72-1004

TRANSNUCLEAR

June 3, 2002
NUH03-02-34

Ms. Mary Jane Ross-Lee
Spent Fuel Project Office, NMSS
U. S. Nuclear Regulatory Commission
11555 Rockville Pike M/S O13-D-13
Rockville, MD 20852

Subject: Submittal of Revision 3 of Application for Amendment No. 5 to the NUHOMS® Certificate of Compliance No. 1004 (TAC NO. L23343).

References:
1. TN Proposal to Resolve NRC's 32PT DSC Thermal Confirmatory Analysis Comments, Telecon dated May 15, 2002.
2. Revision 2 of Application for Amendment No. 5 to the NUHOMS® Certificate of Compliance No. 1004, Submitted March 18, 2002.

Dear Ms. Ross-Lee:

Transnuclear, Inc. (TN) herewith submits Revision 3 of our application for Amendment No.5 to the NUHOMS® Certificate of Compliance No. 1004.

TN originally had requested approval of a 32PT DSC basket configuration with two alternate options: welded steel rails and solid aluminum rails. To resolve NRC's thermal confirmatory analysis comments for this application, we proposed during a recent telecon (Reference 1) to delete the welded steel transition rail design and revise the thermal analysis presented in the application to reflect only the solid aluminum rail design. Revision 3 of the application implements these changes.

To facilitate your staff's review, ANSYS input files which support the revised thermal analysis have also been included on a CD enclosed with this submittal.

This submittal includes proprietary documents which may not be used for any purpose other to support your staff's review of the application. In accordance with 10 CFR 2.790, Transnuclear, Inc. is providing an affidavit (Enclosure 1) specifically requesting that you withhold this proprietary information from public disclosure.

Please replace the affected pages of the Revision 2 application (Reference 2) with the changed pages submitted herewith.

NMSS01 PnP

Should you or your staff require additional information to support review of this application, please do not hesitate to contact me at 510-744-6053.

Sincerely,

UB Chopra

U. B. Chopra

Licensing Manager

Docket 72-1004

Enclosures:

1. Affidavit for withholding proprietary information.
2. Ten Copies of Revision 3 of Application for Amendment No. 5 to the NUHOMS® Certificate of Compliance No. 1004 (Changed Pages Only, Proprietary Version).
3. Three Copies of Revision 3 of Application for Amendment No. 5 to the NUHOMS® Certificate of Compliance No. 1004 (Changed Pages Only, Non-Proprietary Version).
4. CD with supporting ANSYS input files for the thermal analysis (Proprietary Information).

AFFIDAVIT PURSUANT
TO 10 CFR 2.790

Transnuclear, Inc.)
State of California) SS.
County of Alameda)

I, Robert M. Grenier, depose and say that I am Manager of Transnuclear, Inc. Fremont Operation, duly authorized to make this affidavit, and have reviewed or caused to have reviewed the information which is identified as proprietary and referenced in the paragraph immediately below. I am submitting this affidavit in conformance with the provisions of 10 CFR 2.790 of the Commission's regulations for withholding this information.

The information for which proprietary treatment is sought is contained in the drawings included in Enclosure 2 and the ANSYS input files included in Enclosure 4 (CD) of this submittal and as listed below:

1. FSAR Appendix M, Proprietary Version (Enclosure 2)
2. ANSYS Input Files (CD, Enclosure 4)

This section of the document and these input files have been appropriately designated as proprietary.

I have personal knowledge of the criteria and procedures utilized by Transnuclear, Inc. in designating information as a trade secret, privileged or as confidential commercial or financial information.

Pursuant to the provisions of paragraph (b) (4) of Section 2.790 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure, included in the above referenced document, should be withheld.

1) The information sought to be withheld from public disclosure is design drawings of the NUHOMS® Cask and ANSYS files relating to the thermal analysis of the NUHOMS® Cask, which is owned and has been held in confidence by Transnuclear, Inc.

2) The information is of a type customarily held in confidence by Transnuclear, Inc. and not customarily disclosed to the public. Transnuclear, Inc. has a rational basis for determining the types of information customarily held in confidence by it.

3) The information is being transmitted to the Commission in confidence under the provisions of 10 CFR 2.790 with the understanding that it is to be received in confidence by the Commission.

4) The information, to the best of my knowledge and belief, is not available in public sources, and any disclosure to third parties has been made pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence.

5) Public disclosure of the information is likely to cause substantial harm to the competitive position of Transnuclear, Inc. because:

a) A similar product is manufactured and sold by competitors of Transnuclear, Inc.

b) Development of this information by Transnuclear, Inc. required thousands of man-hours and hundreds of thousands of dollars. To the best of my knowledge and belief, a competitor would have to undergo similar expense in generating equivalent information.

c) In order to acquire such information, a competitor would also require considerable time and inconvenience related to the development of a design and analysis of a dry spent fuel storage system.

d) The information required significant effort and expense to obtain the licensing approvals necessary for application of the information. Avoidance of this expense would decrease a competitor's cost in applying the information and marketing the product to which the information is applicable.

e) The information consists of description of the design and analysis of a dry spent fuel storage and transportation system, the application of which provides a competitive economic advantage. The availability of such information to competitors would enable them to modify their product to better compete with Transnuclear, Inc., take marketing or other actions to improve their product's position or impair the position of Transnuclear, Inc.'s product, and avoid developing similar data and analyses in support of their processes, methods or apparatus.

f) In pricing Transnuclear, Inc.'s products and services, significant research, development, engineering, analytical, licensing, quality assurance and other costs and expenses must be included. The ability of Transnuclear, Inc.'s competitors to utilize such information without similar expenditure of resources may enable them to sell at prices reflecting significantly lower costs.

Further the deponent sayeth not.

SHANNON L. CHRISTENSEN
COMM. # 1264196
NOTARY PUBLIC-CALIFORNIA
ALAMEDA COUNTY
COMM. EXP. MAY 18, 2004

Robert M. Grenier

Robert M. Grenier
Manager of Transnuclear, Inc. Fremont Operation

Subscribed and sworn to me before this 3rd day of June, 2002, by Robert M. Grenier.

Shannon L Christensen

Notary Public

ATTACHMENT B

Suggested Changes to Technical Specifications of CoC 1004 Amendment 4

Technical Specifications Included:

- Section 1.2.1
- Section 1.2.3
- Section 1.2.3a
- Section 1.2.4
- Section 1.2.4a
- Section 1.2.7
- Section 1.2.11
- Section 1.2.15
- Section 1.2.15a
- Section 1.2.17
- Section 1.3.1

1.2.17 61BT and 32PT DSC Vacuum Drying Duration Limit

Limit/Specifications:

1. Time limit for duration of Vacuum Drying is 96 hrs after completion of 61BT DSC draining.
2. Time limit for duration of Vacuum Drying is *75* hrs after completion of 32PT DSC draining.

Applicability: This specification is applicable to a 61BT DSC with greater than 17.6 kw heat load and a 32PT DSC with a design basis heat load.

Objective: To ensure that 61BT and 32PT DSC basket structure does not exceed 800^0 F.

Action:

1. If the DSC vacuum drying pressure limit of Technical Specification 1.2.2 cannot be achieved at 72 hours for 61BT DSC or *51* hours for the 32PT DSC after completion of DSC draining, the DSC must be backfilled with 0.1 atm or greater helium pressure within 24 hours.

2. Determine the cause of failure to achieve the vacuum drying pressure limit as defined in Technical Specification 1.2.2.

3. Initiate vacuum drying after actions in Step 2 are completed or unload the DSC within 30 days.

Surveillance: No maintenance or tests are required during the normal storage. Monitoring of the time duration during the vacuum drying operation is required.

Bases: The time limits of 96 hours for the 61BT DSC and *75* hours for the 32PT DSC were selected to ensure that the temperature of the DSC basket structure is within the design limits during vacuum drying.

ATTACHMENT C
Changed FSAR (including Appendix M) Pages

List of Changed Appendix M Pages

- *M.1-1 through M.1-12 including Revised Drawings*
- *M.2-35*
- *M.3.1-2 through M.3-1-4*
- *M.3.1-4a (New Page)*
- *M.3.2-2*
- *M.3.6-2*
- *M.4 (Entire Section)*
- *M.11-8*

M.1 General Discussion

This Appendix M to the NUHOMS® Final Safety Analysis Report (FSAR) addresses the Important to Safety aspects of storing spent fuel in the NUHOMS®-32PT system. The NUHOMS®-32PT system consists of a NUHOMS®-32PT Dry Shielded Canister (DSC) stored in a Model 80 or Model 102 NUHOMS® Horizontal Storage Module (HSM) and transferred in a OS197 or OS197H Transfer Cask (TC). There is no change to the HSM or the TC as described in the NUHOMS® FSAR.

The format of this Appendix follows the guidance provided in NRC Regulatory Guide 3.61 [1.1]. The analysis presented in this Appendix shows that the NUHOMS®-32PT system meets all the requirements of 10CFR72 [1.1]. A separate analysis will be submitted to address the safety related aspects of transporting spent fuel in the NUHOMS®-32PT DSC in accordance with 10CFR71 [1.3].

The NUHOMS®-32PT system provides confinement, shielding, criticality control and passive heat removal independent of any other facility structures or components. The NUHOMS®-32PT DSC also maintains structural integrity of the fuel during storage.

Note: References to sections or chapters within this Appendix are identified with a prefix M (e.g., Section M.2.3 or Chapter M.2). References to sections or chapters of the FSAR outside of this Appendix (main body of the FSAR) are identified with the applicable FSAR section or chapter number (e.g., Section 2.3 or Chapter 2).

M.1.1 Introduction

The NUHOMS® System provides a modular canister based spent fuel storage and transport system. The system includes DSCs, HSMs, and the TC.

This Appendix M provides the supporting safety analysis for the addition of the 32PT DSC system. Only those features that are being revised or added to the NUHOMS® System are addressed and evaluated in this Appendix. The HSM and TC designs remain unchanged. The NUHOMS®-32PT DSC is similar to the existing 24P DSCs with the following exceptions:

- The basket has a capability to store 32, rather than 24, Pressurized Water Reactor (PWR) fuel assemblies.
- The canister shell thickness is reduced from 0.625 inches to 0.5 inches.
- The canister has been upgraded to provide a leak tight confinement.
- The basket represents a new design.
- The canister shell length and the thickness of the top and bottom end closure assemblies have been modified to accommodate the new basket design and the revised payload.

The NUHOMS®-32PT DSC system is designed to store intact standard PWR fuel assemblies with or without Burnable Poison Rod Assemblies (BPRAs). The NUHOMS®-32PT DSC system is designed for a maximum heat load of 24 kW/canister and a maximum of 1.2 kW/assembly when heat load zoning is considered. The fuel which may be stored in the NUHOMS®-32PT DSC is presented in Section M.2.

M.1.2 General Description of the NUHOMS®-32PT DSC

M.1.2.1 NUHOMS®-32PT DSC Characteristics

Each NUHOMS®-32PT DSC consists of a fuel basket and a canister body (shell, canister inner bottom and top cover plates and shield plugs). A sketch of the 32PT DSC components is shown in Figure M.1-1. A set of reference drawings is presented in Section M.1.5.

As shown in Table M.1-1, the 32PT DSC system consists of four design configurations or Types as follows:

- 32PT-S100, Short Canister (186.2 inch length), qualified for lift with a 100-ton capacity crane
- 32PT-L100, Long Canister (192.2 inch length), qualified for lift with a 100-ton capacity crane
- 32PT-S125, Short Canister (186.2 inch length), qualified for lift with a 125-ton capacity crane
- 32PT-L125, Long Canister (192.2 inch length), qualified for lift with a 125-ton capacity crane

These four design configurations allow flexibility to accommodate the payload fuel types described in Section M.2, with and without BPRAs, and accommodate most of the fuel handling cranes in the United States. Dimensions and estimated weights of the NUHOMS®-32PT DSC are shown in Table M.1-1.

The thickness for the individual plate components of the top and bottom end cover plates has been increased to accommodate the higher internal pressure, while the top and bottom end shield plug thickness has been reduced relative to the 24P DSC configuration. The NUHOMS®-32PT DSC shell thickness is 0.50 inches instead of 0.625 inches as used for the NUHOMS®-24P or –52B DSC designs. The materials used to fabricate the DSC are shown in the Parts List on Drawings NUH-32PT-1001, -1002, -1003, -1004, and -1006.

The confinement vessel for the NUHOMS®-32PT DSC consists of a shell which is a welded stainless steel cylinder with an integrally-welded, stainless steel bottom closure assembly; and a stainless steel top closure assembly, which includes the vent and drain system.

There are no penetrations through the confinement vessel. The draining and venting systems are covered by the seal welded outer top closure plate and vent and siphon port plugs. To preclude air in-leakage, the canister cavity is inerted and pressurized above atmospheric pressure with helium. The NUHOMS®-32PT DSCs are designed and tested to meet the leak tight criteria of ANSI N14.5-1997.

The basket structure consists of a grid assembly of welded stainless steel plates or tubes that make up a grid of 32 fuel compartments. Each fuel compartment accommodates aluminum and/or neutron absorbing plates (which are made of either borated aluminum or metal matrix composites such as Boralyn®, Metamic® or equivalent) that provide the necessary criticality control and heat conduction paths from the fuel assemblies to the canister shell. The space between the fuel compartment grid assembly and the perimeter of the DSC shell is bridged by transition rail structures. The transition rails are solid aluminum segments that support the fuel compartment grid assembly and transfer mechanical loads to the DSC shell. They also provide the thermal conduction path from the basket assembly to the canister shell wall, making it efficient in rejecting heat from its payload. This method of construction forms a robust structure of compartment assemblies which provides for storage of 32 fuel assemblies. The nominal clear dimension of each fuel compartment opening is 8.7 in. x 8.7 in., which provides clearance around the fuel assemblies.

During dry storage of the spent fuel in the NUHOMS®-32PT system, no active systems are required for the removal and dissipation of the decay heat from the fuel. The NUHOMS®-32PT DSC is designed to transfer the decay heat from the fuel to the basket, from the basket to the canister body and ultimately to the ambient via the HSM or TC.

Each canister is identified by a Mark Number, NUHOMS®-32PT DSC-XX, Type YNNN, where XX is a sequential number corresponding to a specific canister, and YNNN refers to the DSC Type as described previously (Y = S or L; while NNN = 100 or 125). Each canister is also marked with the patent number.

M.1.2.2 Operational Features

M.1.2.2.1 General Features

The NUHOMS®-32PT DSCs are designed to safely store 32 intact standard PWR fuel assemblies with or without BPRAs. The NUHOMS®-32PT DSC is designed to maintain the fuel cladding temperature below allowable limits during storage, short-term accident conditions, short-term off-normal conditions and fuel transfer operations.

The criticality control features of the NUHOMS®-32PT DSC are designed to maintain the neutron multiplication factor k-effective less than the upper subcritical limit equal to 0.95 minus benchmarking bias and modeling bias under all conditions.

M.1.2.2.2 Sequence of Operations

The sequence of operations to be performed in loading fuel into the NUHOMS®-32PT DSCs is presented in Chapter M.8.

M.1.2.2.3 Identification of Subjects for Safety and Reliability Analysis

M.1.2.2.3.1 Criticality Prevention

Criticality is controlled by geometry, soluble boron in spent fuel pool and by utilizing fixed neutron poison material in the fuel basket. If required, depending on fuel assembly design and initial enrichment, Poison Rod Assemblies (PRAs), as shown in Figure M.1-2 are also used for criticality control. These features are only necessary during the loading and unloading operations that occur in the loading pool (underwater). However, the PRAs are left in place following the completion of the DSC draining and drying operations which are discussed in M.8.1.3. During storage, with the DSC cavity dry and sealed from the environment, criticality control measures within the installation are not necessary because of the low reactivity of the fuel in the dry NUHOMS®-32PT DSC and the assurance that no water can enter the DSC cavity during storage.

M.1.2.2.3.2 Chemical Safety

There are no chemical safety hazards associated with operations of the NUHOMS®-32PT system.

M.1.2.2.3.3 Operation Shutdown Modes

The NUHOMS®-32PT DSC system is a totally passive system so that consideration of operation shutdown modes is unnecessary.

M.1.2.2.3.4 Instrumentation

No change.

M.1.2.2.3.5 Maintenance Techniques

No change.

M.1.2.3 Cask Contents

The NUHOMS®-32PT DSC system is designed to store 32 intact standard PWR fuel assemblies with or without BPRAs. Each NUHOMS®-32PT DSC is designed for a maximum heat load of 24 kW/canister and 1.2 kW/assembly if zoning for heat load is used. The fuel that may be stored in the NUHOMS®-32PT DSC is presented in Chapter M.2.

Chapter M.5 provides the shielding analysis. Chapter M.6 covers the criticality safety of the NUHOMS®-32PT DSC system and its contents, listing material densities, moderator ratios, and geometric configurations.

M.1.3 Identification of Agents and Contractors

Transnuclear, Inc. (TN) provides the design, analysis, licensing support and quality assurance for the NUHOMS®-32PT system. Fabrication of the NUHOMS®-32PT system cask is done by one or more qualified fabricators under TN's quality assurance program described in Chapter M.13. This program is written to satisfy the requirements of 10 CFR 72, Subpart G and covers control of design, procurement, fabrication, inspection, testing, operations and corrective action. Experienced TN operations personnel provide training to utility personnel prior to first use of the NUHOMS®-32PT system and prepare generic operating procedures.

Managerial and administrative controls, which are used to ensure safe operation of the casks, are provided by the host utility. NUHOMS®-32PT system operations and maintenance are performed by utility personnel. Decommissioning activities will be performed by utility personnel in accordance with site procedures.

TN provides specialized services for the nuclear fuel cycle that support transportation, storage and handling of spent nuclear fuel, radioactive waste and other radioactive materials. TN is the holder of Certificate of Compliance 1004.

M.1.4 Generic Cask Arrays

No change.

M.1.5 Supplemental Data

The following Transnuclear drawings are enclosed:

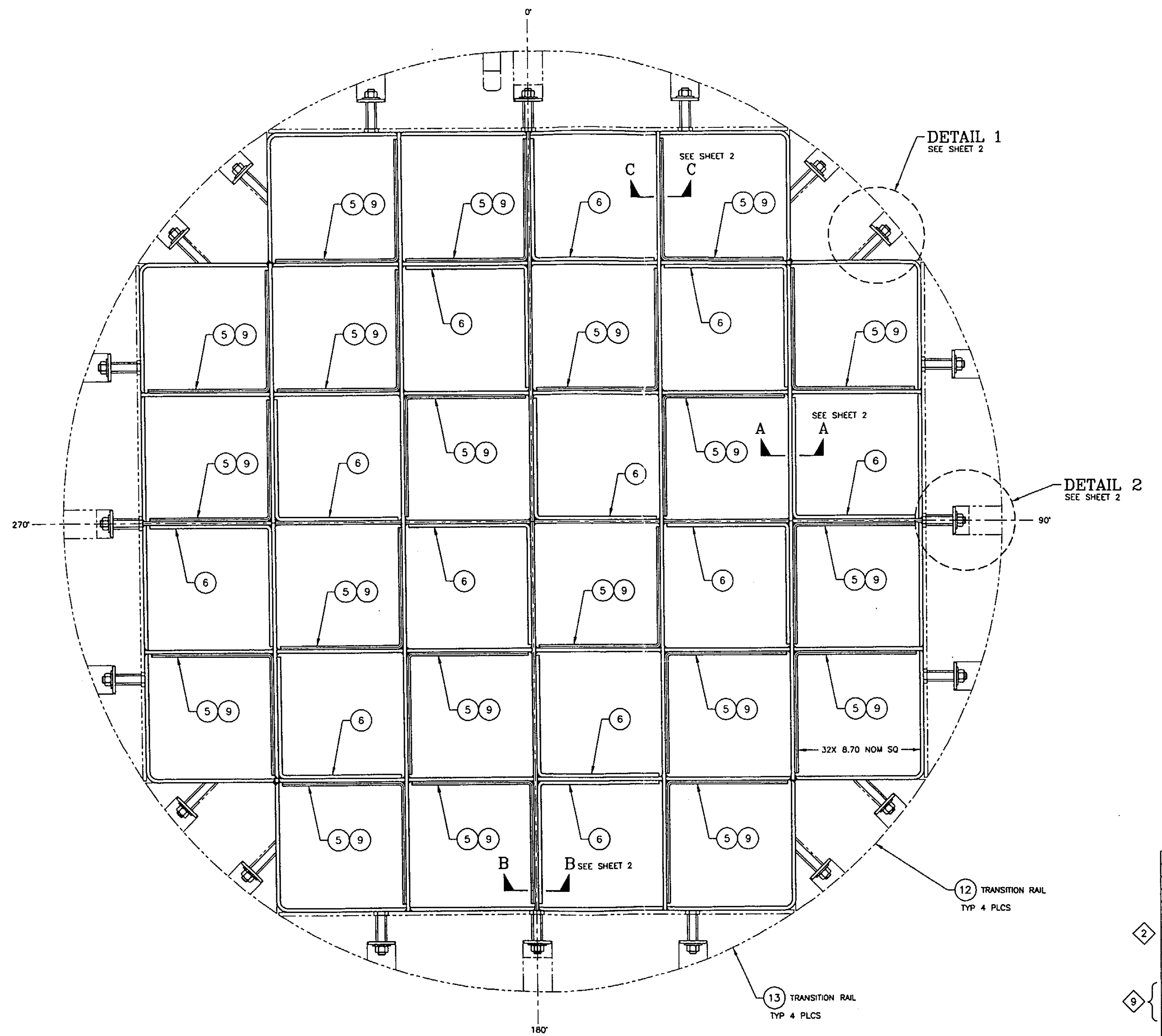
1. NUHOMS®-32PT Transportable Storage Canister for PWR Fuel, Main Assembly, Drawing NUH-32PT-1001*NP-SAR*, Revision 1.

2. NUHOMS®-32PT Transportable Storage Canister for PWR Fuel, Shell Assembly, Drawing NUH-32PT-1002*NP-SAR*, Revision 1.

3. NUHOMS®-32PT Transportable Storage Canister for PWR Fuel, Basket Assembly Option 1, Drawing NUH-32PT-1003*NP-SAR*, Revision *1*.

4. NUHOMS®-32PT Transportable Storage Canister for PWR Fuel, Basket Assembly Option 2, Drawing NUH-32PT-1004*NP-SAR*, Revision *1*.

5. NUHOMS®-32PT Transportable Storage Canister for PWR Fuel, Aluminum Transition Rails, Drawing NUH-32PT-1006*NP-SAR*, Revision *1*.



SECTION THRU BASKET AT MIDLENGTH

THICKNESS OF ITEMS 5, 6, AND 9 EXAGGERATED FOR CLARITY

NOTES:

1. (PROPRIETARY).

2. ALTERNATE DETAILS OR METHODS OF ATTACHMENT ARE ACCEPTABLE WITH TN APPROVAL.

3. (PROPRIETARY).

4. (PROPRIETARY).

5. FUEL COMPARTMENT CELLS MAY BE FABRICATED/INSTALLED FROM SINGLE AND/OR MULTIPLE PLATE SECTIONS. DETAILS AND WELDING MUST MAINTAIN STRENGTH OF THE CONTINUOUS PLATE AND ARE SUBJECT TO TN APPROVAL.

6. (PROPRIETARY).

7. (PROPRIETARY).

8. (PROPRIETARY).

9. ALTERNATE DETAILS OR METHODS OF ATTACHMENT ARE ACCEPTABLE WITH TN APPROVAL. RAIL TO BE SLOTTED TO PERMIT UNRESTRAINED THERMAL EXPANSION.

10. (PROPRIETARY).

11. WELD SYMBOLS ARE PER ANSI/AWS 2.4-98. WELD SIZES ARE MINIMUM. ALTERNATE WELDS OF EQUIVALENT STRENGTH MAY BE USED WITH TN APPROVAL.

12. CUTOUTS AT BOTTOM OF EACH FUEL COMPARTMENT CELL SHALL BE MADE TO FACILITATE DRAINING.

13. BASKET ASSEMBLY TO HAVE SUFFICIENT CLEARANCE WHEN INSERTED INTO CANISTER TO ALLOW FOR THERMAL EXPANSION.

14. (PROPRIETARY).

