basis fuel can be stored in the 32PTH DSC.

2.1.1 Detailed Payload Description

CE 14x14 fuel assemblies are to be stored without NFAHs

This payload consists of 32 PWR UO_2 fuel assemblies ~~with or~~ without Non-Fuel Assembly Hardware (NFAH) which includes Burnable Poison Rod Assemblies, (BPRAs), Vibration Suppression Inserts (VSI) or Thimble Plug Assemblies (TPAs). Each 32PTH DSC can accommodate a maximum of sixteen damaged fuel assemblies, with the remaining assemblies intact. The fuel to be stored in the 32PTH DSC is limited to fuel with a maximum assembly average initial enrichment of 5.00 weight % U-235 The maximum allowable burnup is given as a function of initial fuel enrichment but does not exceed 60,000 MWd/MTU. The minimum cooling time is five years.

The 32PTH DSC may store up to 32 PWR fuel assemblies arranged in accordance with a heat load zoning configuration as shown in Figure 2-1, with a maximum decay heat of 1.5 kW per assembly and a maximum heat load of 34.8 kW per ~~DSC,~~ (33.8 kW per DSC for CE 14x14).

The 32PTH DSC can accommodate up to 16 structurally intact damaged fuel assemblies. A fuel assembly that is damaged in such a manner as to impair its structural integrity, has missing or displaced structural components such as grid spacers, or cannot be handled using normal handling methods can not be considered a candidate for storage in the 32 PTH DSC. Neither can fuel that is no longer in the form of an intact fuel bundle and consists of, or contains, debris such as loose fuel pellets, rod segments, etc. Damaged fuel assemblies shall be placed into the sixteen inner most basket fuel compartments, as shown in Figure 2-2, which contain top and bottom end caps that confine any loose material and gross fuel particles to a known, sub-critical volume during normal, off-normal and accident conditions and to facilitate handling and retrievability. Reactor records, visual/videotape records, fuel sipping, ultrasonic examination, and radio chemistry are examples of techniques utilized by utilities to identify damaged fuel.

The maximum fuel cladding temperature limit of 570°C (1058°F) is applicable to accidents or off-normal thermal transients [15].

Calculations were performed to determine the fuel assembly type which was most limiting for each of the analyses including shielding, criticality, thermal and confinement. These evaluations are performed in Chapters 5 and 6. The fuel assembly classes considered are listed in Table 2-1. It was determined that the Framatome 17x17 is the enveloping fuel design for the shielding, thermal and confinement source term calculation because of its total assembly weight and highest initial heavy metal loading. The bounding source term for shielding analysis is given in Table 2-3. Table 2-4 presents the thermal and radiological source terms for the Non-Fuel Assembly Hardware (NFAH).

These values are consistent with the cumulative exposures and cooling times of the fuel assemblies. The gamma spectra for the bounding fuel assembly and NFAH are presented in Chapter 5.

The shielding evaluation is performed assuming 32 fuel assemblies with the parameters (1.5kW) shown in Table 2-3. Any fuel assembly that is thermally qualified by Table 2-2 is also acceptable from a shielding perspective since the maximum decay heat load is 1.5 kW and only eight (8) are allowed in the 32PTH DSC. The shielding analysis assumes 32, 1.5 kW assemblies are in the 32PTH DSC. Minimum initial enrichments are defined for each of the zones to assure the shielding evaluation is bounding.

For criticality safety, the WE 17x17 standard assembly is the most reactive assembly type for a given enrichment. This assembly is used to determine the most reactive configuration in the DSC. Using this most reactive configuration, criticality analysis for all other fuel assembly classes is performed to determine the maximum enrichment allowed as a function of the soluble boron concentration and fixed poison plate loading. The analyses results are presented in Chapter 6.