15. HOLES IN ITEMS 5, 6, AND 9 TO BE SLOTTED TO ALLOW THERMAL EXPANSION.

16. SIZE ITEM 10 AS NEEDED TO FIT IN OPENING AND TO CLEAR STUD. TACK WELD IN PLACE.

PARTS LIST

	ITEM NO.	QTY REQ'D	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL SPECIFICATION	QUALITY CATEGORY
	13	4	NUH-32PT-1006	R90 ALUMINUM TRANSITION RAIL	--	A
	12	4	NUH-32PT-1006	R45 ALUMINUM TRANSITION RAIL	--	A
	11	140		OVAL WASHER	SST	NITS
	10	28		ALUMINUM PLUG	TYPE 6061	NITS
	9	20		ALUMINUM SHEET, .05 THK	TYPE 1100	B
	8	128		SHEET	ASTM A240 TYPE 304	A
2	7	A/R		SCREW, FLAT COUNTERSUNK HEAD CAP	SST	C
	6	12		ALUMINUM SHEET, .125 THK	TYPE 1100	B
	5	20		NEUTRON ABSORBING SHEET, .075 THK		B
9	4	140		STD WASHER, ø1/2	SST	C
9	3	140		HEX NUT, ø1/2	SST	C
9	2	140		STUD, ø1/2	ASTM A479, TYPE XM-19	C
	1	A/R		PLATE, .25 THK	ASME SA-240 TYPE XM-19	A

ALL DIMENSIONS ARE APPLICABLE AT 70°F AND ALL TOLERANCING APPLIES AFTER WELDING AND FINAL ASSEMBLY UNLESS NOTED OTHERWISE.

DIMENSIONS ARE IN INCHES AND DEGREES UNLESS NOTED OTHERWISE. DIMENSIONING AND TOLERANCING IN ACCORDANCE WITH ASME Y14.5M-1994.

BREAK AND DEBURR ALL SHARP EDGES

3rd ANGLE PROJECTION

DO NOT SCALE DRAWING

TRANSNUCLEAR

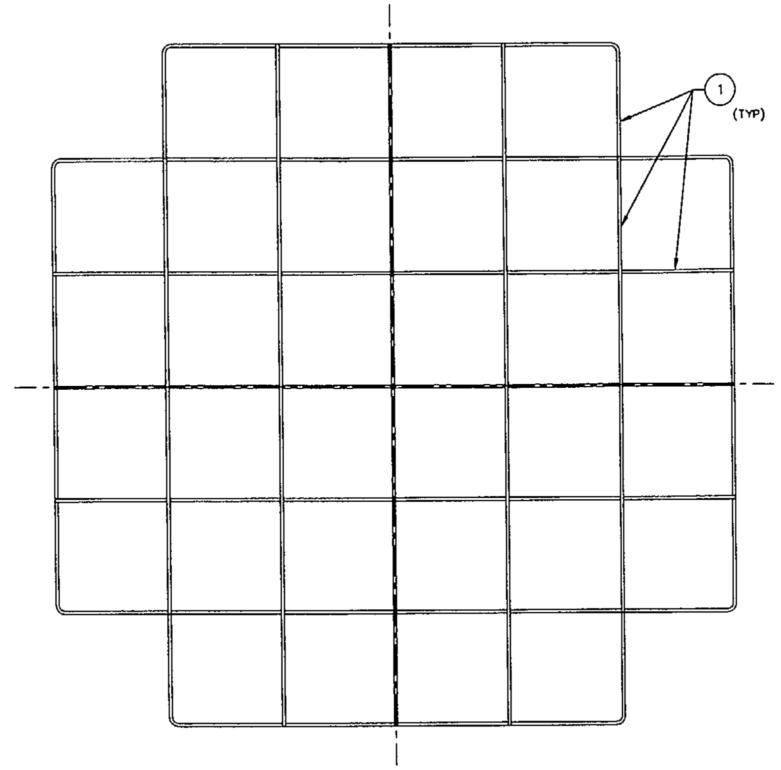
TITLE: SAFETY ANALYSIS REPORT
NUHOMS® 32PT TRANSPORTABLE STORAGE CANISTER FOR PWR FUEL BASKET ASSEMBLY – OPTION 1

FILE NO.	DWG. NO.	SCALE	SHEET	REV. NO.
NUH32PT.1003.SAR	NUH-32PT-1003NP-SAR	NONE	1 OF 2	1

MADE FROM DRAWING NUH-32PT-1003NP, REV 1

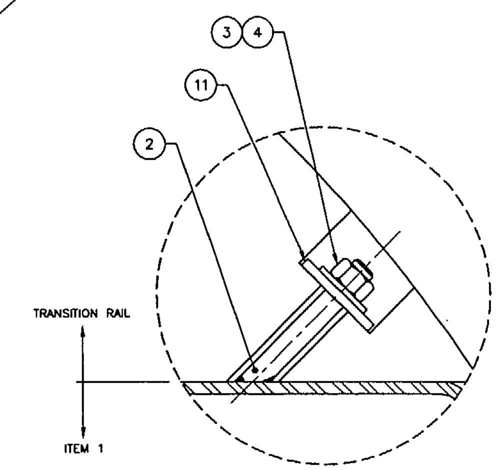
U.S. Patent No. 4,780,269 & 5,438,597
Transnuclear, Inc.

WELDING AND CONNECTION DETAILS

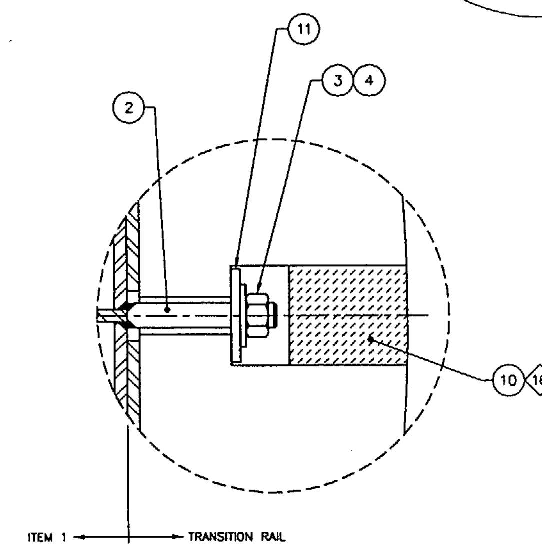


SECTION THRU BASKET AT MIDLENGTH
SHOWING ITEM 1 ONLY

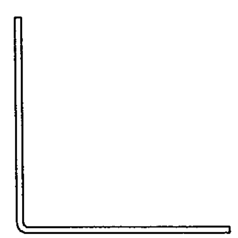
PROPRIETARY



DETAIL 1 9



DETAIL 2 9



ITEM 5
NEUTRON ABSORBING SHEET
NOT TO SCALE

ITEM 6
ALUMINUM SHEET
NOT TO SCALE

ITEM 9
ALUMINUM SHEET
NOT TO SCALE

MADE FROM DRAWING
NUH-32PT-1003NP, REV 1

U.S. Patent No. 4,780,269 & 5,438,597
Transnuclear, Inc.

(SEE SHEET 1 FOR PARTS LIST)

ITEM NO.	QTY REQ'D	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL SPECIFICATION	QUALITY CATEGORY

PARTS LIST

ALL DIMENSIONS ARE APPLICABLE AT 70°F AND ALL TOLERANCING APPLIES AFTER WELDING AND FINAL ASSEMBLY UNLESS NOTED OTHERWISE.

DIMENSIONS ARE IN INCHES AND DEGREES UNLESS NOTED OTHERWISE. DIMENSIONING AND TOLERANCING IN ACCORDANCE WITH ASME Y14.5M-1994.

BREAK AND DEBURR ALL SHARP EDGES

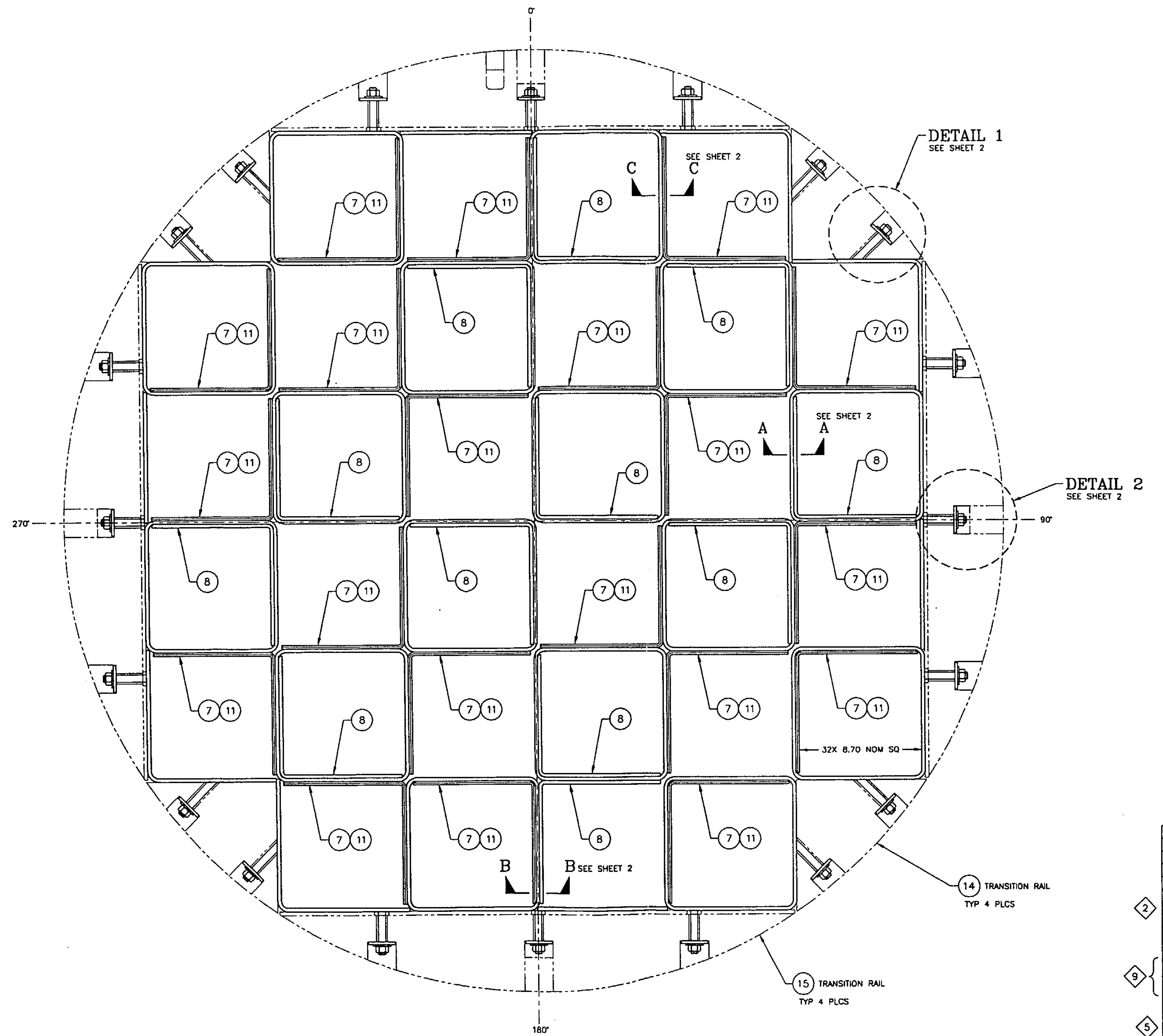
3rd ANGLE PROJECTION

DO NOT SCALE DRAWING

TRANSNUCLEAR

TITLE: SAFETY ANALYSIS REPORT
NUHOMS® 32PT TRANSPORTABLE STORAGE CANISTER FOR PWR FUEL BASKET ASSEMBLY- OPTION 1

FILE NO.	DWG. NO.	SCALE	SHEET	REV. NO.
NUH32PT.1003.SAR	NUH-32PT-1003NP-SAR	NONE	2 OF 2	1



SECTION THRU BASKET AT MIDLENGTH
THICKNESS OF ITEMS 7, 8, AND 11 EXAGGERATED FOR CLARITY

NOTES:

1. (PROPRIETARY).
2. ALTERNATE DETAILS OR METHODS OF ATTACHMENT ARE ACCEPTABLE WITH TN APPROVAL.
3. (PROPRIETARY).
4. (PROPRIETARY).
5. TUBES MAY BE EXTRUDED OR FORMED. ONE OR TWO LONGITUDINAL FULL PENETRATION WELD SEAMS ARE ALLOWED IN THE FLAT SIDES OF EACH FORMED TUBE. 100% VISUAL INSPECTION OF BOTH SIDES OF WELD SHALL BE PERFORMED. SEAMLESS OR WELDED AND DRAWN SLEEVES ARE ALSO ACCEPTABLE.
6. (PROPRIETARY).
7. (PROPRIETARY).
8. (PROPRIETARY).
9. ALTERNATE DETAILS OR METHODS OF ATTACHMENT ARE ACCEPTABLE WITH TN APPROVAL. RAIL TO BE SLOTTED TO PERMIT UNRESTRAINED THERMAL EXPANSION.
10. (PROPRIETARY).
11. WELD SYMBOLS ARE PER ANSI/AWS 2.4-98. WELD SIZES ARE MINIMUM. ALTERNATE WELDS OF EQUIVALENT STRENGTH MAY BE USED WITH TN APPROVAL.
12. CUTOUTS AT BOTTOM OF EACH FUEL COMPARTMENT CELL SHALL BE MADE TO FACILITATE DRAINING.
13. BASKET ASSEMBLY TO HAVE SUFFICIENT CLEARANCE WHEN INSERTED INTO CANISTER TO ALLOW FOR THERMAL EXPANSION.
14. (PROPRIETARY).
15. (PROPRIETARY).
16. HOLES IN ITEMS 7, 8, AND 11 TO BE SLOTTED TO ALLOW THERMAL EXPANSION.
17. SIZE ITEM 12 AS NEEDED TO FIT IN OPENING AND TO CLEAR STUD. TACK WELD IN PLACE.

	ITEM NO.	QTY REQ'D	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL SPECIFICATION	QUALITY CATEGORY
	15	4	NUH-32PT-1006	R90 ALUMINUM TRANSITION RAIL	--	A
	14	4	NUH-32PT-1006	R45 ALUMINUM TRANSITION RAIL	--	A
	13	140		OVAL WASHER	SST	NITS
	12	28		ALUMINUM PLUG	TYPE 6061	NITS
	11	20		ALUMINUM SHEET, .05 THK	TYPE 1100	B
	10	128		SHEET	ASTM A240 TYPE 304	A
2	9	A/R		SCREW, FLAT COUNTERSUNK HEAD CAP	SST	C
	8	12		ALUMINUM SHEET, .125 THK	TYPE 1100	B
	7	20		NEUTRON ABSORBING SHEET, .075 THK		B
9	6	140		STD WASHER, ø1/2	SST	C
9	5	140		HEX NUT, ø1/2	SST	C
9	4	140		STUD, ø1/2	ASTM A479, TYPE XM-19	C
	3	4		CORNER PLATE, .25 THK	ASME SA-240 TYPE XM-19	A
	2	4		PLATE, .25 THK	ASME SA-240 TYPE XM-19	A
5	1	32		TUBE, .25 THK	ASME SA-240 TYPE XM-19	A

PARTS LIST

ALL DIMENSIONS ARE APPLICABLE AT 70°F AND ALL TOLERANCING APPLIES AFTER WELDING AND FINAL ASSEMBLY UNLESS NOTED OTHERWISE.

DIMENSIONS ARE IN INCHES AND DEGREES UNLESS NOTED OTHERWISE. DIMENSIONING AND TOLERANCING IN ACCORDANCE WITH ASME Y14.5M-1994.

BREAK AND DEBURR ALL SHARP EDGES

3rd ANGLE PROJECTION

DO NOT SCALE DRAWING

TRANSNUCLEAR

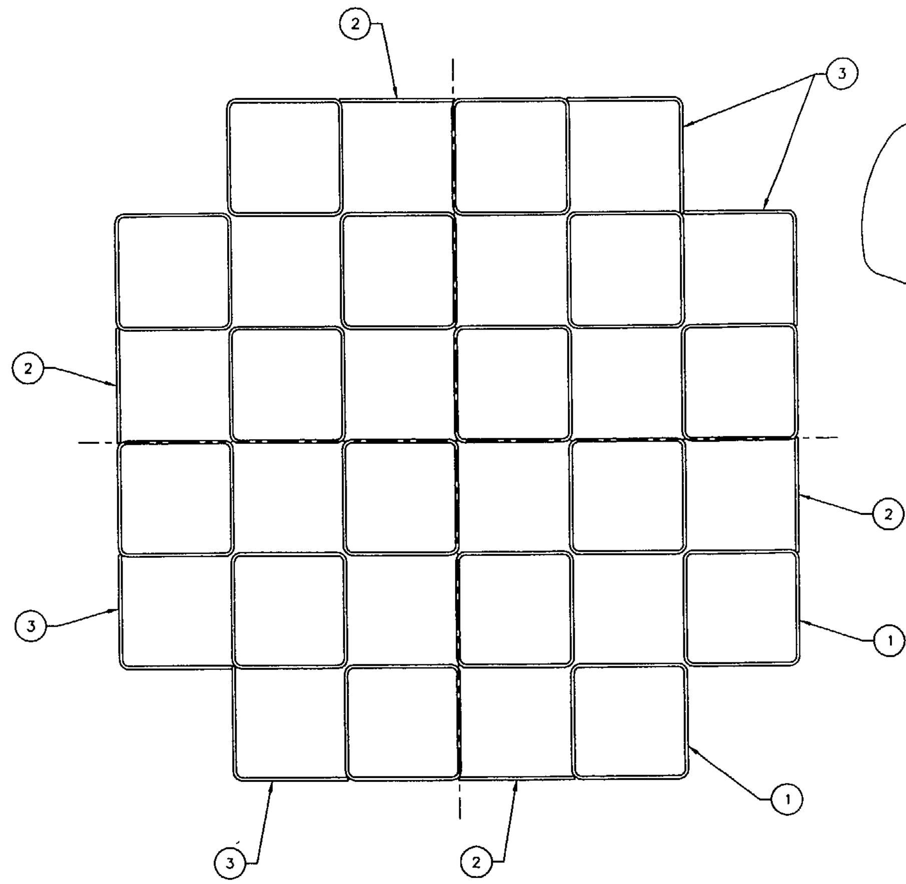
TITLE: SAFETY ANALYSIS REPORT
NUHOMS® 32PT TRANSPORTABLE STORAGE CANISTER FOR PWR FUEL BASKET ASSEMBLY – OPTION 2

FILE NO.	DWG. NO.	SCALE	SHEET	REV. NO.
NUH32PT.1004.SAR	NUH-32PT-1004NP-SAR	NONE	1 OF 2	1

MADE FROM DRAWING NUH-32PT-1004NP, REV 1

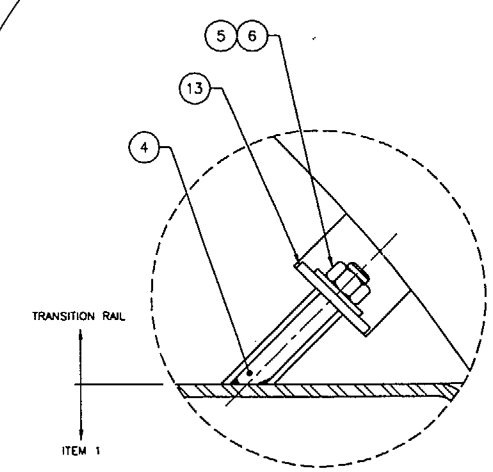
U.S. Patent No. 4,780,269 & 5,438,597
Transnuclear, Inc.

WELDING AND CONNECTION DETAILS

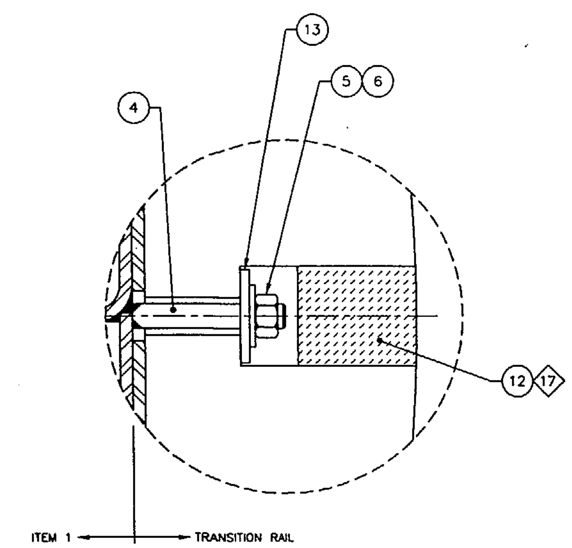


SECTION THRU BASKET AT MIDLENGTH
SHOWING ITEMS 1, 2, AND 3 ONLY

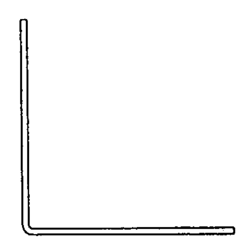
PROPRIETARY



DETAIL 1 ⟨9⟩



DETAIL 2 ⟨9⟩



ITEM 7
NEUTRON ABSORBING SHEET
NOT TO SCALE

ITEM 8
ALUMINUM SHEET
NOT TO SCALE

ITEM 11
ALUMINUM SHEET
NOT TO SCALE

MADE FROM DRAWING
NUH-32PT-1004NP, REV 1

U.S. Patent No. 4,780,269 & 5,438,597
Transnuclear, Inc.

(SEE SHEET 1 FOR PARTS LIST)

ITEM NO.	QTY REQ'D	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL SPECIFICATION	QUALITY CATEGORY

PARTS LIST

ALL DIMENSIONS ARE APPLICABLE AT 70°F AND ALL TOLERANCING APPLIES AFTER WELDING AND FINAL ASSEMBLY UNLESS NOTED OTHERWISE.

DIMENSIONS ARE IN INCHES AND DEGREES UNLESS NOTED OTHERWISE. DIMENSIONING AND TOLERANCING IN ACCORDANCE WITH ASME Y14.5M-1994.

BREAK AND DEBURR ALL SHARP EDGES

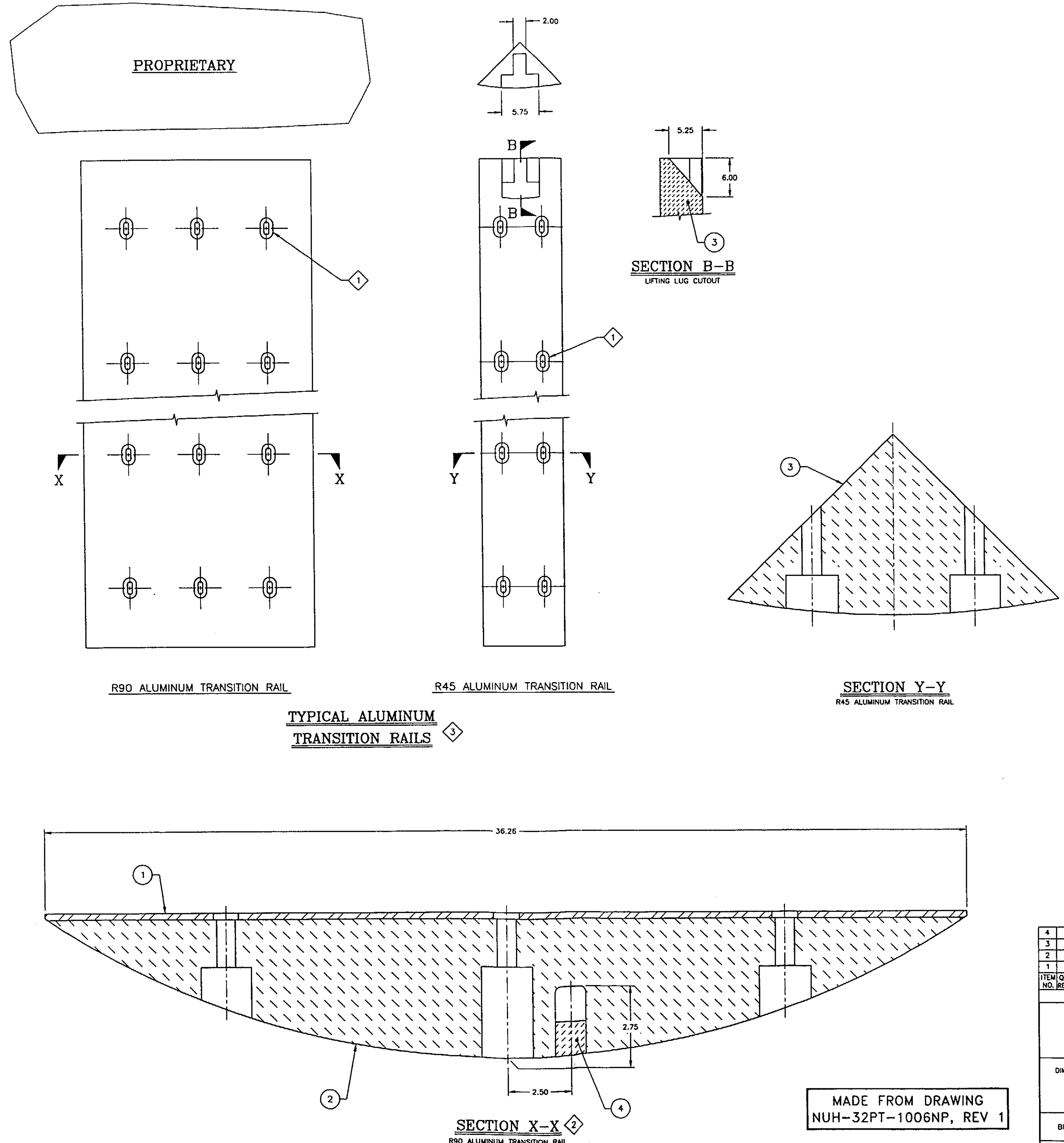
3rd ANGLE PROJECTION

DO NOT SCALE DRAWING

TRANSNUCLEAR

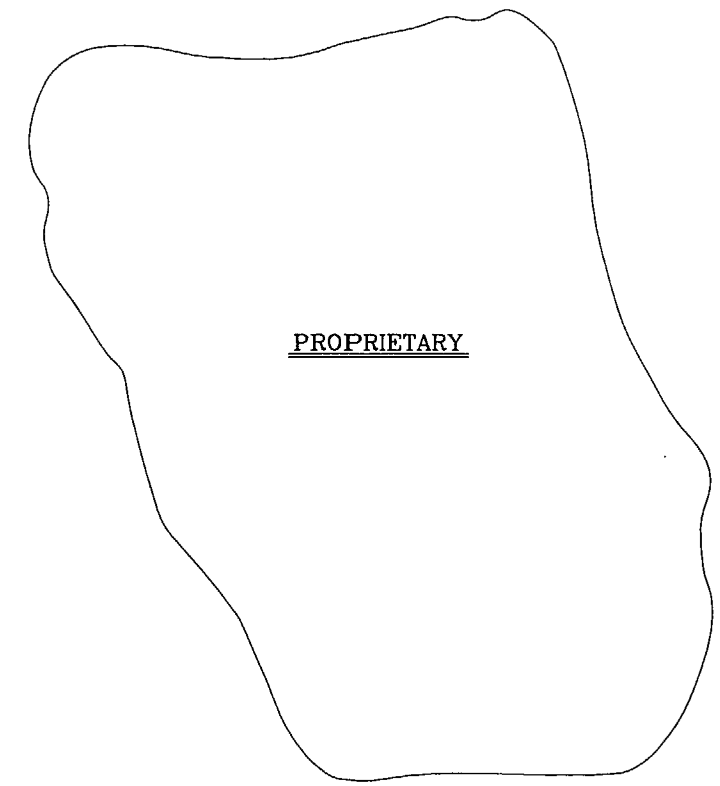
TITLE: SAFETY ANALYSIS REPORT
NUHOMS® 32PT TRANSPORTABLE STORAGE CANISTER FOR PWR FUEL BASKET ASSEMBLY – OPTION 2

FILE NO.	DWG. NO.	SCALE	SHEET	REV. NO.
NUH32PT.1004.SAR	NUH-32PT-1004NP-SAR	NONE	2 OF 2	1



NOTES:

1. TRANSITION RAIL ATTACHMENT HOLES ARE FOR ATTACHING ITEMS 1, 2, AND 3 TO BASKET ASSEMBLY. LOCATE FASTENER SLOTS AT 7 ELEVATIONS (MIN) ALONG RAIL LENGTH. MINIMUM 2 ROWS PER RAIL SEGMENT. ALTERNATE DETAILS OR METHODS OF ATTACHMENT ARE ACCEPTABLE WITH TN APPROVAL.
2. FABRICATOR MAY USE FLUSH MOUNTED SCREWS TO ATTACH ITEM 1 TO ITEM 2 PRIOR TO INSTALLATION IN BASKET. PROVISIONS SHALL BE MADE TO PERMIT RELATIVE THERMAL EXPANSION BETWEEN SST PLATE AND ALUMINUM RAILS.
3. TRANSITION RAILS MAY BE FABRICATED IN MULTIPLE SEGMENTS.
4. ALL DIMENSIONS ARE NOMINAL UNLESS NOTED OTHERWISE.
5. ITEMS 2 AND 3 MAY BE DRILLED AND TAPPED TO FACILITATE LIFTING.



MADE FROM DRAWING
NUH-32PT-1006NP, REV 1

U.S. Patent No. 4,780,269 & 5,438,597
Transnuclear, Inc.

PARTS LIST

ITEM NO.	QTY REQ'D	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL SPECIFICATION	QUALITY CATEGORY
4	1		ALUMINUM PLUG, BAR STOCK	TYPE 6061	NITS
3	1		R45 ALUMINUM RAIL	TYPE 6061	A
2	1		R90 ALUMINUM RAIL	TYPE 6061	A
1	1		TRANSITION RAIL PLATE, .25 THK	ASTM A240 TYPE XM-19	A

ALL DIMENSIONS ARE APPLICABLE AT 70°F AND ALL TOLERANCING APPLIES AFTER WELDING AND FINAL ASSEMBLY UNLESS NOTED OTHERWISE.

DIMENSIONS ARE IN INCHES AND DEGREES UNLESS NOTED OTHERWISE. DIMENSIONING AND TOLERANCING IN ACCORDANCE WITH ASME Y14.5M–1994.

BREAK AND DEBURR ALL SHARP EDGES

3rd ANGLE PROJECTION

DO NOT SCALE DRAWING

TRANSNUCLEAR

TITLE: SAFETY ANALYSIS REPORT
NUHOMS® 32PT TRANSPORTABLE STORAGE CANISTER FOR PWR FUEL ALUMINUM TRANSITION RAILS

FILE NO.	DWG. NO.	SCALE	SHEET	REV. NO.
NUH32PT.1006.SAR	NUH-32PT-1006NP-SAR	NONE	1 OF 1	1

M.1.6 References

1.1 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.

1.2 10CFR72, Rules and Regulations, Title 10, Chapter 1, Code of Federal Regulations - Energy, U.S. Nuclear Regulatory Commission, Washington, D.C., "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste."

1.3 10CFR71, Rules and Regulations, Title 10, Chapter 1, Code of Federal Regulations - Energy, U.S. Nuclear Regulatory Commission, Washington, D.C., "Packaging and Transportation of Radioactive Material."

Table M.1-1
Nominal Dimensions and Weight of the NUHOMS®-32PT DSC

	32PT DSC Design Configuration			
	32PT-S100	**32PT-S125**	**32PT-L100**	**32PT-L125**
Canister Length (in.)	186.2	186.2	192.2	192.2
Outside Diameter (in)	67.19	67.19	67.19	67.19
Cavity Length (in.)	169.6	167.1	175.6	173.1
Cavity Diameter (in)	66.19	66.19	66.19	66.19
Nominal DSC Loaded Weight, Dry (kips)	*88.1*	*100.4*	*89.1*	*101.4*

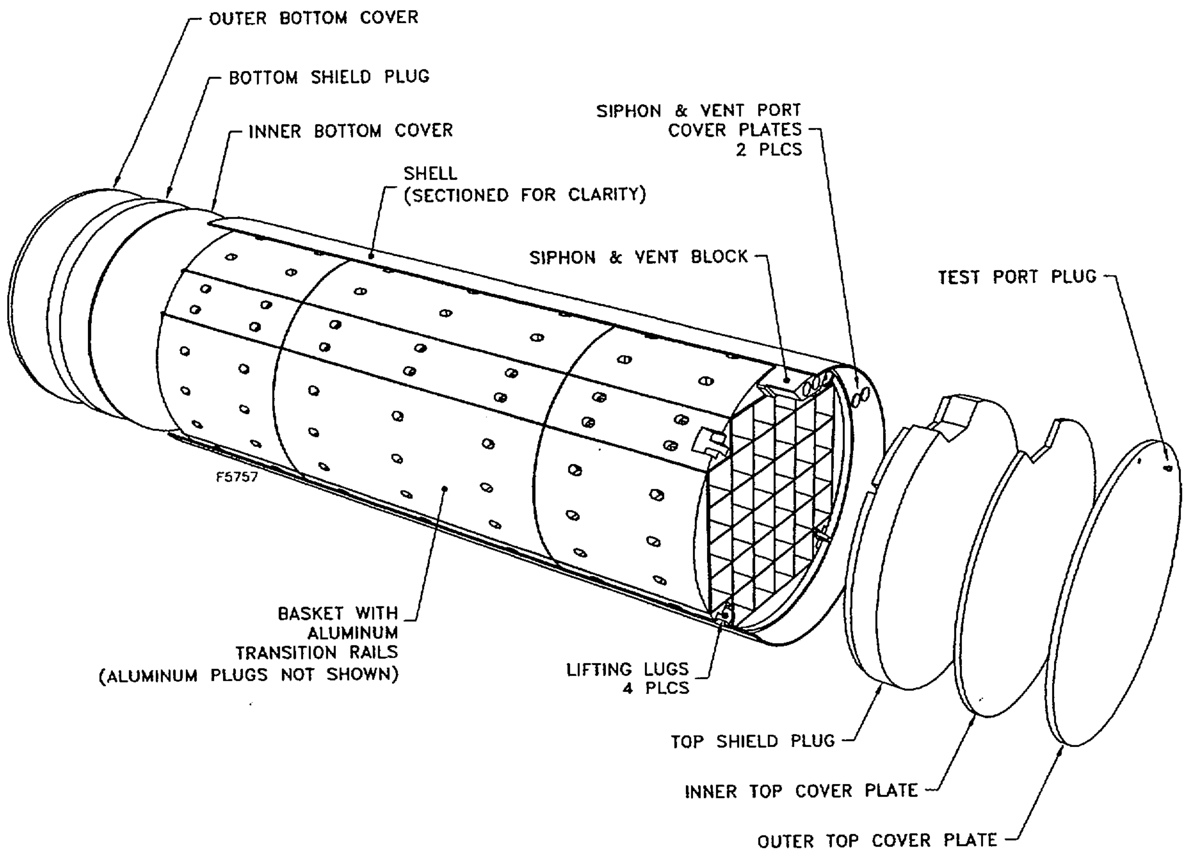
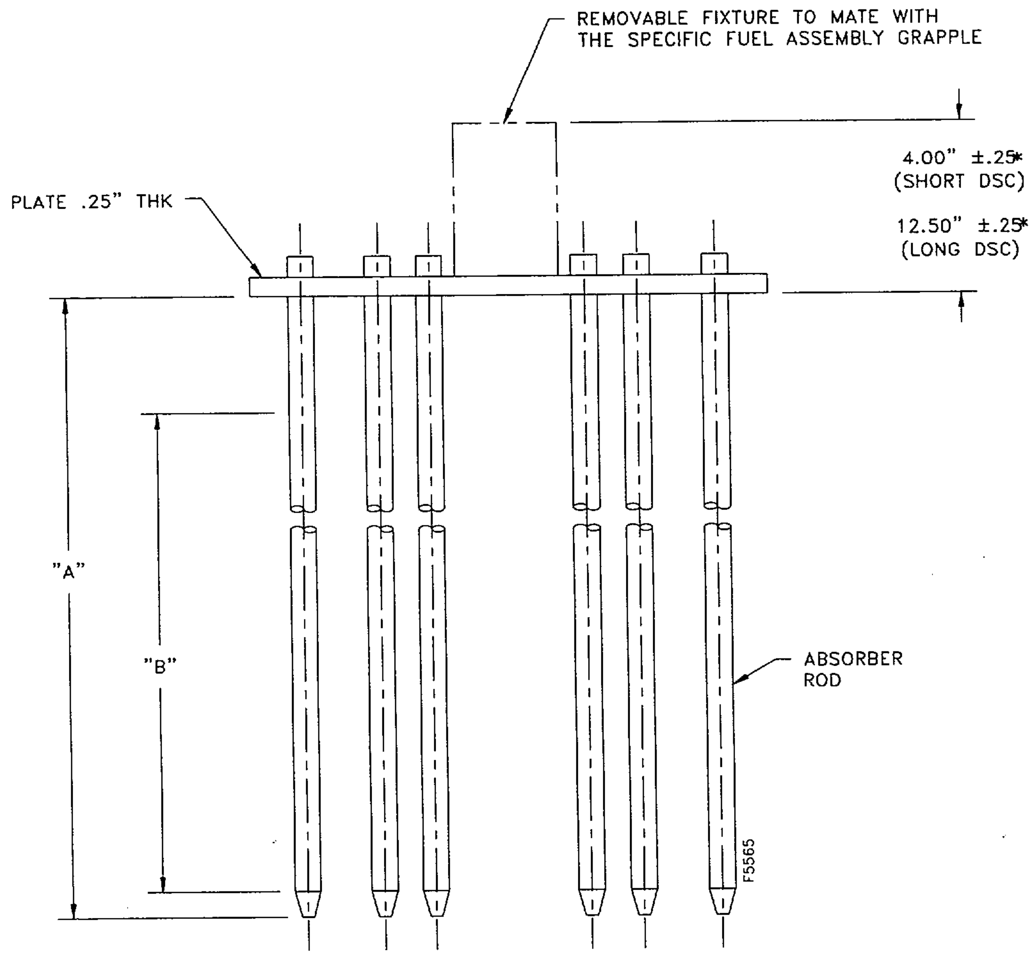


Figure M.1-1
NUHOMS®-32PT DSC Components



*THESE DIMENSIONS ARE FOR USE WITH WESTINGHOUSE 17x17 FUEL ASSEMBLIES. DIMENSIONS WILL VARY AS REQUIRED BY FUEL ASSEMBLY TYPE.

DIMENSION	FUEL ASSEMBLY TYPE				
	WE 17x17	B&W 15x15	WE 15x15	CE 14x14	WE 14x14
ABSORBER ROD OD NOMINAL (in)	.362	.438	.450	.975	.432
MINIMUM ABSORBER ROD DIMENSION "A" (IN)	156	160	156	143	156
MINIMUM B_4C PELETS STACK HEIGHT, "B" (IN)	151	151	150	129	150
CLAD THICKNESS NOMINAL (in)	.018	.022	.023	.049	.022
No. OF RODS	24	16	20	5	16
MATERIAL	304 SST	304 SST	304 SST	304 SST	304 SST

Figure M.1-2
Poison Rod Assemblies (PRAs)

Table M.2-20
Summary of NUHOMS®-32PT Component Design Loadings[(1)]

Component	Design Load Type	FSAR Section Reference	Design Parameters	Applicable Codes
32PT-DSC:	---	---	---	ASME Code, 1998 Edition with 2000 Addenda, Section III, Subsection NB and Appendix F (Shell) and Subsections NG, NF and Appendix F (Basket) with exceptions noted in Table M.3.1-2.
	Flood	M.2.2.2	Maximum water height: 50 ft.	10CFR72.122(b)
	Seismic	M.2.2.3	Horizontal ground acc: 0.25g Vertical ground acc.: 0.17g	NRC Reg. Guides 1.60 & 1.61
	Dead Load	M.3.6.1.2 M.3.6.1.3	Maximum enveloping weight of loaded 32PT DSCs: 101,200 lbs.	ANSI 57.9-1984
	Normal and Off-Normal Pressure	M.3.6.1.2 M.3.6.1.3	Enveloping internal pressure of ≤15 psig (Normal) and < 20 psig (Off-Normal)	10CFR72.122(h)
	Test Pressure	M.3.6.1.2	Enveloping internal pressure of *18* psig applied w/o DSC outer top cover plate	10CFR72.122(h)
	Normal and Off-Normal Operating Temperature	M.3.6.1.2 M.3.6.1.3 M.3.6.2.2 M.4.4 M.4.5	DSC with spent fuel rejecting 24 kW (PWR) decay heat. Ambient air temperature -40°F to 117°F	ANSI 57.9-1984
	Normal Handling Loads	M.3.6.1.2 M.3.6.1.3	1. Hydraulic ram load of 80,000 lb.(DSC HSM insertion) 60,000 lb (DSC HSM extraction) 2. Transfer (to/from ISFSI) Loads of: 2a. +/-1.0g axial 2b. +/-1.0g transverse 2c. +/-1.0g vertical 2d. +/-0.5g axial +/-0.5g transverse +/-0.5g vertical	ANSI 57.9-1984
	Off-Normal Handling Loads	M.3.6.1.2	Hydraulic ram load of: 80,000 lb (DSC HSM insertion) 80,000 lb (DSC HSM extraction)	ANSI-57.9-1984

The NUHOMS®-32PT basket is a welded assembly of stainless steel plates or tubes that make up a fuel support assembly grid designed to accommodate up to 32 PWR fuel assemblies. The basket structure consists of the fuel support structure, the transition rails, aluminum heat transfer material, and neutron absorbing material.

The 32PT basket assembly is shown on drawings NUH-32PT-1003, *-1004 and -1006.* These drawings are provided in Section M.1.5.

- The fuel support structure is fabricated from high strength (Type XM-19) stainless steel and contains 32 square fuel compartments in a box arrangement.
- The transition rails provide the transition between the "rectangular" fuel support grid and the cylindrical internal diameter of the DSC shell. There are two sizes of transition rails. The large rails are referred to as the R90 transition rails. The smaller transition rails are referred to as the R45 transition rails.

  NOTE: The NUHOMS®-32PT basket configuration with welded steel transition rails presented in Chapter M.1 and the corresponding thermal analysis presented in Chapter M.4 have been deleted. Accordingly, the structural analysis for the basket with welded steel rail option as presented in this Chapter M.3 will be deleted following approval of this application.

  The revised thermal analysis for the basket configuration with solid aluminum rail design presented in Chapter M.4 demonstrates that the calculated basket component temperatures are lower than the temperatures for the steel rail design. The structural analysis presented in Chapter M.3 uses higher temperatures resulting from the steel rail design for both the steel and aluminum transition rail configurations. Hence, the DSC structural analysis for the solid aluminum rail design is conservative.

- *Two material/fabrication designs are evaluated for the transition rails:*
  - Solid Aluminum Rails: The transition rails are solid sections of 6061 aluminum alloy. The large (R90) rails include an XM-19 "cover plate" between the fuel support grid and the aluminum body. The structural evaluation of the rails uses properties for annealed aluminum (no credit is taken for enhanced properties obtained by heat treatment).
  - Welded Steel Transition Rails: The steel transition rails are welded steel structures fabricated with 3/8" thick Type 304 stainless steel. To enhance heat transfer through the rails, aluminum plates are connected to the transition rail structure. No credit is taken for these aluminum plates in the structural evaluation of the steel transition rails.
- The fuel support grid structure contains aluminum alloy 1100 plates as heat transfer material and neutron absorbing plates. No credit is taken for the structural capacity of the aluminum heat transfer plates or neutron absorbing materials in the structural evaluation of the support grid structure.

- The connections between the transition rails and fuel support structure are not required to maintain structural capacity of the basket assembly. These connections are primarily to simplify fabrication and are designed to allow free thermal expansion of the connected parts.

The basket structure is open at each end such that longitudinal fuel assembly loads are applied directly to the DSC/cask body and not to the basket structure. The fuel assemblies are laterally supported by the XM-19 fuel support structure. The basket is laterally supported by the basket transition rails and the DSC inner shell.

Inside the TC, the DSC rests on two 3" wide rails ("cask rails"), attached to the inside of the TC at +/-18.5° from the bottom centerline of the DSC. In the HSM, the DSC is supported by rails located at +/-30° from the bottom centerline of the DSC.

The nominal open dimension of each fuel compartment cell is 8.70 in. x 8.70 in. which provides clearance around the fuel assemblies. The overall basket length is less than the DSC cavity length to allow for thermal expansion and tolerances.

M.3.1.2 Design Criteria

Design criteria for the DSC shell and basket are provided in Section M.2.2.

M.3.1.2.1 DSC Shell Assembly Confinement Boundary

The primary confinement boundary consists of the DSC shell, the inner top cover plate, the inner bottom cover plate, the siphon vent block, the siphon/vent port cover plates, and the associated welds. Figure M.3-1 provides a graphic representation of the 32PT-DSC confinement boundary. The outer top cover plate forms the redundant confinement boundary.

The welds made during fabrication of the 32PT-DSC that affect the confinement boundary of the DSC include the inner bottom cover plate to shell weld and the circumferential and longitudinal seam welds applied to the shell. These welds are inspected (radiographic or ultrasonic inspection, and liquid penetrant inspection) according to the requirements of Subsection NB of the ASME Code.

The top inner cover plate and associated welds, the welds applied to the vent and siphon port covers, and the closure welds applied to the vent & siphon block, define the primary confinement boundary at the top end of the 32PT-DSC. These welds are in accordance with the alternative ASME Code Section III requirements of ASME Code Case N-595-2. These welds are applied using a multiple-layer technique and are liquid penetrant (PT) examined in accordance with Code Case N-595-2 [3.1] and Section III NB-5000.

During fabrication, leak tests of the 32PT-DSC shell assembly are performed in accordance with ANSI N14.5-1997 [3.13] to demonstrate that the shell is leaktight ($1x10^{-7}$ std. cm^3/sec). The DSC inner top cover closure welds, including the vent and siphon pressure boundary welds, are also leak tested after fuel loading to demonstrate that the ANSI N14.5 leaktight criteria is met following installation of the outer cover plate root pass weld.

The basis for the allowable stresses for the confinement boundary is ASME Code Section III, Division I, Subsection NB Article NB-3200 [3.1] for normal (Level A) condition loads , off-normal (Level B) condition loads and off-normal/accident (Level C) condition loads, and Appendix F for accident (Level D) condition loads. See Section M.2.2 for additional design criteria.

M.3.1.2.2 DSC Basket

The basket is designed to meet heat transfer, nuclear criticality, and structural requirements. The basket structure provides sufficient rigidity to maintain a subcritical configuration under the applied loads. The Type XM-19 stainless steel members in the NUHOMS®-32PT basket are the primary structural components. The aluminum heat transfer plates and neutron poison plates are the primary heat conductors, and provide the necessary criticality control. The transition rails provide support to the fuel compartment grid for mechanical loads and also transfer heat from the fuel compartments to the DSC shell.

The stress analyses of the basket do not take credit for the neutron absorbing/heat transfer plate material.

The basket structural design criteria is provided in Section M.2.2. The basis for the allowable stresses for the stainless steel components in the basket assembly is Section III, Division 1, Subsection NG of the ASME Code [3.1]:

- Normal conditions are evaluated using criteria from NG-3200.
- Accident conditions are classified as Level D events and are evaluated using stress and stability criteria from Section III, Appendix F of the ASME Code [3.1].

M.3.1.2.3 Alternatives to the ASME Code for the 32PT DSC

The primary confinement boundary of the NUHOMS®-32PT DSC consists of the DSC shell, the inner top cover plate, the inner bottom cover plate, the siphon vent block, and the siphon/vent port cover plate. Even though the ASME B&PV code is not strictly applicable to the DSC, it is TNW's intent to follow Section III, Subsection NB of the Code as closely as possible for design and construction of the confinement vessel. The DSC may, however, be fabricated by other than N-stamp holders and materials may be supplied by other than ASME Certificate Holders. Thus the requirements of NCA are not imposed. TNW's quality assurance requirements, which are based on 10CFR72 Subpart G and NQA-1 are imposed in lieu of the requirements of NCA-3800. The SAR is prepared in place of the ASME design and stress reports. Surveillances are performed by TNW and utility personnel rather than by an Authorized Nuclear Inspector (ANI).

The basket is designed, fabricated and inspected in accordance with the ASME Code Subsection NG. The following alternative provisions to the ASME Code Section III requirements are taken:

The poison rod assemblies, poison plates, and aluminum heat transfer plates are not considered for structural integrity. Therefore, these materials are not required to be Code materials. The quality assurance requirements of NQA-1 is imposed in lieu of NCA-3800. The basket is not

Code stamped. Therefore, the requirements of NCA are not imposed. Fabrication and inspection surveillances are performed by TNW and utility personnel rather than by an ANI.