For calculating the maximum internal pressure in the NUHOMS®-32PTH DSC, it is assumed that 1% of the fuel rods are damaged for normal conditions, up to 10% of the fuel rods are damaged for off normal conditions, and 100% of the fuel rods will be damaged following a design basis accident event. A minimum of 100% of the fill gas and 30% of the fission gases within the ruptured fuel rods are assumed to be available for release into the DSC cavity, consistent with NUREG-1536 [17].

The maximum internal pressures used in the structural analysis for the NUHOMS®-32PTH DSC are 15, 20, and 120 psig for normal, off-normal and accident conditions, respectively, during storage and transfer operations and 70 psig during storage accident conditions.

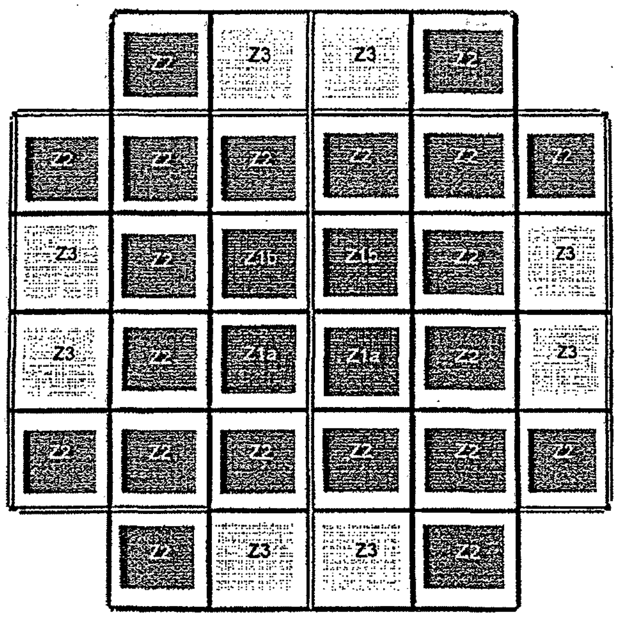
The structural integrity of the fuel cladding due to the side drop is analyzed in Section 3.5.3. The end and corner drops are not considered credible during storage and transfer. The structural integrity of the fuel cladding due to these loads will be addressed by the users under their site license (10CFR50)

Table 2-1
Spent Fuel Assembly Physical Characteristics

Parameter	15x15 WE & WES	17 x 17 WE	17x17 MK BW	17x17 WEV	17x17 WEOFA	14x14 CE
Maximum Assembly Average Initial Enrichment, wt % U235 (max)	5.00	5.00	5.00	5.00	5.00	5.00
Clad Material	Zr-4/Zirlo	Zr-4/Zirlo	M5	Zr-4/Zirlo	Zr-4/Zirlo	Zr-4/Zirlo
No of fuel rods	204	264	264	264	264	176
No of guide/instrument tubes	21	25	25	25	25	5
Assembly Length[3]	162.2	162.4	162.4	162.4	162.4	159.5
Max Uranium Loading (MTU)	467	467	476	467	467	385
Assembly Cross Section	8.424 x 8.424	8.426 x 8.426	8.425 x 8.425	8.426 x 8.426	8.426 x 8.426	8.25 x 8.25
Max Assembly Weight with Insert components[4]	1528	1575	1554	1533	1533	1450[5]

(1) Nominal values shown unless stated otherwise
(2) All dimensions are inches
(3) Includes allowance for irradiation growth
(4) Weights of TPAs and VSIs are enveloped by BPRAs
(5) Without NFAHs

Remove superscript



For 15x15 and 17x17 Assemblies

- Q_{zi} is the max decay heat per assembly in zone i
- Total Decay Heat ≤ 34.8 kW
- 4 fuel assemblies in zone 1 with
  - total decay heat ≤ 3.2 kW
  - Q_{z1a} ≤ 1.05 kW in the lower compartments
  - Q_{z1b} ≤ 0.8 kW in the upper compartments
- 20 fuel assemblies in zone 2 with Q_{z2} ≤ 1.1 kW
- 8 fuel assemblies in zone 3 with Q_{z3} ≤ 1.5 kW