A complete list of the alternatives to the ASME Code and corresponding justification for the NUHOMS®-32PT DSC and basket is provided in Table M.3.1-1 and Table M.3.1-2.

Table M.3.2-1
Summary of the NUHOMS®-32PT System Component Nominal Weights

Component Description	CALCULATED WEIGHT (kips)			
	32PT-S100	32PT-S125	32PT-L100	32PT-L125
DSC Shell Assembly(1)	13.06	14.28	13.24	14.46
DSC Top Shield Plug Assembly(2)	8.71	9.93	8.71	9.93
DSC Internal Basket Assembly	*22.69*	*22.35*	*23.50*	*23.16*
Total Empty Weight	***44.47***	***46.57***	***45.46***	***47.56***
32 PWR Spent Fuel Assemblies	≤ 43.68(3)	≤ 53.82(4)	≤ 43.68(3)	≤ 53.82(4)
Total Loaded DSC Weight (Dry)	***88.15***	***100.38***	***89.14***	***101.38***
Water in Loaded DSC	6.81(5)	10.75	6.40(6)	11.37
Total Loaded DSC Weight (Wet)	***95.0***	***111.1***	***95.5***	***112.8***
Cask Spacer	1.10	1.10	0.79	0.79
OS197 (OS197H) TC Empty Weight(7)	106.67	111.25	106.67	111.25
Total Loaded TC Weight	***196.0***	***212.7***	***196.6***	***213.4***
HSM Single Module Weight Maximum (Empty)	**263.0**	**263.0**	**263.0**	**263.0**
HSM Single Module Weight Maximum (Loaded)	***351.2***	***363.4***	***352.1***	***364.4***

Notes:

1. Excludes top cover plates and shield plug.
2. Includes top cover plates and shield plug.
3. Based on a fuel weight of 1,365 lbs per assembly. This is a limit for the 32PT-S100 and 32PT-L100 DSCs to ensure that the maximum lift weight of the loaded TC is under 100 tons.
4. Based on B&W 15x15 fuel (with control components) weight of 1,682 lbs per assembly.
5. Based on water volume reduced to 50% of capacity to ensure that the maximum lift weight of the loaded TC is under 100 tons for the 32PT-S100 DSC.
6. Based on water volume reduced to 45% of capacity to ensure that the maximum lift weight of the loaded TC is under 100 tons for the 32PT-L100 DSCs.
7. Includes cask top cover plate. The neutron shield is filled with demineralized water for the 32PT-S125 and 32PT-L125 DSCs. For the 32PT-S100 and 32PT-L100 DSCs, the neutron shield is not filled with demineralized water to ensure that the maximum lift weight of the loaded cask is under 100 tons .

(C) Design Basis Thermal Loads

The normal condition temperature distributions for the 32PT-DSC are presented in Section M.4. Stress analysis for normal thermal loads for the DSC shell assembly are provided in Section M.3.6.1.2(C) and in Section M.3.4.4 for the basket assembly.

(D) Operational Handling Loads

There are two categories of handling loads: (1) inertial loads associated with on-site handling and transporting the DSC between the fuel handling/loading area and the HSM, and (2) loads associated with loading the DSC into, and unloading the DSC from, the HSM. These handling loads are described in Section 8.1.1.1C.

Based on the surface finish and the contact angle of the DSC support rails inside the HSM (described in Chapter 4), a bounding coefficient of friction is conservatively assumed to be 0.25. Therefore, the nominal ram load required to slide the DSC under normal operating conditions is approximately *29,400* lbs., calculated as follows:

$$P = \frac{0.25W}{Cos\theta} = 0.29W \qquad = 0.29\ (\mathit{100{,}400}\ \text{lbs.}) \approx \mathit{29{,}400}\ \text{lbs.}$$

Where:

P = Push/Pull Load,

W = Loaded DSC Weight ≈ *101,400* lbs. (See Table M.3.2-1), and

θ = 30 degrees, Angle of the Canister Support Rail.

However, the DSC bottom cover plate and grapple ring assembly are designed to withstand a normal operating insertion force equal to 80,000 pounds and a normal operating extraction force equal to 60,000 pounds. To insure retrievability for a postulated jammed DSC condition, the ram is sized with a capacity for a load of 80,000 pounds, as described in Section 8.1.2. These loads bound the friction force postulated to be developed between the sliding surfaces of the DSC and TC during worst case off-normal conditions.

(E) Design Basis Live Loads

As discussed in Section 3.2.4, a live load of 200 pounds per square foot is conservatively selected to envelope all postulated live loads acting on the HSM, including the effects of snow and ice. Live loads which may act on the TC are negligible, as discussed in Section 3.2.4.

M.3.6.1.2 Dry Shielded Canister Analysis

The standardized NUHOMS®-32PT DSC shell assembly is analyzed for the normal, off-normal and postulated accident load conditions using two basic ANSYS [3.11] finite element models: a top-end half-length model of the DSC shell assembly and a bottom-end half-length model of the

M.4 Thermal Evaluation

M.4.1 Discussion

The NUHOMS®-32PT system is designed to passively reject decay heat during storage and transfer for normal, off-normal and accident conditions while maintaining temperatures and pressures within specified regulatory limits. Objectives of the thermal analyses performed for this evaluation include: (1) determination of maximum and minimum temperatures with respect to material limits to ensure components perform their intended safety functions, (2) determination of temperature distributions for the NUHOMS®-32PT DSC components to support the calculation of thermal stresses for the structural components, (3) determination of maximum internal NUHOMS®-32PT DSC pressures for the normal, off-normal and accident conditions, (4) determination of the maximum fuel cladding temperature, and (5) confirmation that this temperature will remain sufficiently low to prevent unacceptable degradation of the fuel during storage.

The NUHOMS®-32PT DSC falls under the jurisdiction of 10CFR Part 72 when used as a component of an ISFSI. To establish the heat removal capability, several thermal design criteria are established for the basket. These are as discussed below:

- Maximum temperatures of the confinement structural components must not adversely affect the confinement function.
- The maximum initial fuel cladding temperature during storage (long-term) is determined as a function of the initial fuel age using accepted guidelines provided by PNL-6189 [4.1]. In addition, maximum fuel cladding temperature limits are defined for short-term conditions like loading, unloading, transfer and accident conditions using PNL-4835 [4.2]. The temperature threshold accounts for the effects of cladding temperature, decay time, burnup and fission gas build-up at burnups of 45 GWd/MTU. For normal conditions of storage, a long-term fuel temperature limit based on time after discharge has been established and is shown in Table M.4-1. During short-term conditions, the fuel temperature limit is 570°C (1,058°F).
- The maximum DSC cavity internal pressures during normal, off-normal and accident conditions must be below the design pressures of 15 psig, 20 psig and 105 psig, respectively.
- The maximum total heat load per DSC is 24kW with a maximum per assembly heat load of 1.2kW when zoning is used for heat load. Figure M.4-1, Figure M.4-2, and Figure M.4-3 show the heat load zoning configurations used in the NUHOMS®-32PT DSC design.

The analyses consider the effect of the decay heat flux varying axially along a fuel assembly. The axial heat flux profile for a PWR fuel assembly is shown in Figure M.4-4 and is based on [4.3].

A description of the detailed analyses performed for normal storage and transfer conditions is provided in Section M.4.4, off-normal conditions in Section M.4.5, accident conditions in Section M.4.6, and loading/unloading conditions in Section M.4.7. The thermal evaluation concludes that with a design basis heat load of up to 24 kW per DSC, all design criteria are satisfied.

The thermal analysis models for the NUHOMS®-32PT DSC used to determine fuel assembly effective conductivity, peak fuel clad temperatures and total cask thermal behavior are validated as follows:

The effective thermal conductivity of the fuel assemblies used in the 32PT DSC thermal analysis is based on very conservative assumption of radiation and conduction only where any convection is neglected. The thermal analysis also does not account for any convection in the basket regions.

*In [*4.17*], effective fuel conductivity values were calculated by the DOE and used to predict the fuel cladding temperatures. These calculated cladding temperatures were then compared to temperatures calculated using Wooton-Epstein method and a finite element model (COBRA-SFS). Effective conductivities are benchmarked against SNF storage cask test (e.g. TN24P and REA 2023 storage casks).* Figure M.4-15 *shows a comparison of the effective fuel conductivity values used for NUHOMS®-32PT DSC analysis (K_{eff}-applied) (versus K_{eff}-recommended by the DOE report) [*4.17*].*

The comparison in Figure M.4-15 *shows that effective fuel conductivities used in thermal analyses for NUHOMS®-32PT DSC are lower than the recommended values, which leads to a conservative prediction of the maximum fuel cladding temperature.*

*The basket design used for the NUHOMS®-32PT DSC is similar to the basket design of the Transnuclear TN-32 cask. Both designs use a tube and support rail type of basket which is significantly different than the spacer disc and guide sleeve type of basket design used for the NUHOMS®-24P DSCs. The methodology used to analyze the thermal performance of the NUHOMS®-32PT DSC is similar to the methodology used for analyzing the TN-32 cask. Thermal performance of TN-32 casks has been evaluated via thermal testing at different manufacturing sites. The result of these tests were submitted to the NRC [*4.18*]. Evaluation of the thermal testing shows that the assumptions made for the thermal analysis of the casks are conservative. Owing to the similarities of the TN-32 and NUHOMS®-32PT basket designs, the TN-32 evaluation is also applicable to 32PT design.*

M.4.2 Summary of Thermal Properties of Materials

The analyses use interpolated values where appropriate for intermediate temperatures. The interpolation assumes a linear relationship between the reported values. *The use of linear interpolation between temperature values in the tables for determining intermediate value of property is justified by the near-linear behavior as a function of temperature for the range of interest.*

The emissivity of stainless steel is 0.587 [4.7]. For additional conservatism an emissivity of 0.46 for stainless steel is used for the basket steel plates in the analysis. *The emissivity of aluminum rail material (type 6061) is 0.06 [4.21]. The tables below provide the thermal properties of materials used in the analysis of the NUHOMS®-32PT DSC.*

1. PWR Fuel with Helium Backfill

The effective thermal conductivity is the lowest calculated value for the various PWR fuel assembly types that may be stored in this DSC and corresponds to the B&W 15x15 PWR assembly.

Fuel in Helium, Transverse			
Temperature (°F)	**K (Btu/min-in-°F)**	**ρ (lb_m/in^3)**	**C_p (Btu/lb_m-°F)**
205	3.991e-4	0.120	0.0618
286	4.605e-4		0.0642
387	5.442e-4		0.0665
493	6.472e-4		0.0682
595	7.724e-4		0.0696
695	8.868e-4		0.0707
796	1.041e-3		0.0716

Fuel in Helium, Axial			
Temperature (°F)	**K (Btu/min-in-°F)**	**ρ (lb_m/in^3)**	**C_p (Btu/lb_m-°F)**
200	1.029e-3	0.120	0.0617
300	1.089e-3		0.0645
400	1.149e-3		0.0657
500	1.202e-3		0.0683
600	1.255e-3		0.0697
800	1.368e-3		0.0716

2. PWR Fuel in Vacuum

Temperature (°F)	K (Btu/min-in-°F)	ρ (lb_m/in^3)	C_p (Btu/lb_m-°F)
269	1.274E-04	0.120	0.0638
333	1.629E-04		0.0654
420	2.177E-04		0.0671
515	2.956E-04		0.0686
611	3.862E-04		0.0698
706	4.887E-04		0.0708
804	6.140E-04		0.0717

3. SA-240, Type 304 Stainless Steel [4.4]

Temperature (°F)	K (Btu/min-in-°F)	ρ (lbm/in^3)	C_p (Btu/lb_m-°F)
70	0.0119	0.284	0.116
100	0.0121		0.117
150	0.0125		0.119
200	0.0129		0.121
250	0.0133		0.124
300	0.0136		0.125
350	0.0140		0.127
400	0.0144		0.128
500	0.0151		-
600	0.0157		-
700	0.0164		-
800	0.0169		-

4. SA-240 Type XM-19 (22Cr-13Ni-5Mn) [4.4]

Temperature (°F)	K (Btu/min-in-°F)	ρ (lb_m/in^3)	C_p (Btu/lb_m-°F)
70	8.89e-3	0.284	0.113
100	9.17e-3		0.116
150	9.58e-3		0.119
200	9.86e-3		0.120
300	0.0107		0.125
400	0.0114		0.127
500	0.0122		0.130
600	0.0129		0.133
700	0.0138		0.135
800	0.0144		0.137
900	0.0150		0.137

5. Aluminum, Type 1100 [4.4]

Temperature (°F)	K (Btu/min-in-°F)	ρ (lb_m/in^3)	C_p (Btu/lb_m-°F)
70	0.185	0.098	0.214
100	0.183		0.216
150	0.181		0.219
200	0.178		0.222
250	0.177		0.224
300	0.175		0.227
350	0.174		0.229
400	0.173		0.232
751	*0.173(*)*		*0.232**

* *For aluminum Type 1100 and aluminum based neutron poison material, the calculated maximum temperatures do not exceed 620 °F during normal storage conditions and 751 °F during blocked vent conditions. The assumption of constant conductivity value at 400 °F for temperatures up to 751 °F is justified since, for pure aluminum, the conductivity change is approximately 2% for range of 400 °F – 751 °F [4.19]. Therefore, this small change would have a negligible impact on thermal results.*

6. Aluminum, Type 6061 *(used for transition rails only)* [4.4]

Temperature (°F)	K (Btu/min-in-°F)	ρ (lb_m/in^3)	C_p (Btu/lb_m-°F)
70	0.133	0.098	0.213
100	0.135		0.215
150	0.136		0.218
200	0.138		0.221
250	0.139		0.223
300	0.140		0.226
350	0.141		0.228
400	0.142		0.230
600	0.142(*)		0.230(*)

(*) Assumed values.

7. Aluminum Based Neutron Poison (from Section M.4.3)

Temperature (°F)	K (Btu/min-in-°F)	ρ (lb_m/in^3)	C_p (Btu/lb_m-°F)
68	0.0963	0.098	0.214
212	0.116		0.222
482	0.120		0.232
571	0.120		0.232
751	*0.120(*)*		*0.232(*)*

(*) Assumed values.

8. Air [4.5]

Temperature (°F)	K (Btu/min-in-°F)	ρ (lb_m/in^3)	C_p (Btu/lb_m-°F)
71	2.075E-5	N/A	N/A
107	2.199E-5		
206	2.528E-5		
314	2.869E-5		
404	3.139E-5		
512	3.447E-5		
602	3.693E-5		
692	3.929E-5		
764	4.114E-5		
800	4.203E-5		

9. Helium [4.6]

Temperature (°F)	K (Btu/min-in-°F)	ρ (lb_m/in^3)	C_p (Btu/lb_m-°F)
200	1.361E-4	N/A	N/A
300	1.493E-4		
400	1.635E-4		
500	1.793E-4		
600	1.949E-4		
700	2.094E-4		
800	2.232E-4		

10. Basket Grid Structure: XM-19 plus Helium or Air Gap

To account for imperfect contact between the XM-19 basket grid plates and adjacent components, a uniform gap of 0.0075 inch between the XM-19 plates and adjacent components is assumed. To model this gap, the effective conductivity of XM-19 and 0.0075 inch gap regions was calculated and applied to the XM-19 basket grid elements in the model. The effective conductivity is calculated using the parallel resistance method. This method is appropriate because for the geometry of the basket, the temperature gradients will be highest along the length of the plates, not through the thickness.

The formula used to calculate effective thermal conductivity is:

$$k_{eff} = \frac{\left(k_g \cdot 2 \cdot w_g + k_{ss} \cdot w_{ss}\right)}{w_{tot}};$$

where:

k_{eff}, w_{tot} - *effective thermal conductivity and total thickness of the region,*

k_g, w_g - *thermal conductivity and thickness of the gas gap, and*

k_{ss}, w_{ss} - *thermal conductivity and thickness of the XM-19 plate.*

The effective thermal conductivity of the composite region calculated for Helium and Air gaps are as given below:

Effective Conductivity of Basket Grid Structure Material: XM-19 + Helium or Air Gap		
Temperature, °F	**k_{eff} w/ Helium, Btu/(min·in·°F)**	**k_{eff} w/ Air, Btu/(min·in·°F)**
200	9.311E-03	9.304E-03
300	1.010E-02	1.009E-02
400	1.075E-02	1.075E-02
500	1.154E-02	1.153E-02
600	1.220E-02	1.219E-02
700	1.298E-02	1.297E-02
800	1.364E-02	1.363E-02

M.4.3 Specifications for Components

The thermal conductivity of the neutron poison plates must be verified by testing. The neutron poison plates must have the following minimum thermal conductivity [4.8]:

Temperature (°F)	**Thermal Conductivity (Btu/hr-in-°F)**
68	5.78
212	6.98
482	7.22
571	7.22
600	7.22
650	7.22

M.4.4 Thermal Evaluation for Normal Conditions of Storage (NCS) and Transfer (NCT)

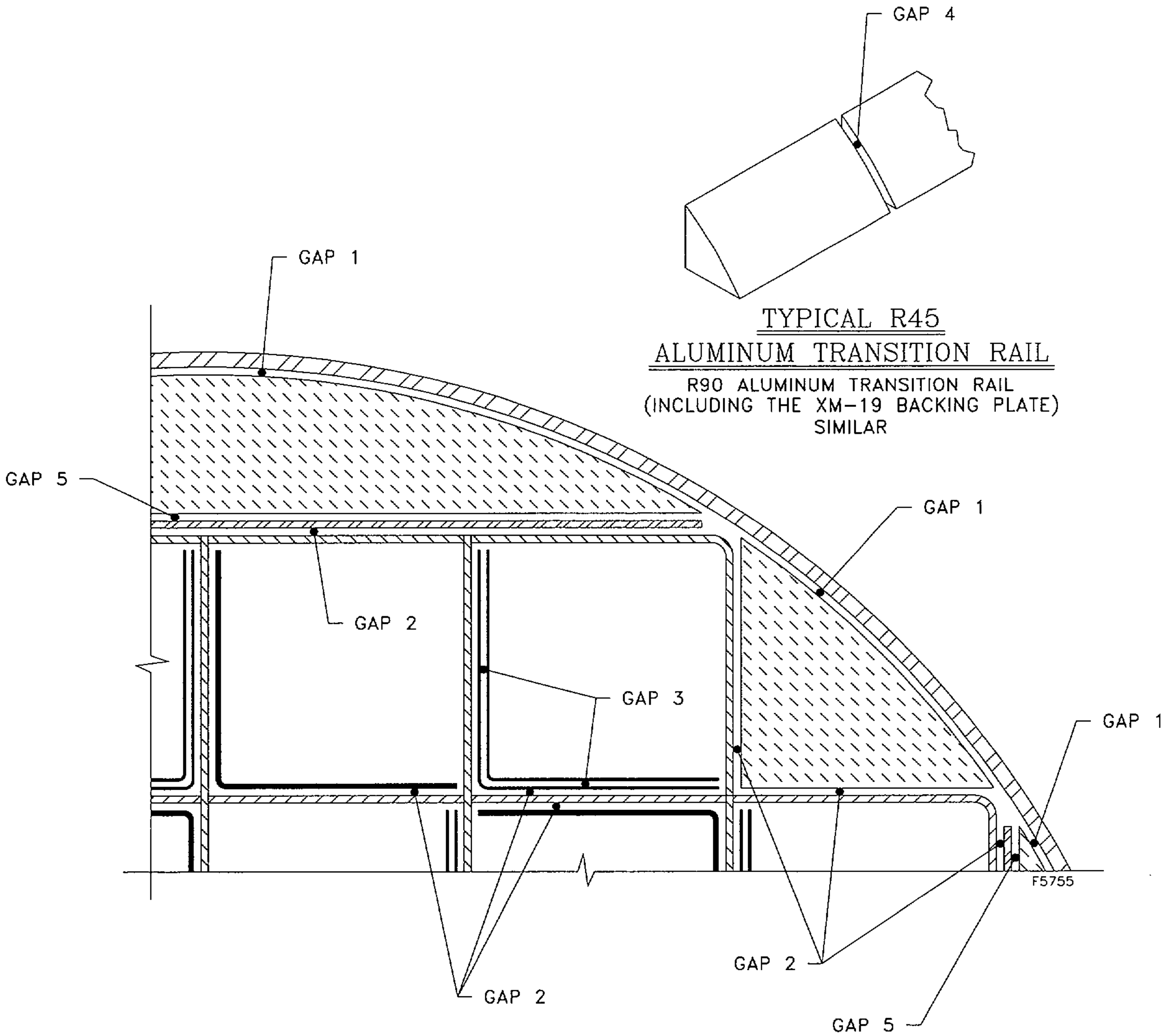
M.4.4.1 NUHOMS®-32PT DSC Thermal Models

The NUHOMS®-32PT DSC finite element models are developed using the ANSYS computer code [4.9]. ANSYS is a comprehensive thermal, structural and fluid flow analysis package. It is a finite element analysis code capable of solving steady state and transient thermal analysis problems in one, two or three dimensions. Heat transfer via a combination of conduction, radiation and convection can be modeled by ANSYS. Solid entities are modeled by SOLID70 Elements for 3-D models and PLANE55 elements for 2-D models. Heat transfer across small gaps was modeled by LINK32 1-D conduction elements.

M.4.4.1.1 NUHOMS®-32PT DSC Basket and Payload Model

The three-dimensional model (Figure M.4-5) represents the NUHOMS®-32PT DSC with *all* aluminum transition rails, and includes the geometry and material properties of the basket components, the basket rails, and DSC. *The cross-section view is shown in* Figure M.4-6. The model simulates the effective thermal properties of the fuel with a homogenized material occupying the volume within the basket where the 141.8 inch active length of the fuel is used. *The material properties from Section* M.4.2 *are used for the fuel region.* Within the model, heat is transferred via conduction through fuel regions, the poison plates, steel of the basket and the gas gaps between the poison plate and steel members. Generally, good surface contact is expected between adjacent components within the basket structure. However, to bound the heat conductance uncertainty between adjacent components *owing to imperfect contact between the neutron poison material, aluminum and the basket grid structure, uniform gaps along the entire surfaces are assumed. This is a conservative assumption because, although there will be imperfect contact between the adjacent plates, they will be in contact with each other at most of the locations. Therefore, thermal resistance to heat flow from the fuel assembly out to the DSC surface is lower with imperfect contact as compared with uniform gaps along the entire surfaces. The gaps used in the thermal analysis of the 32PT DSC are summarized in the table below and shown in the figure below.*

Gap Number	*Gap Location*	*Gap Size, Inches*
1	*DSC Shell and Transition Rails*	*0.08*
2	*Basket grid structural plates and adjacent rails, or aluminum or composite material poison plates*	*0.0075*
3	*Aluminum and composite material poison plates*	*0.00375*
4	*Between any two pieces of aluminum rails in axial direction*	*0.125*
5	*Aluminum block and XM-19 plate for R-90 rail*	*0.0075*



All heat transfer across the gaps is by gaseous conduction. Other modes of heat transfer are conservatively neglected. *Radiation heat transfer is considered in the gap between the DSC shell and aluminum rails only for the 70 °F ambient storage in HSM case.* Heat is transferred through the basket support rails via conduction.

Each aluminum rail may be fabricated as a single piece or in separate segments (3 maximum). Rails consisting of three segments are assumed for thermal analyses. An axial gap of 0.125 in. is considered between any two pieces of aluminum rail. The elements representing the XM-19 grid structure include an adjustment to the conductivity to account for gaps between the basket components.

The 3-D model was extended to approximately half the length of the DSC cavity, or 83.5 in. to model the bottom half of the canister. A symmetry boundary was applied on the axial top of the model. The heat generations were applied over the active fuel, starting from 8.625 in. from the bottom of the fuel regions and extending all the way to the top of the model. The placement of the active fuel and the model size results in slight overprediction of temperatures since the symmetry boundary at (167/2-8.625)=74.875 in. from the beginning of active fuel is located well beyond half of the active fuel, or 141.8/2=70.9 in., where peak temperatures would be expected. Longer DSC cavity configurations (32PT-L100 and 32PT-L125) provide larger radial surface areas for heat dissipation and are therefore bounded by the shorter cavity (32PT-S100 and 32PT-S125) DSC configurations.

A mesh sensitivity study is performed by increasing the mesh size to reduce the original element size to 50% in the axial direction for the 3-D NUHOMS®-32PT DSC model. The total number of elements in the model is increased from 78,182 to 140,728. The long-term storage and normal operating conditions case (70 °F ambient temperature) is considered for this study. A Jackobi Conjugate Gradient Solver is applied and the solution converges after four equilibrium iterations.

All material properties, component dimensions, and boundary conditions are the same as those used in the original model. The component temperature differences between the two models are listed in the following table.

Component	***Original Model***	***Maximum Temperature Difference***
	Peak Temp, °F	$\lvert \Delta T \rvert$, °F
Fuel cladding	*613*	*0.3*
Grid structure	*597*	*0.3*
Poison plates	*597*	*0.3*
Transition rails	*369*	*0.1*

Since none of the component temperatures changes by more than 0.05% (0.3 °F), the original finite element model is not mesh sensitive.

M.4.4.1.2 Heat Generation

Heat generation is calculated based on the dimensions of the fuel and basket. The heat is assumed to be distributed evenly radially through the 8.7 in. square nominal fuel cell opening. Axial variations are accounted for in ANSYS by using the peaking factors in Figure M.4-4 along the active length of the PWR fuel assembly. Heat generation rates with the corresponding peaking factors are applied according to the decay heat load zoning configurations 1 through 3 given in Figure M.4-1, Figure M.4-2, and Figure M.4-3.

The equation below shows a typical calculation for peak heat generation (for 1.2 kW heat load) based on these peaking factors.

$$\dddot{q} = \frac{1.2kW \cdot 1.108 \cdot 3414 \frac{Btu/hr}{kW} \cdot \frac{1hr}{60\min}}{(8.7in)^2 \cdot 141.8in} = 7.049e-3 \frac{Btu}{\min \cdot in^3}$$

A peaking factor is applied to the base heat generation rate based on axial location of each element within 12 zones of the active fuel region (a half-length model). The volumetric heat generation multiplied by the average peaking factor of each zone is then used in the ANSYS models.

An example of the ANSYS input file routine, which applies the decay heat load for outer fuel assemblies is shown in Section M.4.9.1.

The normal conditions of storage are used for the determination of the maximum fuel cladding temperature, basket component temperatures, NUHOMS®-32PT DSC internal pressure and thermal stresses. The 10CFR Part 71.71(c) insolation averaged over a 24-hour period is used as steady state boundary condition.

M.4.4.1.3 Thermal Model of DSC in Horizontal Storage Module

The methodology used to calculate the HSM concrete and DSC shell temperatures with 32PT DSC is the same as that used for the NUHOMS®-24P DSC design described in FSAR Section 8.1.3. The axial location of the cross-section is the mid-section of the HSM, which also corresponds to the mid-section of the DSC at the approximate center of the active fuel.

There are two inlet and two outlet vents at each of the two sidewalls of the HSM. The location of these vents is designed such that it results in nearly uniform natural circulation flow patterns around the heat-generating region of a fuel assembly. The methodology given in Section 8.1.3 is used to calculate bulk air temperatures within the HSM. Note that bulk air temperatures are based on the conservative assumption of 100% of the heat removal from the DSC surface by convection ignoring any heat removal by radiation to the heat shield and concrete. These conservative assumptions provide reasonable assurance that the selected cross-section of the HSM/DSC results in hottest temperatures.

To determine the temperature distribution on the surface of the *DSC during storage*, a two-dimensional ANSYS model of the cross section of the HSM with loaded DSC is used to represent the NUHOMS®-32PT system (Figure M.4-7). Solid entities are modeled in ANSYS by PLANE55 two-dimensional thermal elements. Radiation within the HSM is modeled in ANSYS by MATRIX50 super elements.

The decay heat from the payload is modeled as a uniform heat flux on the inner surface of the DSC shell. Heat from the DSC surface dissipates via natural convection to the air within the HSM and via radiation to the HSM heat shield and walls. Heat dissipates from the HSM heat shield via radiation to walls and then via conduction through the walls of the HSM, via convection to the HSM air and via convection and radiation from the HSM outer surfaces to the ambient environment.

There are two lengths NUHOMS®-32PT DSCs. The outside DSC lengths are 186.2 and 192.2 inches. The NUHOMS® HSM can accommodate DSCs with lengths from 186.05 to 195.92 inches. The shorter HSM and shorter 32PT DSC is used to calculate the maximum HSM concrete temperatures. This configuration is conservative in calculating HSM concrete temperatures because it has higher thermal resistance to the air flow compared to the configuration with the longer HSM and longer 32PT DSC.

M.4.4.1.4 TC Thermal Model

To determine the temperature distribution on the surface of the DSC during transfer operations, a two-dimensional model of the cross-section of the TC with loaded DSC (Figure M.4-8) *is used.* Solid entities *are* modeled in ANSYS by PLANE55 two-dimensional thermal elements. Radiation within the cask cavity *is* modeled in ANSYS by MATRIX50 super elements.

The decay heat from the payload is modeled as a uniform heat flux on the inner surface of the DSC shell. The decay heat from the DSC surface dissipates via conduction and radiation to the inner surface of the TC. Heat transferred through the cask via conduction and dissipates to the environment from the outer cask surfaces from the outer cask surfaces by a combination of natural convection and radiation.

The solar absorptivity of the outside transfer cask surface is conservatively assumed equal to 1.0 and applied as a uniform solar heat flux using the surface effect element SURF151 (type 6) overlaid on the outside surface of solid elements PLANE55 adjacent to the top half outside cask surface. An emissivity of the outside transfer cask surface of 0.587 is applied through additional surface effect element SURF151 (type 9) overlaid on the same solid elements as material property (mat 10).

An example of ANSYS input file routine that overlays surface effect elements on the top outside surface of the cask is included in Section M.4.9.2.

M.4.4.1.5 Boundary Conditions, Storage

Normal Conditions of Storage analyses of the NUHOMS®-32PT DSC within the HSM are carried out for the following ambient conditions:

- Maximum normal ambient temperature of 100°F with insolation,
- Minimum normal ambient temperature of 0°F without insolation, and
- *Long-term* average maximum ambient temperature of 70°F, with insolation.

The HSM thermal model described above provide the surface temperatures of the DSC shell that are applied as boundary conditions to the DSC shell in the basket and payload models which calculate the temperature distribution in the basket components and fuel.

M.4.4.1.6 Boundary Conditions, Transfer

In accordance with Section 8.1, analyses of the NUHOMS®-32PT DSC within the TC were performed for the following ambient conditions:

- Maximum normal ambient temperature of 100°F with insolation, and
- Minimum normal extreme ambient temperature of 0°F without insolation.

The maximum calculated DSC temperatures *using the TC thermal model described above,* are conservatively applied to the exterior surface of the DSC in the DSC/Basket/Payload finite element model.

M.4.4.2 Maximum Temperatures

M.4.4.2.1 Fuel Cladding

M.4.4.2.1.1 Long-Term Storage Temperatures

The maximum fuel cladding temperature for long-term storage with 70°F ambient condition is evaluated for each of the three decay heat load zoning configurations. Maximum fuel cladding temperatures for each of these five specific decay heat conditions are evaluated and compared with the corresponding fuel cladding temperature limit for long-term storage in Table M.4-1.

The conservatisms in the cladding temperature limit method and conservative assumptions included in the calculation of maximum cladding temperatures are described below:

1) *The effective thermal conductivity values used for the fuel regions are conservative compared to the test data. These effective conductivity values assume no convection in the fuel assembly regions. If the effective conductivity values given by DOE [*4.17*]are used, the maximum cladding temperature is reduced by 7 °F.*

2) *The cladding temperature limit is calculated based on methodology given in PNL-6189[*4.1*]. In this report, it is documented (Appendix C, page C.8 of PNL-6189) that there is a margin of 32 °C in CSFM model prediction of cladding temperature limit (408 °C) when compared to the limit predicted by test data (450 °C) at Federal Republic of Germany (FRG) at approximately 40 MPa cladding hoop stress because of assumed faster creep rate in the CSFM model.*

3) *The PNL-6189 report methodology to calculate cladding temperature limit is based on a fuel rod failure probability of less than 0.5% (5 in 1,000) if the cladding temperature limit is exceeded. The 32PT canister design assumes failure of 1%, 10% and 100% of all the rods from all the assemblies during normal, off-normal and accident conditions, respectively. The maximum cladding temperature occurs in the fuel assembly that is closest to the center of the basket. The difference in maximum cladding temperature between the fuel assemblies at the center of the basket and assemblies in the middle and outer periphery of the basket are approximately 30 °F and 110 °F, respectively. Therefore, there is significantly greater margin in the calculated cladding temperature for the majority of the fuel assemblies in the 32PT canister.*

4) *Credit for any convection in the DSC basket cavity is not taken.*

5) *Conservative gaps are assumed between basket component plates even though adjacent basket components are connected to each other by mechanical fasteners.*

Based on these conservatisms, there is significantly higher margin in the calculated maximum cladding temperatures than those shown in Table M.4-1. *Thus, there is reasonable assurance that the cladding will maintain its integrity during storage conditions.*

M.4.4.2.1.2 Short-Term Event Temperatures

The short-term events are defined in Section M.4.1 for storage and transfer. The results are reported for heat load zoning configuration 1 and 3 which yield the highest fuel cladding temperatures. The maximum fuel cladding temperatures for short-term normal conditions of storage and transfer are given in Table M.4-2.

M.4.4.2.1.3 DSC Basket Material Temperatures

The maximum *and minimum* temperatures of the basket assembly *components* for normal conditions of storage and transfer for heat load zoning configurations 1, 2 and 3 are listed in Table M.4-3, Table M.4-4, and Table M.4-5, respectively. The minimum component temperatures reported in these tables represent the minimum temperature for those components at the hottest radial cross section, not the minimum absolute component temperature in the entire basket. The maximum basket temperature distributions for configuration 1 during normal conditions of storage and transfer are presented in Figure M.4-9 and Figure M.4-10, respectively. *The temperature distribution from the bottom to the top of the DSC at the hottest cross-section is shown in* Figure M.4-17 *for 70°F ambient storage case.*

M.4.4.3 Minimum Temperatures

Under the minimum temperature condition of 0°F ambient, the resulting DSC component temperatures will approach 0°F if no credit is taken for the decay heat load. Since the DSC materials, including confinement structures, continue to function at this temperature, the minimum temperature condition has no adverse effect on the performance of the NUHOMS®-32PT DSC.

M.4.4.4 Maximum Internal Pressures

M.4.4.4.1 Pressure Calculation

This section describes the pressure calculations used to determine maximum internal pressures during storage and transfer within the NUHOMS®-32PT DSC and basket when loaded with a payload of worst case B&W 15x15 fuel assemblies with a maximum burnup of 45 GWd/MTU.

The calculations include the DSC free volume, the quantities of DSC backfill gas, fuel rod fill gas, and fission products and the average DSC cavity gas temperature. The 32PT-S100, 32PT-S125, 32PT-L100 and 32PT-L125 canister configurations are considered. The 32PT-L100 and 32PT-L125 DSC internal pressure evaluations also include the contribution due to BPRAs. *The internal pressures are then calculated using:*

$$P = \frac{nRT}{V}$$

where:

n = *Total number of moles of gases,*

R = *Universal gas constant,*

T = *Gas temperature (°R),*

V = *Gas volume, and*

P = *Internal pressure.*

M.4.4.4.2 Free Volume

M.4.4.4.2.1 DSC Cavity

The DSC Cavity free volumes are shown below:

Canister Type	32PT-S100	32PT-S125	32PT-L100	32PT-L125
Cavity Volume (in^3)	585,129	576,526	605,774	597,172
Basket Volume (in^3)	163,508	161,105	169,353	166,951
Fuel Volume (in^3)	177,619	177,619	189,760	189,760
Free Volume (in^3)	244,002	237,802	246,661	240,461

M.4.4.4.3 Quantity of Helium Fill Gas in DSC

The DSC free volume is assumed to be filled with 3.5 psig (18.2 psia) of helium. The maximum temperatures from the 70°F ambient storage case are used to estimate the number of moles of helium backfill. The Long Cavity (L100 and L125) DSC results are bounded by the Short *Cavity* (S100 and S125) DSC, and hence, it is conservative to use the Short Cavity DSC results.

The average long-term helium fill temperature for the worst case payload is *444 °F (904 °R), however a value of* 449°F (909°R) *is used which has negligible impact on the results.* Using the ideal gas law, the quantity of helium in *each* DSC is calculated and the results are presented in Table M.4-6.

M.4.4.4.4 Quantity of Fill Gas in Fuel Rod

The volume of the helium fill gas in a B&W 15x15 fuel pin at cold, unirradiated conditions is 1.6 in^3, and there are 208 fueled pins in an assembly. The maximum fill pressure is 415 psig (429.7 psia) and the fill temperature is assumed to be room temperature (70°F or 530°R). The quantity of fuel rod fill gas in 32 fuel assemblies is:

$$n_{he} = \frac{(429.7\,psia)(6894.8\,Pa/psi)(32 \cdot 208 \cdot 1.6\,in^3)(1.6387x10^{-5}\,m^3/in^3)}{(8.314\,J/mol \cdot K)(530\,°R)(5/9\,K/°R)}$$

$$n_{he} = 211.2\,g - moles$$

Based on NUREG 1536 [4.10], the maximum fraction of the fuel pins that are assumed to rupture and release their fill and fission gas for normal, off-normal and accident events is 1, 10 and 100%, respectively. 100% of the fill gas in each ruptured rod is assumed to be released. The amount of helium fill gas released for each of these conditions is summarized below.

Case	Percentage of Rods Ruptured	Moles of Helium Fill Gas Released
Normal	1	2.11
Off-Normal	10	21.12
Accident	100	211.2

M.4.4.4.5 Quantity of Fission Product Gases in Fuel Rod

The B&W 15x15 fuel assembly used in the pressure calculations is assumed to be burned to 45,000 MWd/MTU, which is the highest burnup proposed for the NUHOMS®-32PT configuration. The maximum burnup creates a bounding case for the amount of fission gases produced in the fuel rod during reactor operation. The amounts of tritium, krypton-85 and xenon-131m at STP for each assembly are summarized below.

Isotope	Volume (liters/assy)	Volume (in^3/assy)
Tritium (H^3)	0.26	16
Kr^{85}	60.4	3,686
Xe^{131m}	547	33,380
Total	607.7	37,081

The total fission gas volume for a *fuel assembly* is equal to 607.7 liters (37,081 in^3). The total amount of fission gas products produced is calculated using 32°F as:

$$n_{fg} = \frac{(32)(14.7)(6894.8\,Pa/psi)(37{,}081\,in^3)(1.6387x10^{-5}\,m^3/in^3)}{(8.314\,J/mol \cdot K)(460\,°R + 32°F)(5/9\,K/°R)}$$

$$n_{fg} = 867\,g - moles$$

The amount of fission gas released into the DSC cavity for normal, off-normal and accident condition cases assuming a 30% gas release from the fuel pellets and a 1%, 10%, and 100% rod rupture percentage, respectively, is summarized below.

Case	Percentage of Rods Ruptured	Moles of Fission Gas Released
Normal	1	2.6
Off-Normal	10	26.0
Accident	100	260

M.4.4.4.6 Quantity of Gas in Control Components (BPRAs)

The 32PT-L100 and 32PT-L125 DSC configurations may include BPRAs. For the controlling B&W 15x15 assembly, up to 16 BPRAs may be present. These BPRAs have an initial helium fill of 14.7 psia, and if 100% of the boron is consumed, and 30% released into the DSC, a total of 53.8 gmoles of gas could be released to the DSC assuming 100% cladding rupture. *This is based on 24 BPRAs per DSC (Appendix J, Section J.4).*

In the NUHOMS®-32PT DSC, a maximum of 16 BPRAs per DSC are allowed. Therefore, use of 24 BPRAs per DSC for gas generation is conservative for DSC internal pressure calculations.

The percentage of BPRA rods ruptured during normal, off-normal and accident conditions is assumed to be 1%, 10% and 100%, respectively, similar to the assumptions for the fuel rod rupturing. The maximum amount of gas released to the DSC cavity from the BPRAs for normal, off-normal and accident conditions is given below.

Case	Percentage of Rods Ruptured	Moles of Fission Gas Released per DSC from BPRAs
Normal	1	0.538
Off-Normal	10	5.38
Accident	100	53.8

The maximum average helium temperature for normal conditions of storage and transfer occurs when the 32PT DSC is in the TC with an ambient temperature of 100°F and maximum insolation. This case bounds the 100°F ambient case in the HSM. In addition the maximum pressure will occur with the 45,000 MWd/MTU burnup fuel so that lesser burnups will be enveloped by this calculation. The average helium temperature is *572°F (1032°R), however* 578°F (1,038°R) *is conservatively used*. The maximum normal operating condition pressures are summarized in Table M.4-7.

M.4.4.5 Maximum Thermal Stresses

The maximum thermal stresses during normal conditions of storage and transfer are calculated in Section M.3.

M.4.4.6 Evaluation of Cask Performance for Normal Conditions

The NUHOMS®-32PT DSC shell and basket are evaluated for the calculated temperatures and pressures in Section M.3. The maximum fuel cladding temperatures are well below the allowable *long-term* fuel temperature limits and the *short-term* limit of 1,058°F (570°C). The maximum DSC internal pressure remains below 15.0 psig during normal conditions of storage and transfer. Based on the thermal analysis, it is concluded that the NUHOMS®-32PT DSC design meets all applicable normal condition thermal requirements.

M.4.5 Thermal Evaluation for Off-Normal Conditions

The NUHOMS®-32PT system components are evaluated for the extreme ambient temperatures of -40°F (winter) and 117°F (summer). Should these extreme temperatures ever occur, they would be expected to last for a very short duration of time. Nevertheless, these ambient temperatures are conservatively assumed to occur for a significant duration to result in a steady-state temperature distribution in the NUHOMS®-32PT system components.

The 117°F off-normal ambient temperature is considered extreme in a given 24-hour period. It is reasonable to consider a 24-hour average given the large thermal mass of the canister, HSM and transfer casks. The temperature of the fuel is not expected to vary with temperature cycles over 24-hour periods.

In order to calculate a conservative 24-hour average temperature given a maximum temperature, a minimum daily range must be specified. From Table 1 in Chapter 24 of [4.20], the minimum mean daily temperature range in the contiguous United States with a maximum summer ambient above 110°F is 27°F in Needles, California. For the 117°F ambient condition, [4.20] is used to derive a daily average for the steady-state condition with a mean range of 27°F. The mean range is defined as the difference between the average daily maximum and the average daily minimum during the warmest month of the year. The use of a mean range is appropriate since the HSM and DSC would take several days to heat up to steady-state conditions in such a scenario.

Reference [4.20] gives a method for calculating the temperature variations in a day, given a daily range in Chapter 26, Table 3. Percentages ranging between 0 and 100% of the mean range are given as a function of hour in the day. The temperature variation is calculated using this methodology for a maximum temperature of 117°F with daily range of 27°F. A sample calculation shows the expected temperature at 8 o'clock in the morning:

$$T_{amb} = 117 - 0.84 \cdot 27 = 94.3°F$$

The remaining calculated temperatures are presented in the table below.

Ambient Temperature Variation on 117°F Ambient Day.		
Time, hour	***% Daily Range***	***T, °F***
1	*87*	*93.5*
2	*92*	*92.2*
3	*96*	*91.1*
4	*99*	*90.3*
5	*100*	*90.0*
6	*98*	*90.5*
7	*93*	*91.9*
8	*84*	*94.3*
9	*71*	*97.8*
10	*56*	*101.9*
11	*39*	*106.5*
12	*23*	*110.8*
13	*11*	*114.0*
14	*3*	*116.2*
15	*0*	*117.0*
16	*3*	*116.2*
17	*10*	*114.3*
18	*21*	*111.3*
19	*34*	*107.8*
20	*47*	*104.3*
21	*58*	*101.3*
22	*68*	*98.6*
23	*76*	*96.5*
24	*82*	*94.9*

The corresponding average is 101.8°F. 107°F was used as the ambient air temperature in the stead-state analyses to be conservative for the maximum off-normal condition.

M.4.5.1 Off-Normal Maximum/Minimum Temperatures during Storage

The thermal performance of the NUHOMS®-32PT DSC within the HSM under the extreme minimum ambient temperatures of -40°F with no insolation and 117°F with maximum insolation are evaluated with heat load zoning configurations 1, 2 and 3.

M.4.5.1.1 Boundary Conditions, Storage

Off-normal conditions of storage analyses of the NUHOMS®-32PT DSC within the HSM includes:

- Maximum off-normal ambient temperature of 117°F with insolation, and
- Minimum off-normal ambient temperature of -40° F without insolation.

The HSM and TC thermal models described above provide the surface temperatures that are applied to the DSC, basket and payload model.

M.4.5.2 Off-Normal Maximum/Minimum Temperatures during Transfer

The thermal performance of the NUHOMS®-32PT DSC during transfer under the extreme minimum ambient temperature of -40°F with no insolation and 117°F with maximum insolation, and decay heat load configurations 1, 2 and 3 are examined. For transfer operations when ambient temperatures exceed 100°F up to 117°F, a solar shield is used.

M.4.5.2.1 Boundary Conditions, Transfer

In accordance with Section 8.1, analyses of a 24 kW DSC within the TC are performed for the following ambient conditions:

- Maximum normal ambient temperature of 117°F with solar shield in place, and
- Minimum off-normal extreme ambient temperature of -40°F without insolation.

These analyses, which use a total decay heat load of 24.0 kW per DSC, determine maximum DSC surface temperatures. The maximum calculated DSC temperatures are conservatively applied to the entire exterior surface of the DSC in the DSC/basket/payload finite element model.

M.4.5.3 Off-Normal Maximum and Minimum Temperatures During Storage/Transfer

According to the NUHOMS® CoC 1004, Technical Specification 1.2.4, "TC/DSC Transfer Operations at High Ambient Temperatures" for transfer operations, when ambient temperatures exceed 100 °F up to 125 °F, a solar shield shall be used to provide protection against direct solar radiation.

The thermal performance of the DSC during transfer operations when the DSC is in the transfer cask without the sunshade at an ambient temperature of 100°F is limiting and bounds the maximum off-normal 117°F transfer case with sunshade. This is demonstrated by results provided in Table M.4-8 and Table M.4-2.

A comparison of the thermal analysis results for 32PT-DSC during transfer operations for the cases of 100 °F ambient temperature without sunshade and 117 °F ambient temperature with sunshade shows that the maximum fuel cladding temperatures are 730 °F (Table M.4-2) and 719 °F (Table M.4-8), respectively.

M.4.5.3.1 Fuel Cladding

The results are reported in Table M.4-8 for heat load zoning configurations 1 and 3 which yield the highest fuel cladding temperatures.

M.4.5.3.2 DSC Basket Materials

The maximum *and minimum* temperatures of the basket assembly for *off*-normal conditions of storage and transfer for heat load zoning configurations 1, 2 and 3 are listed in Table M.4-9, Table M.4-10, and Table M.4-11, respectively. The minimum temperatures reported for each component are not the minimum absolute component temperature in the entire basket. The minimum *component temperatures* reported in the*se* tables represent the minimum temperature for those components at the hottest radial cross section. The bounding basket temperature distributions for heat load zoning configuration 1 off-normal conditions of storage and transfer are presented in Figure M.4-11 and Figure M.4-12, respectively.

M.4.5.4 Off-Normal Maximum Internal Pressure During Storage/Transfer

The off-normal condition maximum pressure calculation also considers the DSC in the TC at 100°F ambient. This case bounds the case in which the DSC is in the HSM with 117°F ambient and the 117°F TC case with the sunshade in place. *The average helium temperature is 572 °F (1032 °R), however, 578 °F (1,038 °R) is conservatively used.* Per NUREG 1536, the percentage of fuel rods ruptured for off-normal cases is 10%.

A summary of the maximum off-normal operating pressures for the various 32PT DSC configurations are presented in Table M.4-12.

M.4.5.5 Maximum Thermal Stresses

The maximum thermal stresses during off-normal conditions of storage and transfer for the NUHOMS®-32PT DSC are calculated in Section M.3.

M.4.5.6 Evaluation of Cask Performance for Off-Normal Conditions

The NUHOMS®-32PT DSC shell and basket are evaluated for calculated temperatures and pressures in Section M.3. The maximum fuel cladding temperatures are well below the allowable fuel temperature limit of 1,058°F (570°C). The maximum DSC internal pressures remain below 20.0 psig during off-normal conditions of storage and transfer. The pressures and temperatures associated with off-normal conditions in the NUHOMS®-32PT DSC design meet all applicable off-normal thermal requirements.