For CE 14x14 Assemblies

Q_{zi} is the max decay heat per assembly in zone i
Total Decay Heat ≤ 33.8 kW
4 fuel assemblies in zone 1 with Q_{z1} ≤ 0.775 kW
20 assemblies in zone 2 with Q_{z2} ≤ 1.068 kW
8 fuel assemblies in zone 3 with Q_{z3} ≤ 1.5 kW

Figure 2-1
Heat Load Zones

3.9.8.11 One Foot Side Drop Damaged Fuel Evaluation

During off site transport (Part 71) the damaged fuel assemblies need to be evaluated for 1 foot side drop. The transport operation is carried out using the MP 187H Cask, with the DSC and the impact limiters in the horizontal position.

The maximum g load acting on the damaged fuel rods under 1 foot side drop load = 30g. The damaged fuel rod structural integrity under 1 foot side drop load is assessed by computing the bending stress in the rod and comparing it with the yield stress of the cladding material. The fracture assessment of the damaged fuel rod structural integrity is made by using two fracture geometries (ruptured sections) as described below

It is assumed that the damaged fuel tube is burst at the spacers (supports) location, which is the location of maximum bending moment. The loading assumed is on the opposite side of the rod at the burst location. The following two geometries, used for the fracture evaluation of the damaged fuel rods, are based on these assumptions.

Fracture Geometry #1: The first geometry is shown in Figure 3.9.8-1. In this damage mode the fuel tube is assumed to bulge from diameter D to diameter W (W ≥ D) and rupture to a hole of diameter (2a) at the bulge location. It is assumed that (2a/w) = 0.5 for this geometry.

Fracture Geometry #2: The second geometry is shown in Figure 3.9.8-2. The stress intensities factors for this geometry are determined using the solution for a tube with a crack subjected to pure bending moment given in Reference 13. This evaluation is based on a crack length to diameter ratio of 0.47 (or $2a/D_m$=0.47).

The basis for the 0.5 (ruptured hole to tube diameter ratio) for fracture geometry #1 and 0.47 (crack length to tube diameter ratio) for fracture geometry #2 are the experimental tests on "as received" Zircalloy fuel tubes with measured burst temperatures of up to 909°C, which showed flaw opening to diameter ratios of 0.4 to 0.5 [16].

3.9.8.11.1 Structural Integrity Evaluation with Fracture Geometry #1

The fracture geometry #1 (Ruptured Section) is shown in Figure 3.9.8-1. With reference to Figure 3.9.8-1, the methodology for computing the stress intensity factor K_I is as follows:

Fuel Rod OD = D

Oxidized Clad Thickness = t

Average radius, R = (D-t)/2

I = net tube MI.

Under the loads of both the normal transfer and storage conditions, the stresses ~~generated in the~~ canister will not be significantly different between the canister designs with an ~~one~~-piece top and with a composite top. SAR Drawing 10494–72–4, Rev. 0 shows the alternate composite top.

nitrogen or helium

As described in Chapter 8, Section 8.1.1.3, operation steps 7 and 13, a maximum of 60 psig ~~air~~ pressure may be applied at the canister vent port to assist draining of the water. The canister is structurally evaluated for this 60 psi internal pressure using the 2-D ANSYS finite element model described in Appendix 3.9.1, Section 3.9.1.3.2. The outer cover plate of the canister is removed from the 2-D model, since it is not yet installed during the application of this 60 psig nitrogen or helium pressure. The maximum primary stress intensity and the maximum primary plus secondary stress intensity in the canister during the application of 60 psig pressure are calculated to be 8,247 psi and 26,070 psi, respectively. Their corresponding stress limits as per ASME B&PV Code Subsection NB [12] are 16,400 psig and 49,200 psi, respectively. The application of 60 psig pressure to the canister is therefore acceptable.

Based on the results of these analyses, the design of the 32PTH DSC canister is structurally adequate with respect to both transfer and storage loads under the normal conditions.