M.4.6 Thermal Evaluation for Accident Conditions

Since the NUHOMS® HSMs are located outdoors, there is a remote possibility that the ventilation air inlet and outlet openings could become blocked by debris from such unlikely events as floods and tornadoes. The NUHOMS® HSM system design features such as the perimeter security fence and redundant protected location of the air inlet and outlet openings reduces the probability of occurrence of such an accident. Nevertheless, for this conservative generic analysis, such an accident is postulated to occur and is analyzed.

During transfer under maximum ambient temperature and insolation, the loss of the sun shield and the liquid neutron shield in the TC represents the controlling transfer case. Although the temperatures for this case are bounded by the blocked vent case, it is included here to provide a bounding condition for maximum internal pressure.

It is determined in Section 3.3.6 that the HSM and DSC contain no flammable material and the concrete and steel used for their fabrication can withstand any credible fire accident condition. Fire parameters are dependent on the amount and type of fuel within the transporter and the fire accident condition shall be addressed within site-specific applications. Licensees are required to verify that loadings resulting from potential fires and explosions are acceptable in accordance with 10CFR72.212(b)(2). The hypothetical fire evaluation for the NUHOMS®-32PT system is included in Section M.4.6.3.

M.4.6.1 Blocked Vent Accident Evaluation

For the postulated blocked vent accident condition, the HSM ventilation inlet and outlet openings are assumed to be completely blocked for a 40-hour period concurrent with the extreme off-normal ambient condition of 117°F with insolation.

For conservatism, a transient thermal analysis is performed using the 3-D model developed in Section M.4.4.1, for heat load zoning configuration 1, which envelopes the temperature results for heat load zoning configurations 2 and 3. When the inlet and outlet vents are blocked, the air surrounding the DSC in the HSM cavity is contained (trapped) in the HSM cavity. The temperature difference between the hot DSC surface and the surrounding cooler heat shield and concrete surfaces in the HSM cavity will result in closed cavity convection. This closed cavity convection in the HSM cavity is accounted for by calculating an effective conductivity of air. The HSM cavity is modeled as a combination of few separate enclosures as described below:

Enclosure 1 includes the HSM cavity within 0° to 90° sector limited by DSC shell surface, vertical and top horizontal heat shield surfaces. Enclosure 2 includes the HSM cavity within -90° to 0° sector limited by DSC shell, vertical heat shield and space under the bottom line of DSC shell surfaces. Enclosure 3 includes bottom of Enclosure 2 and inside surfaces of HSM side wall and floor. Enclosure 4 includes horizontal space limited by concrete roof surface and top horizontal heat shield surface. Enclosure 5 is vertical space limited by inside surface of concrete side wall and vertical heat shield. To be conservative, the closed cavity convection in Enclosure 3 is neglected and Enclosure 2 was assumed to be the average of Enclosure 1 and 3 (9.09 + 1)/2 = 5.045.

For zones of closed cavity convection to adjust a thermal conductivity of air k_{air} to account convection an empirical generalized formula was applied [4.12]:

$$\frac{k_{eff\ air}}{k_{air}} = C \cdot Ra^n \cdot \left(\frac{L}{\delta}\right)^m$$

where Ra - Raleigh number, L, δ- length and width of an enclosure, C, n, m - constants, to be defined by flow circumstances (Ra) and geometry (L/δ).

Iterative process is used to determine the mean temperatures used in air property calculations. The results are given below:

Enclosure in HSM Cavity	δ, in	L, in	$\overline{T}_{hot}$, °F	$\overline{T}_{cold}$, °F	Gr_δ	Pr	C	n	m	$k_{eff\ air}/k_{air}$
1	9.95	63	561	428	8.91e+6	0.68	0.4	0.2	0	9.09
4	2	40	432	319	1.55e+5	0.683	0.11	0.29	0	3.149
5	3	72	393	271	7.15e+5	0.685	0.197	0.25	-0.111	3.662

These effective conductivities are used in the ANSYS model to determine the transient DSC shell temperatures during blocked vent accident. These DSC shell temperatures are then used as boundary conditions to calculate the basket and fuel cladding temperatures during blocked vent transient.

The calculated temperature distribution within the hottest cross section is shown in Figure M.4-13. Summaries of the calculated NUHOMS®-32PT DSC cladding and component temperatures are listed in Table M.4-13 and Table M.4-14, respectively.

M.4.6.2 Transfer Accident Evaluation

The postulated transfer accident event consists of transfer in the TC in a 117°F ambient environment with loss of the solar shield and the liquid neutron shielding. Only heat load zoning configuration 1 was evaluated, since it envelopes all other configurations for the normal and off-normal conditions of transfer. Since the temperature of the blocked vent case bo*u*nd*s* the transfer accident condition, this case is only evaluated to determine the maximum average gas temperature for the accident DSC internal pressure evaluation.

M.4.6.2.1 Fuel Cladding and Basket Materials

The short-term events are defined in Section M.4.1 for storage and transfer conditions. The blocked vent results are reported for 40 hours. The results are reported for heat load zoning configuration 1 in Table M.4-13. The maximum *and minimum* temperatures of the basket assembly after 40 hours are listed in Table M.4-14. The minimum temperatures reported for each component are not the minimum absolute component temperature in the entire basket. The minimum *component temperatures* reported in thi*s* *t*able represent*s* the minimum temperature for those components at the hottest radial cross-section.

M.4.6.3 Hypothetical Fire Accident Evaluation

For the postulated worst case fire accident, a 300 gallon diesel fire is simulated for a NUHOMS®-32PT DSC with a decay heat load of 24 kW during transfer in the TC. This bounds fire scenarios associated with loading operations and storage within the HSM due to the large thermal mass of the HSM and the HSM vent configuration which provides protection for the DSC and payload.

Steady-state, off-normal conditions are assumed prior to the fire, which consist of a 117°F ambient condition with solar shield in place on the TC. The fire has a temperature of 1,475°F, and an emittance of 0.9 and a duration of 15 minutes based on the 300 gallon diesel fuel source and complete engulfment of the TC for the duration of the fire. Subsequent to the fire, the TC is subjected to 117°F ambient conditions with maximum solar load. Note that these hypothetical fire parameters are very conservative.

The fire transient analysis presented is based on very conservative assumptions. It is assumed that liquid neutron shield (water) is present throughout the 15-minute fire transient even though it is expected to be lost and replaced with air very early in the fire transient. This assumption maximizes the heat input from the fire to the canister because of the high conductivity of water compared to air. To maximize the canister temperature during the post-fire transient, it is assumed that water in neutron shield cavity is lost at the beginning of post-fire transient and replaced by air as the heat flow is now from canister to the ambient.

The gaps included in the thermal model of the 32PT DSC are summarized in Section M.4.4.1.1. These gaps are not removed for calculating the cladding temperatures during accident conditions. The canister shell temperatures increase by a negligibly small amount (<0.3 °F) during fire transient. This increase is small during fire transient as the canister is protected due to the large thermal mass of the transfer cask. This shows that heat input from the fire to the canister is not significant. Since the canister shell temperature is almost unchanged, the cladding temperatures during 15-minute fire transient also are almost unchanged. Therefore, the assumption of not removing the gaps during fire transient has negligible impact on the cladding temperatures.

The calculated temperature response of selected components in the TC and DSC during the first 2,000 minutes of the fire accident is shown in Figure M.4-14. A summary of the calculated maximum fire transient temperatures for these components is listed in Table M.4-16. The calculated maximum fire transient DSC surface temperature is 499°F, which is less than the blocked vent case maximum DSC temperature of 574°F. Therefore, the NUHOMS®-32PT DSC temperatures and pressures calculated for the blocked vent case bound the hypothetical fire accident case.

M.4.6.4 Maximum Internal Pressures

The maximum accident pressure condition for the DSC occurs during the transfer accident case with the loss of the sun shield and liquid neutron shielding in the TC under extreme ambient temperature conditions of 117°F and maximum insolation. Higher average gas temperatures are achieved during the blocked vent case, but since no DSC drop events can occur in conjunction with a blocked vent event, the maximum fraction of fuel pins that can be ruptured is limited. For this transfer accident condition, the average helium temperature is *649 °F (1,109 °R), however,* 664°F (1,124°R) *is conservatively used.* In accordance with NUREG 1536, 100% of the fuel pins are assumed to rupture during this event.

A summary of the maximum accident operating pressures for the various 32PT DSC configurations are presented in Table M.4-15.

M.4.6.5 Evaluation of Cask Performance During Accident Conditions

The temperatures in the NUHOMS® HSM and TC are bounded by the existing analyses because of the same heat load for the NUHOMS®-24P DSC design. The NUHOMS®-32PT DSC shell and basket are evaluated for calculated pressures and temperatures in Section M.3.

The maximum fuel cladding temperature of less than 800°F is below the short-term limit of 1058°F (570°C). The accident pressure in the NUHOMS®-32PT DSC of 103 psig remains below the accident design pressure of 105 psig. It is concluded that the NUHOMS®-32PT system maintains confinement during the postulated accident condition.

M.4.7 Thermal Evaluation for Loading/Unloading Conditions

All fuel transfer operations occur when the NUHOMS®-32PT DSC and TC are in the spent fuel pool. The fuel is always submerged in free-flowing pool water permitting heat dissipation. After fuel loading is complete, the cask and DSC are removed from the pool and the DSC is drained, dried, backfilled with helium and sealed.

The bounding loading condition evaluated for the NUHOMS®-32PT DSC is the heatup of the DSC before its cavity is backfilled with helium. This typically occurs during the performance of the vacuum drying operation of the DSC cavity. A transient thermal analysis is performed to predict the heatup time history for the NUHOMS®-32PT DSC components assuming air is in the DSC cavity.

M.4.7.1 Vacuum Drying Analysis

Heatup of the DSC prior to being backfilled with helium typically occurs as DSC operations are being performed to drain and dry the DSC. The vacuum drying of the DSC generally does not reduce the pressure sufficiently to reduce the thermal conductivity of the *water vapor and* air in the DSC cavity *[4.22] and [4.23]. Therefore, air is assumed during vacuum drying operations. Radiation in the gaps within the basket and rail components is conservatively neglected.* Analyses are performed to determine the transient heat-up during the vacuum drying condition.

M.4.7.1.1 Vacuum Drying Evaluation

A transient thermal analysis is performed using *the three-*dimensional model developed in Section M.4.4.1, decay heat loads for zoning configuration 1, and a maximum DSC temperature of 215°F. The initial temperature of the DSC, basket and fuel is assumed to be 215°F, based on the boiling temperature of the fill water. Table M.4-17 and Table M.4-18 provide the maximum temperatures for the fuel cladding and basket components, respectively. Figure M.4-16 *provides the maximum fuel cladding temperatures during the 75-hour vacuum drying transient. All the temperatures are below their material temperature limits.*

M.4.7.1.2 Reflooding Evaluation

For unloading operations, the DSC will be filled with the spent fuel pool water through the siphon port. During this filling operation, the DSC vent port is maintained open with effluents routed to the plant's off-gas monitoring system. The NUHOMS®-32PT DSC operating procedures recommend that the DSC cavity atmosphere be sampled first before introducing any reflood water in the DSC cavity.

When the pool water is added to a DSC cavity containing hot fuel and basket components, some of the water will flash to steam causing internal cavity pressure to rise. This steam pressure is released through the vent port. The procedures also specify that the flow rate of the reflood water be controlled such that the internal pressure in the DSC cavity does not exceed 20 psig. This is assured by monitoring the maximum internal pressure in the DSC cavity during the reflood event. The reflood for the DSC is considered as a service level D event and the design pressure of the DSC is 105 psig. Therefore, there is sufficient margin in the DSC internal pressure during the reflooding event to assure that the DSC will not be over pressurized.

The maximum fuel cladding temperature during reflooding event *is* significantly less than the vacuum drying condition *owing* to the presence of water/steam in the DSC cavity. The analysis presented in Section M.4.7.1.1 shows that the maximum cladding temperature during vacuum drying after *75* hours is *714*°F. Since the reflooding procedure requires significantly less than *75* hours, the peak cladding temperature during the reflooding operation will be less than *714*°F.

To evaluate the effects of the thermal loads on the fuel cladding during reflooding operations, a conservative assumption of high maximum fuel rod temperature of 750°F and a low quench water temperature of 50°F are used.

The material properties, corresponding to a temperature of 750°F, are used in the evaluation:

Modulus of Elasticity, E (psi) = 11.1 x10^6 [from Figure 4 of 4.13]
Coefficient of thermal expansion, α, (in/in/°F) = 3.73 x 10-6 [4.14]
Poison's Ratio, ν, = 0.38 [4.15]
Yield Stress (irradiated), Sy, = 50,500 psi [4.13]

The fuel cladding is evaluated as a hollow cylinder with an outer surface temperature of T (50°F), and the inner surface temperature of T+ΔT (750°F) using [4-16] equations. The maximum thermal stress in the fuel cladding due to the temperature gradient during reflooding is calculated as follows:

The maximum circumferential stress at the outer surface is given by:

$$\sigma_t = \frac{\Delta T * \alpha \cdot E}{2(1-\nu)\log_e(c/b)} * (1 - \frac{2 * b^2}{(c^2 - b^2)} * \log_e c/b)$$

The maximum circumferential stress at the inner surface is given by:

$$\sigma_t = \frac{\Delta T * \alpha \cdot E}{2(1-\nu)\log_e(c/b)} * (1 - \frac{2 * c^2}{(c^2 - b^2)} * \log_e c/b)$$

The maximum stresses are calculated as 22,420 psi (outer surface) and 24,325 psi (inner surface). Based on the results of the thermal stress analysis, these stresses in the cladding during reflood is much less than the yield stress of 50,500 psi [4.13]. Therefore, cladding integrity is maintained during reflood operations.

Therefore, no cladding damage is expected due to the reflood event. This is also substantiated by the operating experience gained with the loading and unloading of transportation packages like IF-300 [4.11] which show that fuel cladding integrity is maintained during these operations and fuel handling and retrieval is not impacted.

M.4.8 References

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M.4.9 Example Input Files

M.4.9.1 Example ANSYS Input File for Applying Heat Generation

```
      /com apply heat generation to fuel regions
      /com select elements to apply heat generation
csys,0
cmsel,s,f_outer   ! select fuel elements
nsle,s,all
nsel,r,loc,z,act_end ,0
esln,r,0
esel,u,type,,7
bfedele,all,hgen

          /com read in z coordinates of burnup curve and values

*dim,z_fuel,,12
*dim,h_gen,,12
z_fuel(1)=act_end
h_gen(1)=0
z_fuel(2)= act_end +0.0278*act_fuel
h_gen(2)=0.652*heat_gen
z_fuel(3)= act_end +0.0833*act_fuel
h_gen(3)=0.967*heat_gen
z_fuel(4)= act_end +0.1389*act_fuel
h_gen(4)=1.074*heat_gen
z_fuel(5)= act_end +0.1944*act_fuel
h_gen(5)=1.103*heat_gen
z_fuel(6)= act_end +0.25*act_fuel
h_gen(6)=1.108*heat_gen
z_fuel(7)= act_end +0.3056*act_fuel
h_gen(7)=1.106*heat_gen
z_fuel(8)= act_end +0.3611*act_fuel
h_gen(8)=1.102*heat_gen
z_fuel(9)= act_end +0.4167*act_fuel
h_gen(9)=1.097*heat_gen
z_fuel(10)= act_end +0.4722*act_fuel
h_gen(10)=1.094*heat_gen
z_fuel(11)= act_end +0.5278*act_fuel
h_gen(11)=1.094*heat_gen
z_fuel(12)= act_end +0.5833*act_fuel
h_gen(12)=1.095*heat_gen

*get,emin,elem,0,num,min        ! get the minimum element #
*get,emax,elem,0,num,max        ! get the maximum element #
eln=0
*do,cnt,emin,emax,1
  *get,elnn,elem,eln,nxth       ! get next higher element number  than eln and
store in elnn
   eln=elnn
  *get,ei,elem,eln,node,1       ! get nodes which are attached to eln
  nzi=nz(ei)
  *get,ej,elem,eln,node,2       ! get nodes which are attached to eln
  nzj=nz(ej)
  *get,ek,elem,eln,node,3       ! get nodes which are attached to eln
```

```
nzk=nz(ek)
*get,el,elem,eln,node,4        ! get nodes which are attached to eln
nzl=nz(el)
*get,em,elem,eln,node,5        ! get nodes which are attached to eln
nzm=nz(em)
*get,en,elem,eln,node,6        ! get nodes which are attached to eln
nzn=nz(en)
*get,eo,elem,eln,node,7        ! get nodes which are attached to eln
nzo=nz(eo)
*get,ep,elem,eln,node,8        ! get nodes which are attached to eln
nzp=nz(ep)
n_z=(nzi+nzj+nzk+nzl+nzm+nzn+nzo+nzp)/8      ! find average z
*do,i,1,12,1
  *if,n_z,ge,z_fuel(i),then
    *if,n_z,lt,z_fuel(i+1),then
      z_diff=z_fuel(I+1)-z_fuel(I)
      gen_diff=h_gen(I+1)-h_gen(I)
      gen=(n_z-z_fuel(i))/(z_diff)*(gen_diff)+h_gen(i)
      bfe,eln,hgen,,gen
   *endif
  *endif
*enddo
*if,eln,eq,emax,exit
*enddo
```

M.4.9.2 Example ANSYS Input File for Solar Heat Flux Application

```
/com create radiation elements on outer surface of cask

type,9
real,9
mat,10

/com define space node
k,300,0,50,0
n,10000,0,50,0

esel,s,type,,1
esel,a,type,,2
esel,a,type,,3
esel,a,type,,4
esel,a,type,,5

nsle,s,all

esurf,10000

esel,s,type,,9
nsle,s,all
csys,1
nsel,r,loc,x,0,shell_od/2
nsel,a,node,,10000
esln,r,1
edele,all
csys,0

/com create surface elements for insolation

alls
csys,1
esel,s,type,,5
esel,a,type,,1
cmsel,s,a_nsp
cmsel,a,a_ns3
esla,r
type,6
esurf

csys,1
esel,s,type,,6
nsle,s,all
x1=cask_ir+inner_t+lead_t+struct_t
nsel,r,loc,x,x1-gy2,x1+gy2
esln,r,1
edele,all

/com delete elements on bottom half
esel,s,type,,6
nsle,s,all
x1=cask_ir+inner_t+lead_t+struct_t+ns3_t+nsp_t
```

```
nsel,r,loc,x,x1-gy2,x1+gy2
csys,0
nsel,r,loc,y,-100,0
esln,r,1
edele,all

csys,0
```

The ANSYS input file routine to apply insolation to the top outside surface of the cask is as follows:

```
/com 3rd load step, 100 deg F

/com load parameters

T_amb=100.
Insol=123/144/60
.
.
.
/com isolate insolation elements
csys,22
esel,s,type,,6
nsle,s,all
nsel,r,loc,x,cask_ir+inner_t+lead_t+struct_t+ns3_t+nsp_t
esln,r,1
sfedele,all,all,hflux
sfe,all,1,hflux,,insol
csys,0

alls
esel,u,type,,7
nsle,s,all

lswrite,3
```

Table M.4-1
Fuel Cladding *Long-Term* Storage Temperatures

Assembly Decay Heat (kW)	Maximum Temperature (°F)	Limit (°F)
0.63	*613*	615
0.87	*525*	635
0.60	*599*	613
1.20	*499*	681
0.70	*615*	621

Table M.4-2
Fuel Cladding *Short-Term* Normal Condition Maximum Temperatures

Operating Condition	**Configuration 1 (°F)**	**Configuration 3 (°F)**	**Limit (°F)**
0°F Storage	*563*	*565*	1,058
100°F Storage	*636*	*637*	1,058
0°F Transfer	*671*	*666*	1,058
100°F Transfer	*730*	*726*	1,058

Table M.4-3
DSC Basket Assembly Maximum Normal Operating Component Temperatures; Configuration 1

Configuration	$T_{grid,max}$ (°F)	$T_{grid,min}$ (°F)	$T_{rail,max}$ (°F)	$T_{rail,min}$ (°F)	$T_{Al,max}$ (°F)[1]	$T_{DSC\ shell}$ (°F)
DSC in HSM, 0°F	*545*	*233*	*306*	*230*	*545*	277
DSC in HSM, 100°F	*620*	*316*	*397*	*312*	*620*	374
DSC horizontal in cask, 0°F	*656*	*360*	*437*	*355*	*656*	406
DSC horizontal in cask, 100°F	*717*	*433*	*508*	*429*	*717*	482

[1] Includes aluminum and poison plates.

Table M.4-4
DSC Basket Assembly Maximum Normal Operating Component Temperatures; Configuration 2

Configuration	$T_{grid,max}$ (°F)	$T_{grid,min}$ (°F)	$T_{rail,max}$ (°F)	$T_{rail,min}$ (°F)	$T_{Al,max}$ (°F)[1]	$T_{DSC\ shell}$ (°F)
DSC in HSM, 0°F	*531*	*234*	*308*	*229*	*530*	277
DSC in HSM, 100°F	*606*	*316*	*399*	*311*	*606*	374
DSC horizontal in cask, 0°F	*642*	*359*	*439*	*354*	*642*	406
DSC horizontal in cask, 100°F	*704*	*433*	*509*	*428*	*704*	482

[1] Includes aluminum and poison plates.

Table M.4-5
DSC Basket Assembly Maximum Normal Operating Component Temperatures; Configuration 3

Configuration	$T_{grid,max}$ (°F)	$T_{grid,min}$ (°F)	$T_{rail,max}$ (°F)	$T_{rail,min}$ (°F)	$T_{Al,max}$ (°F)[1]	$T_{DSC\ shell}$ (°F)
DSC in HSM, 0°F	*545*	*220*	*292*	*217*	*545*	*264*
DSC in HSM, 100°F	*620*	*304*	*383*	*301*	*619*	*361*
DSC horizontal in cask, 0°F	*650*	*341*	*417*	*337*	*650*	*388*
DSC horizontal in cask, 100°F	*712*	*415*	*489*	*411*	*711*	*465*

[1] Includes aluminum and poison plates.

Table M.4-6
32PT DSC Initial Helium Fill Molar Quantities

DSC Configuration	Helium Fill (g-moles)
S100	119.5
S125	116.5
L100	120.8
L125	117.8

Table M.4-7
32PT DSC Maximum Normal Operating Condition Pressures

	DSC Cavity *Free* Volume (in^3)	Helium Fill (g-moles)	Plenum Helium (g-moles)	BPRA Gas (g-moles)	Fission Products (g-moles)	Total Gas (g-moles)	Pressure (psig)	DSC Design Pressure (psig)
S100	244,002	119.5	2.1	0.00	2.6	124.2	6.9	15
S125	237,802	116.5	2.1	0.00	2.6	121.2	6.9	15
L100	246,661	120.8	2.1	0.54	2.6	126.1	7.0	15
L125	240,461	117.8	2.1	0.54	2.6	123.0	7.0	15

Table M.4-8
Off-Normal Event Fuel Cladding Maximum Temperatures

Operating Condition	Configuration 1 (°F)	Configuration 3 (°F)	Limit (°F)
-40°F Storage	*534*	*536*	1,058
117°F Storage	*641*	*642*	1,058
-40°F Transfer	*655*	*650*	1,058
117°F Transfer(1)	*719*	*715*	1,058

(1) Sunshade is used for ambient temperatures >100°F and ≤117°F.

Table M.4-9
Off-Normal Event DSC Basket Assembly Maximum Component Temperatures; Configuration 1

Configuration	$T_{grid,max}$ (°F)	$T_{grid,min}$ (°F)	$T_{rail,max}$ (°F)	$T_{rail,min}$ (°F)	$T_{Al,max}$ (°F)[1]	$T_{DSC\ shell}$ (°F)
DSC in HSM, -40°F	*515*	*200*	*269*	*197*	*515*	237
DSC in HSM, 117°F	*625*	*322*	*404*	*318*	*625*	382
DSC horizontal in cask, -40°F	*640*	*335*	*420*	*330*	*639*	390
DSC horizontal in cask with shade, 117°F	*706*	*428*	*491*	*425*	*706*	459

[1]Includes aluminum and poison plates.

Table M.4-10
Off-Normal Event DSC Basket Assembly Maximum Component Temperatures; Configuration 2

Configuration	$T_{grid,max}$ (°F)	$T_{grid,min}$ (°F)	$T_{rail,max}$ (°F)	$T_{rail,min}$ (°F)	$T_{Al,max}$ (°F)[1]	$T_{DSC\ shell}$ (°F)
DSC in HSM, -40°F	*500*	*200*	*271*	*196*	*500*	237
DSC in HSM, 117°F	*612*	*322*	*405*	*317*	*611*	382
DSC horizontal in cask, -40°F	*626*	*335*	*421*	*329*	*626*	390
DSC horizontal in cask with shade, 117°F	*693*	*429*	*492*	*424*	*693*	459

[1] Includes aluminum and poison plates.

Table M.4-11
Off-Normal Event DSC Basket Assembly Maximum Component Temperatures; Configuration 3

Configuration	$T_{grid,max}$ (°F)	$T_{grid,min}$ (°F)	$T_{rail,max}$ (°F)	$T_{rail,min}$ (°F)	$T_{Al,max}$ (°F)(1)	$T_{DSC\ shell}$ (°F)
DSC in HSM, -40°F	*515*	*187*	*254*	*184*	*515*	*224*
DSC in HSM, 117°F	*625*	*310*	*390*	*307*	*625*	*368*
DSC horizontal in cask, -40°F	*633*	*315*	*399*	*311*	*633*	*371*
DSC horizontal in cask with shade, 117°F	*701*	*410*	*472*	*407*	*700*	*442*

(1) Includes aluminum and poison plates.

Table M.4-12
32PT DSC Maximum Off-Normal Operating Condition Pressures

	DSC Cavity *Free* Volume (in3)	Helium Fill (g-moles)	Plenum Helium (g-moles)	BPRA Gas (g-moles)	Fission Products (g-moles)	Total Gas (g-moles)	Pressure (psig)	DSC Design Pressure (psig)
S100	244,002	119.5	21.1	0.00	26.0	166.6	14.2	20
S125	237,802	116.5	21.1	0.00	26.0	163.6	14.4	20
L100	246,661	120.8	21.1	5.38	26.0	173.3	15.0	20
L125	240,461	117.8	21.1	5.38	26.0	170.3	15.2	20

Table M.4-13
Accident Fuel Cladding Maximum Temperatures

Operating Condition	Configuration 1 (°F)	Limit (°F)
Blocked Vent, 40 hours	*762*	1,058

Table M.4-14
DSC Basket Assembly Maximum Accident Condition Component Temperatures; Heat Load Zoning Configuration 1

Configuration	$T_{grid,max}$ (°F)	$T_{grid,min}$ (°F)	$T_{rail,max}$ (°F)	$T_{rail,min}$ (°F)	$T_{Al,max}$ (°F)[1]	$T_{DSC\ shell}$ (°F)
DSC in HSM blocked vent, 117°F	*751*	*483*	*583*	*478*	*751*	574

[1] Includes aluminum and poison plates.

Table M.4-15
32PT DSC Maximum Accident Condition Pressures

	DSC Cavity *Free* Volume (in3)	Helium Fill (g-moles)	Plenum Helium (g-moles)	BPRA Gas (g-moles)	Fission Products (g-moles)	Total Gas (g-moles)	Pressure (psig)	DSC Design Presure (psig)
S100	244,002	119.5	211.2	0.00	260.1	590.8	91.9	105
S125	237,802	116.5	211.2	0.00	260.1	587.8	94.0	105
L100	246,661	120.8	211.2	53.80	260.1	645.9	100.6	105
L125	240,461	117.8	211.2	53.80	260.1	642.9	102.9	105

Table M.4-16
Maximum Component Temperatures for the Hypothetical Fire Accident Case for the NUHOMS®-32PT DSC in the TC

Component	Maximum Temperature (°F)	Allowable Range (°F)
DSC Shell	499	**
Cask Structural Shell	1,420	**
Cask Lead Shielding	369	621
Inside of Cask Lid	331	**
Cask Neutron Shield	688	*

* Cask neutron shield is assumed to be lost during fire event. Effects of loss of shielding are evaluated in Section M.11.2.5.

** The components perform their intended safety function within the operating range.

Table M.4-17
Vacuum Drying Fuel Cladding Maximum Temperatures

Operating Condition	Configuration 1 (°F)	Limit (°F)
Vacuum Drying, 75 hours	*714*	1,058

Table M.4-18
DSC Basket Assembly Maximum Component Temperatures During Vacuum Drying After *75* hours; Configuration 1

Configuration	$T_{grid,max}$ (°F)	$T_{grid,min}$ (°F)	$T_{rail,max}$ (°F)	$T_{rail,min}$ (°F)	$T_{Al,max}$ (°F)[1]
Vacuum Drying	*685*	*352*	*384*	*341*	*685*

[1] Includes aluminum and poison plates.

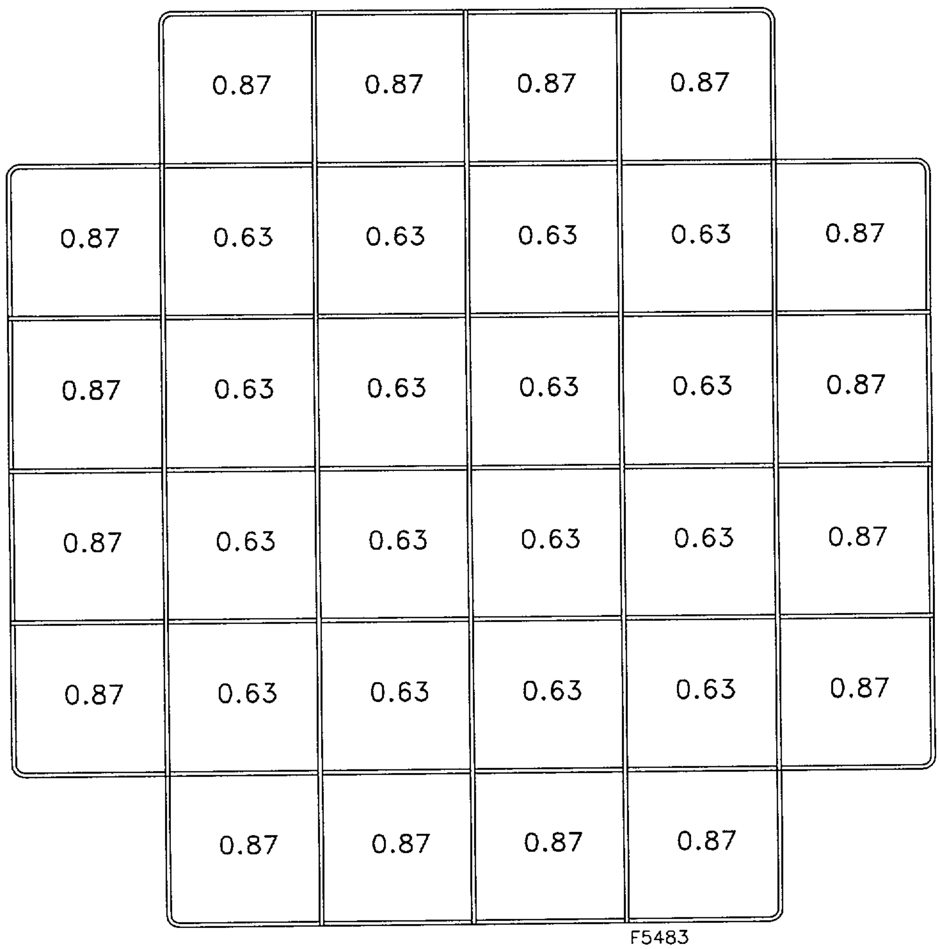


Figure M.4-1
Heat Load Zoning Configuration 1, Maximum Decay Heat for Various Assemblies

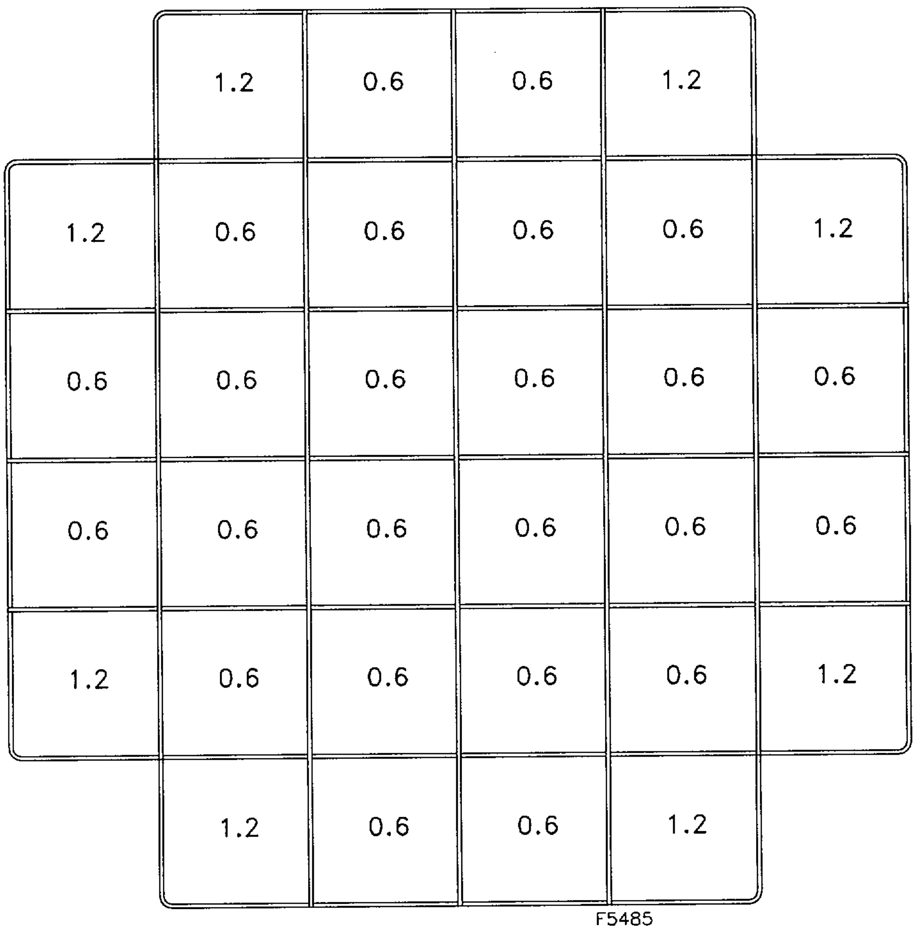
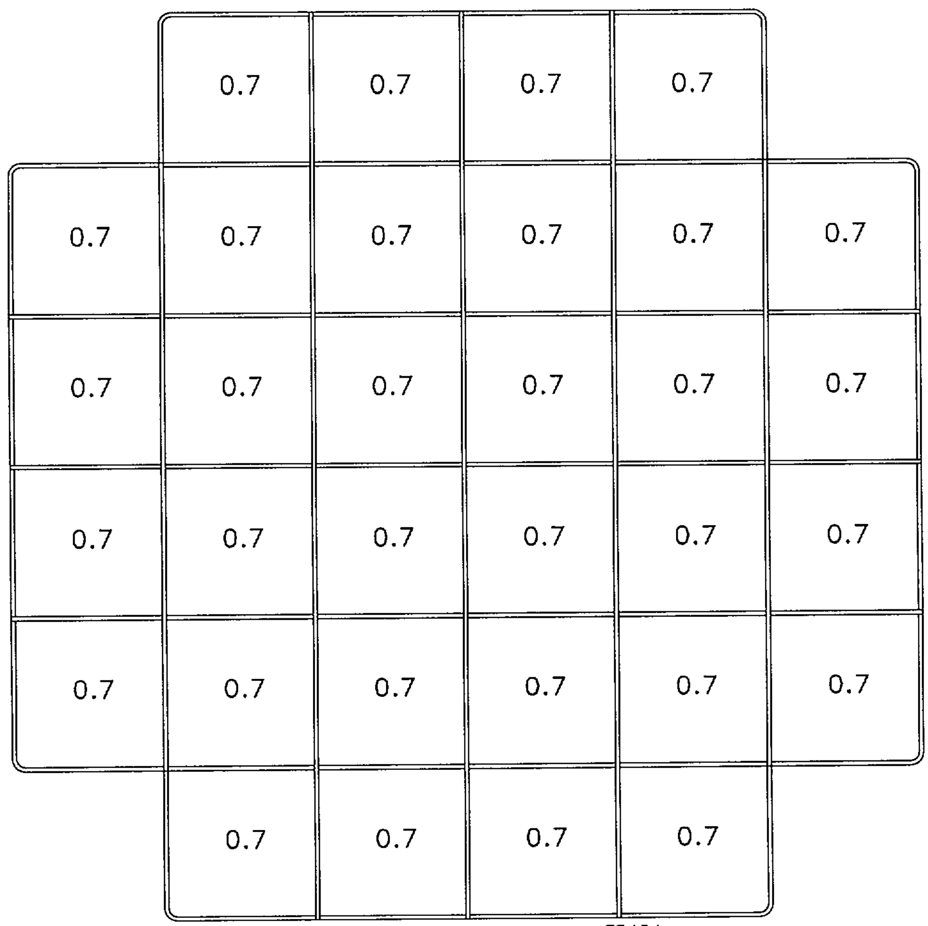


Figure M.4-2
Heat Load Zoning Configuration 2, Maximum Decay Heat for Various Assemblies



F5484

Figure M.4-3
Heat Load Zoning Configuration 3, Maximum Decay Heat for Various Assemblies

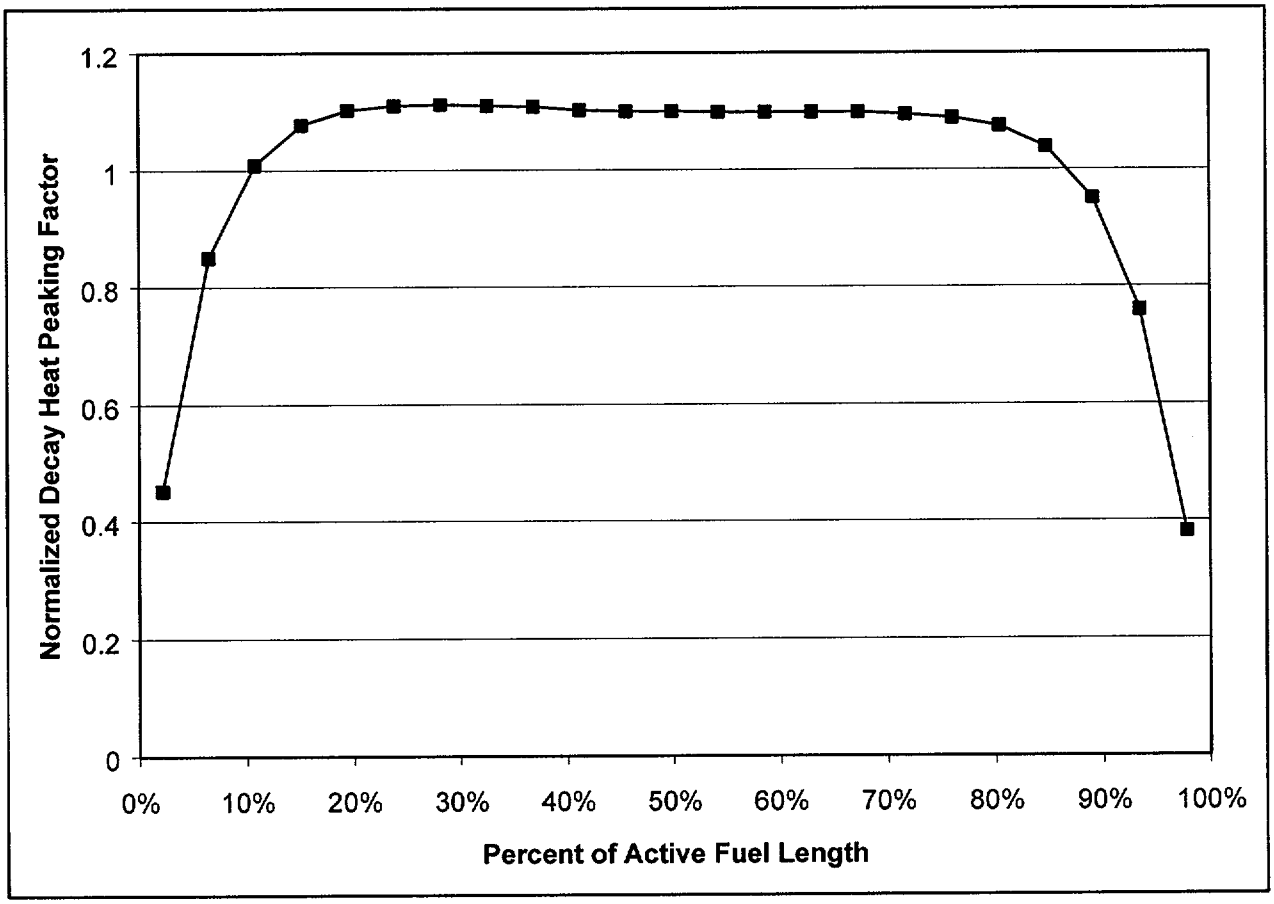


Figure M.4-4
Axial Heat Profile for PWR Fuel

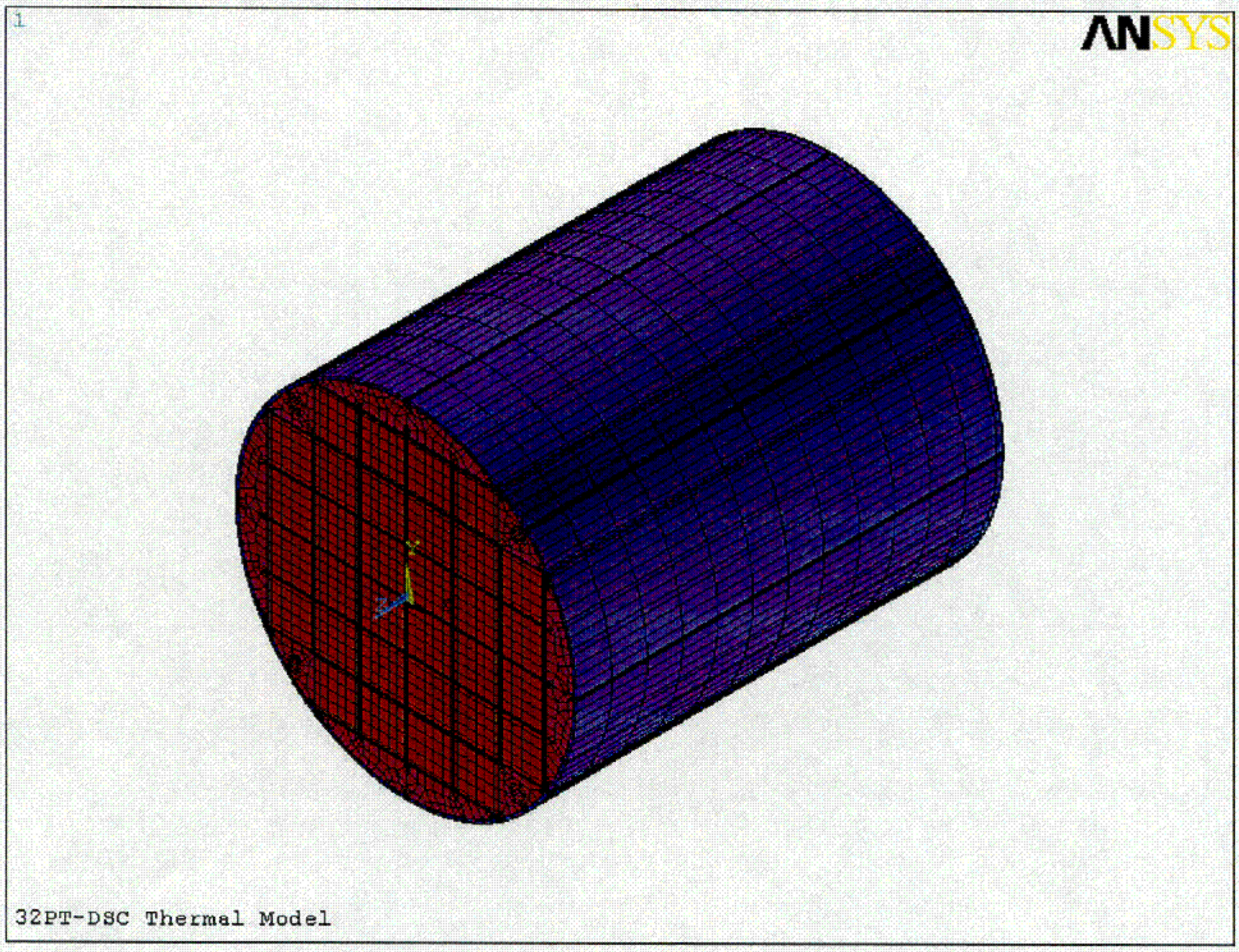


Figure M.4-5
32PT-DSC Thermal ANSYS Model, *Isometric* View

C01

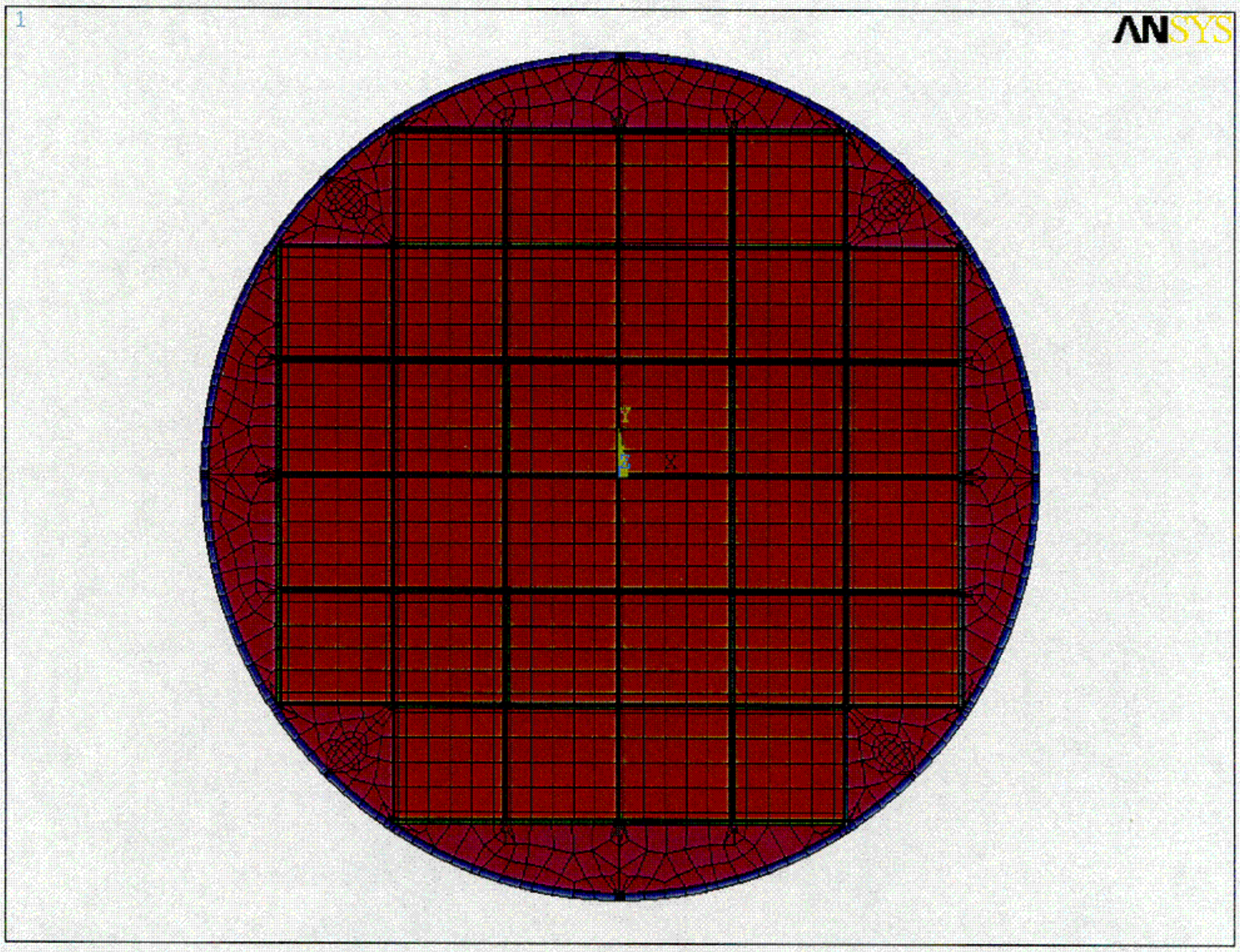


Figure M.4-6
32PT DSC Thermal ANSYS Model, Cross-Section View

C02

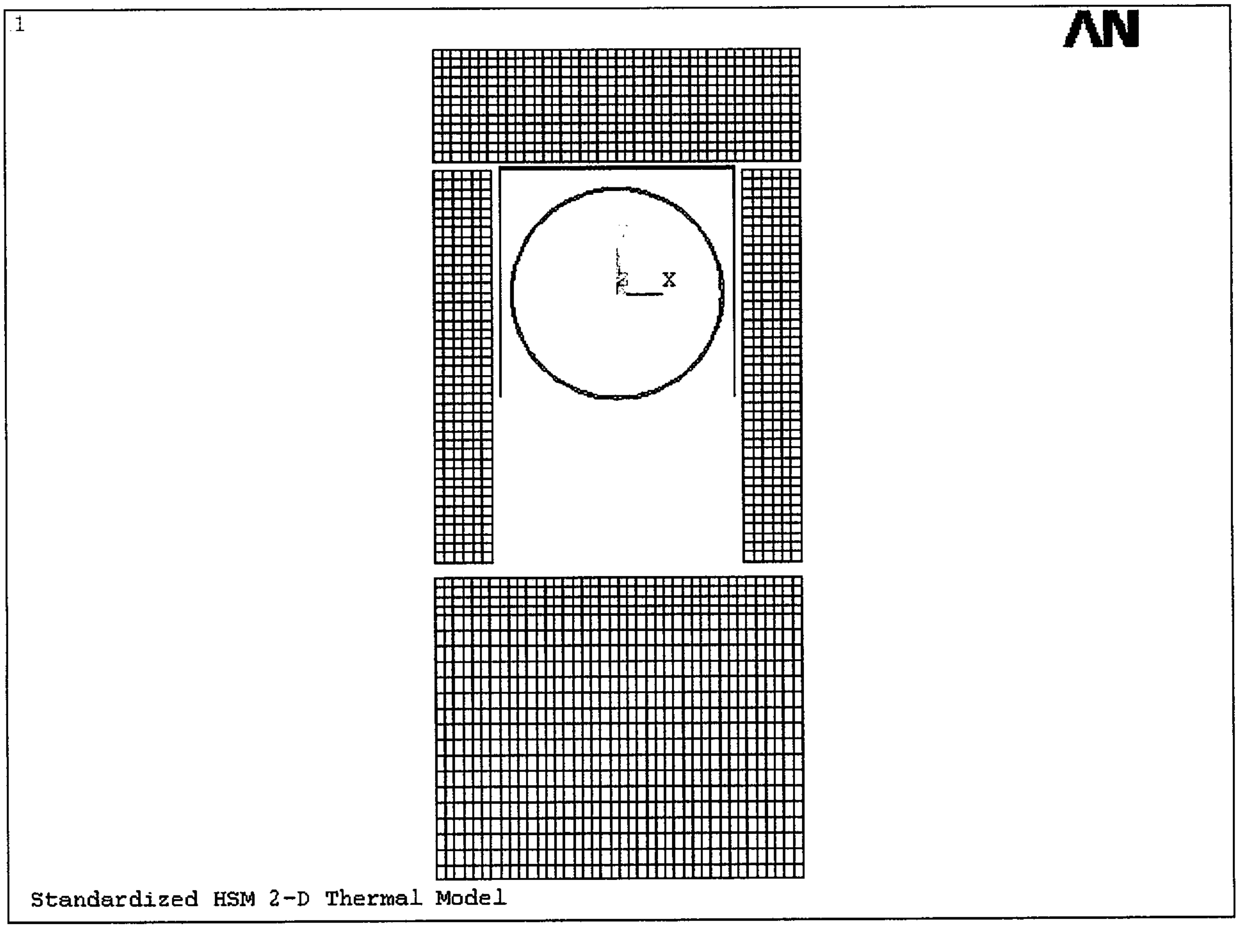


Figure M.4-7
Thermal Model of DSC in HSM

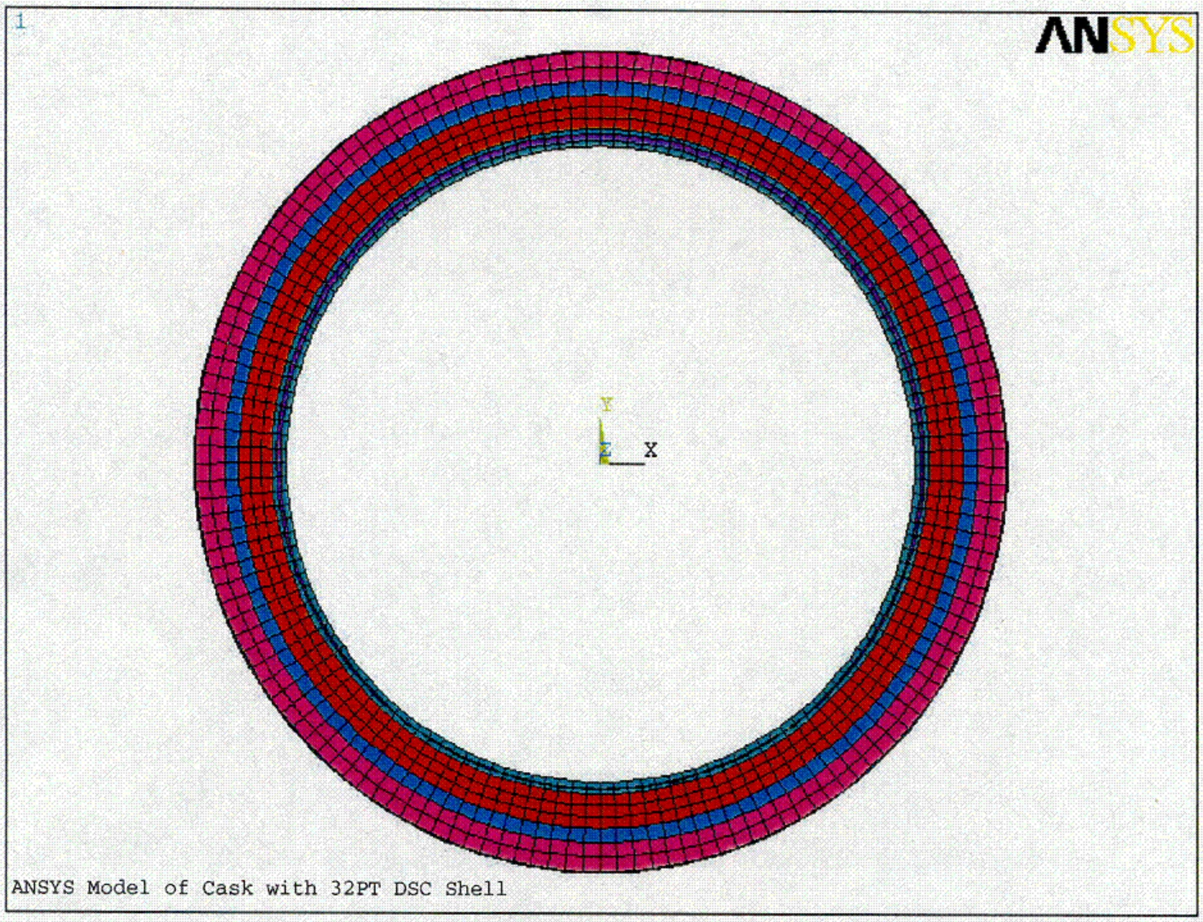


Figure M.4-8
Thermal Model of TC

Heat Load: 0.63 kW/assy Inner 16 cells, 0.87 kW/assy outer 16 cells
Environment Condition: 100°F ambient
Operating Condition: Storage in HSM

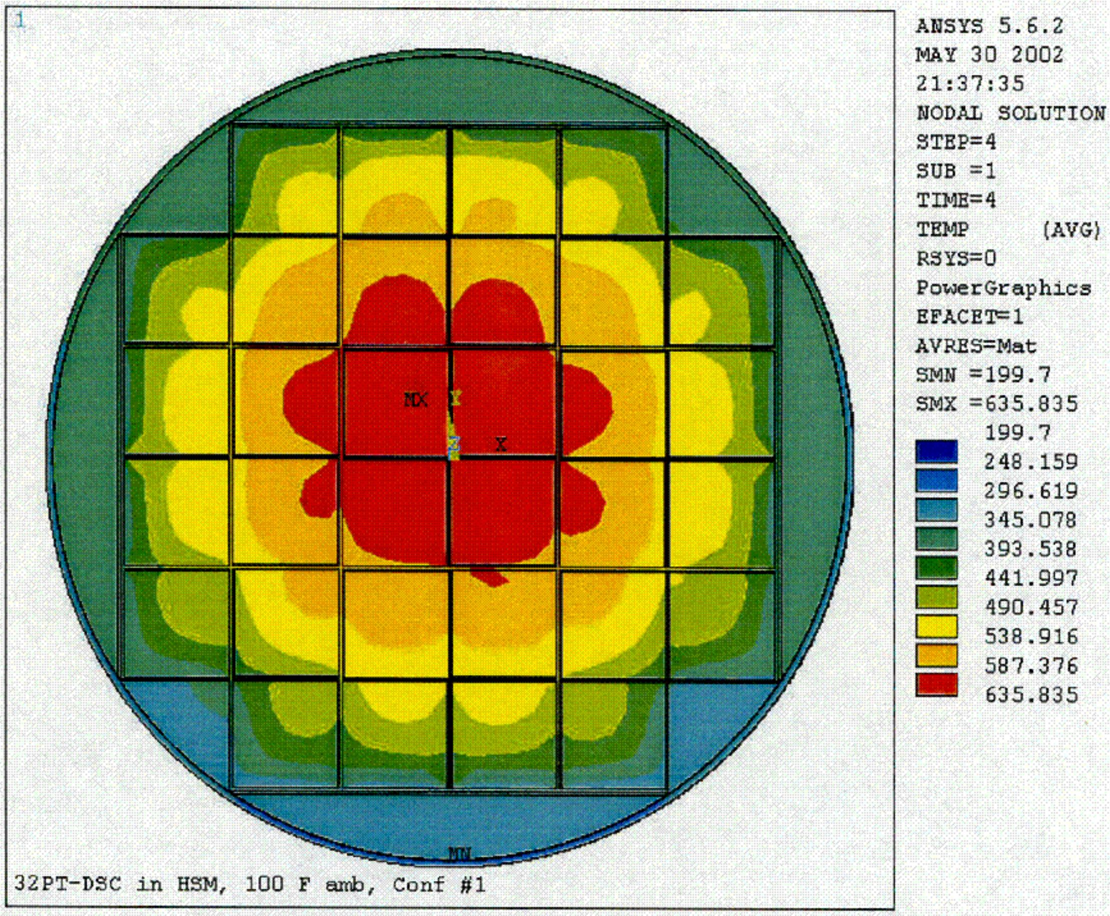


Figure M.4-9
Results for 100°F Storage Case With Heat Load Zoning Configuration 1

C04

Heat Load: 0.63 kW/assy Inner 16 cells, 0.87 kW/assy outer 16 cells
Environment Condition: 100°F ambient
Operating Condition: Transfer in cask

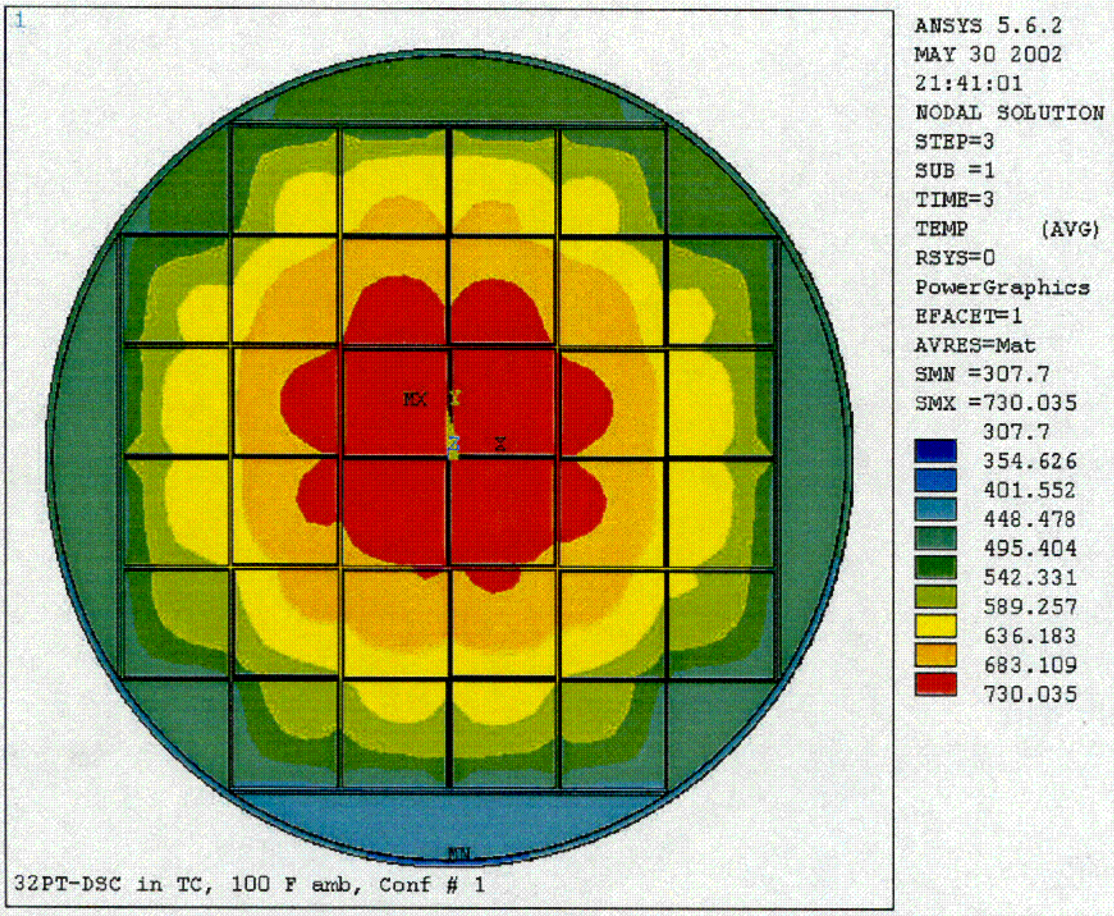


Figure M.4-10
Results for 100°F Transfer Case With Heat Load Zoning Configuration 1

C05

Heat Load: 0.63 kW/assy Inner 16 cells, 0.87 kW/assy outer 16 cells
Environment Condition: 117°F ambient
Operating Condition: Storage in HSM

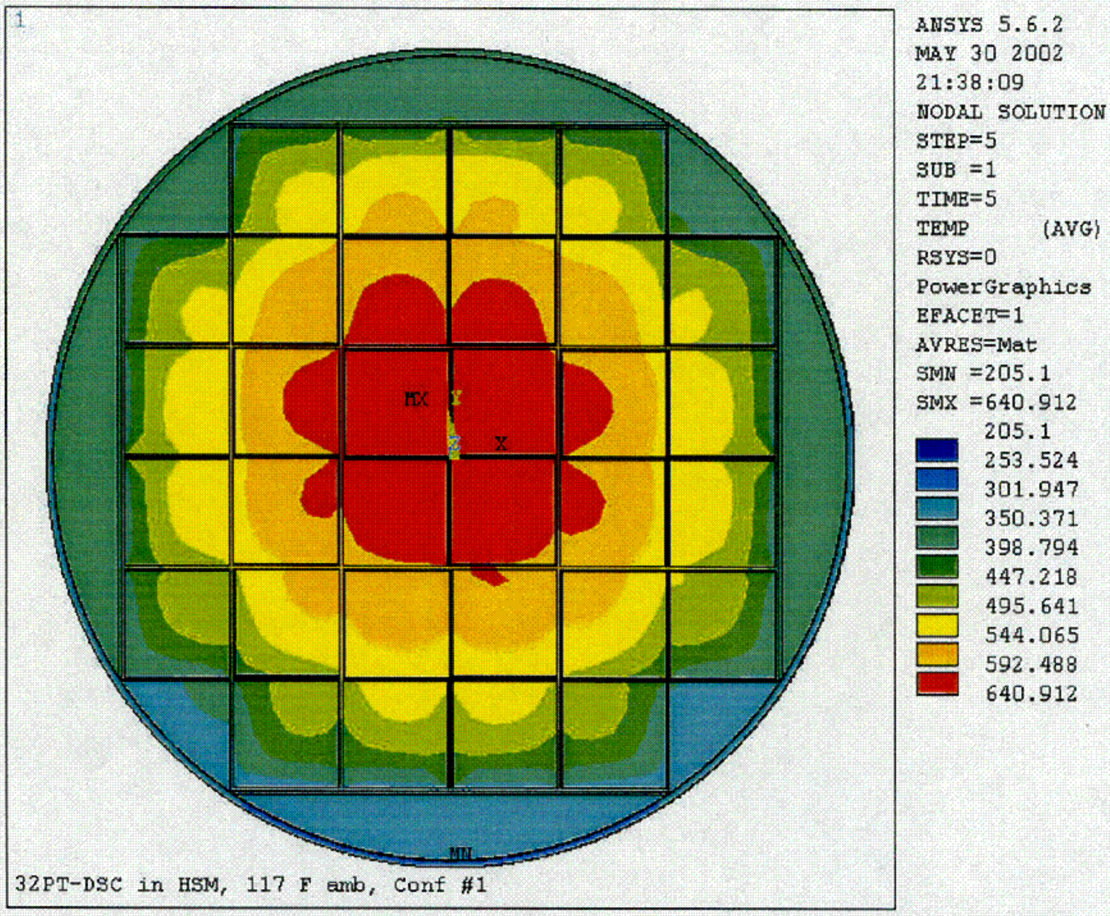


Figure M.4-11
Results for 117°F Storage Case With Heat Load Zoning Configuration 1

C06

Heat Load: 0.63 kW/assy Inner 16 cells, 0.87 kW/assy outer 16 cells
Environment Condition: 117°F ambient
Operating Condition: Transfer in cask

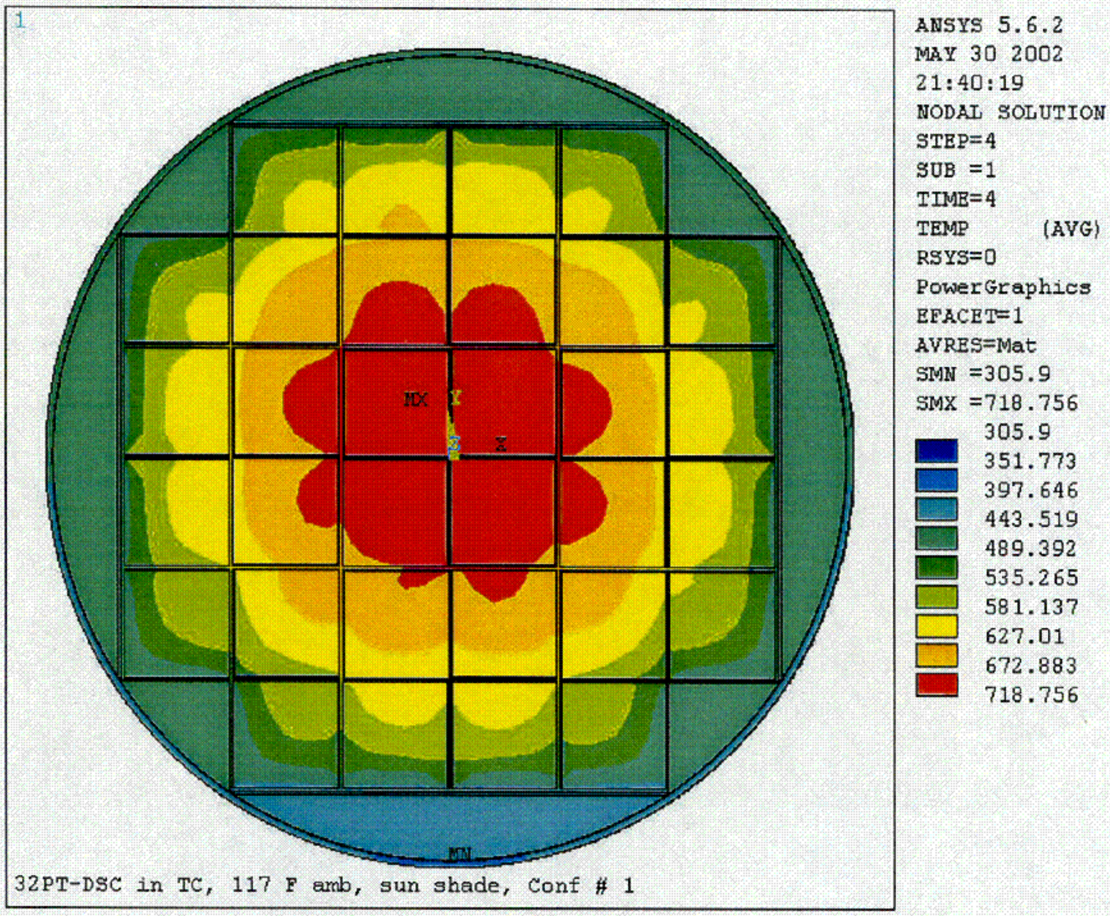


Figure M.4-12
Results for 117°F Transfer Case With Heat Load Zoning Configuration 1

C07

Heat Load: 0.63 kW/assy Inner 16 cells, 0.87 kW/assy outer 16 cells
Environment Condition: 117°F in HSM.
Operating Condition: Blocked Vent Accident, 40 hours

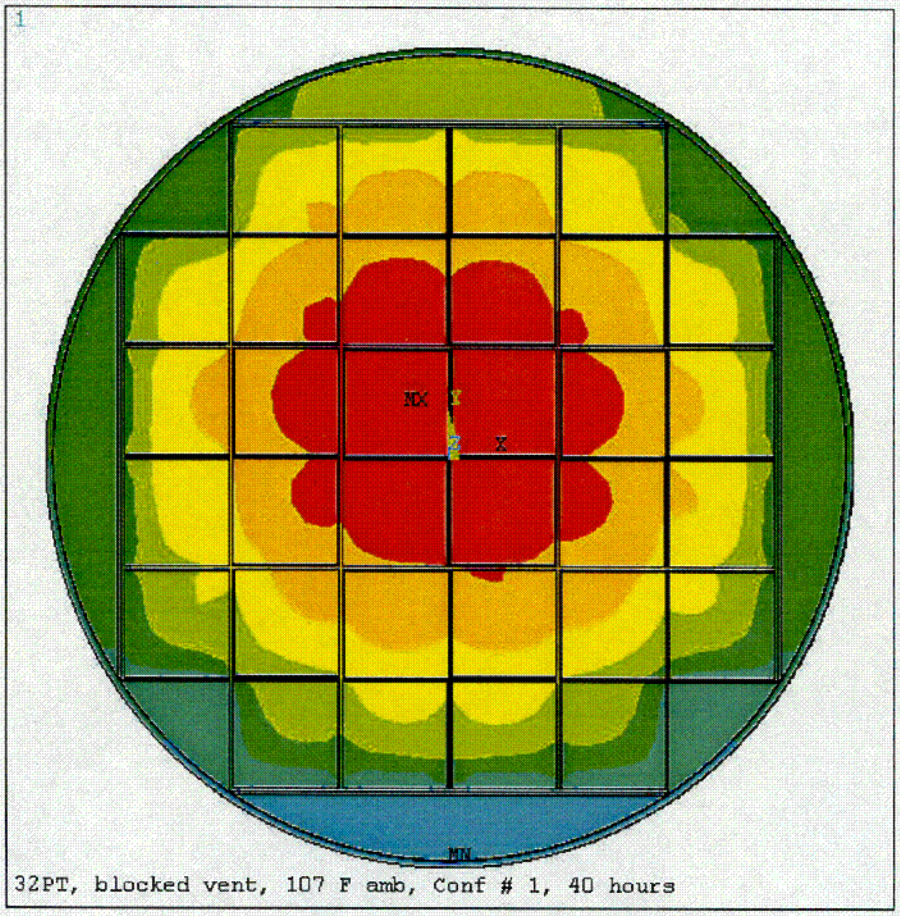


Figure M.4-13
Results for Blocked Vent Case With Heat Load Zoning Configuration 1 at 40 Hours

C08

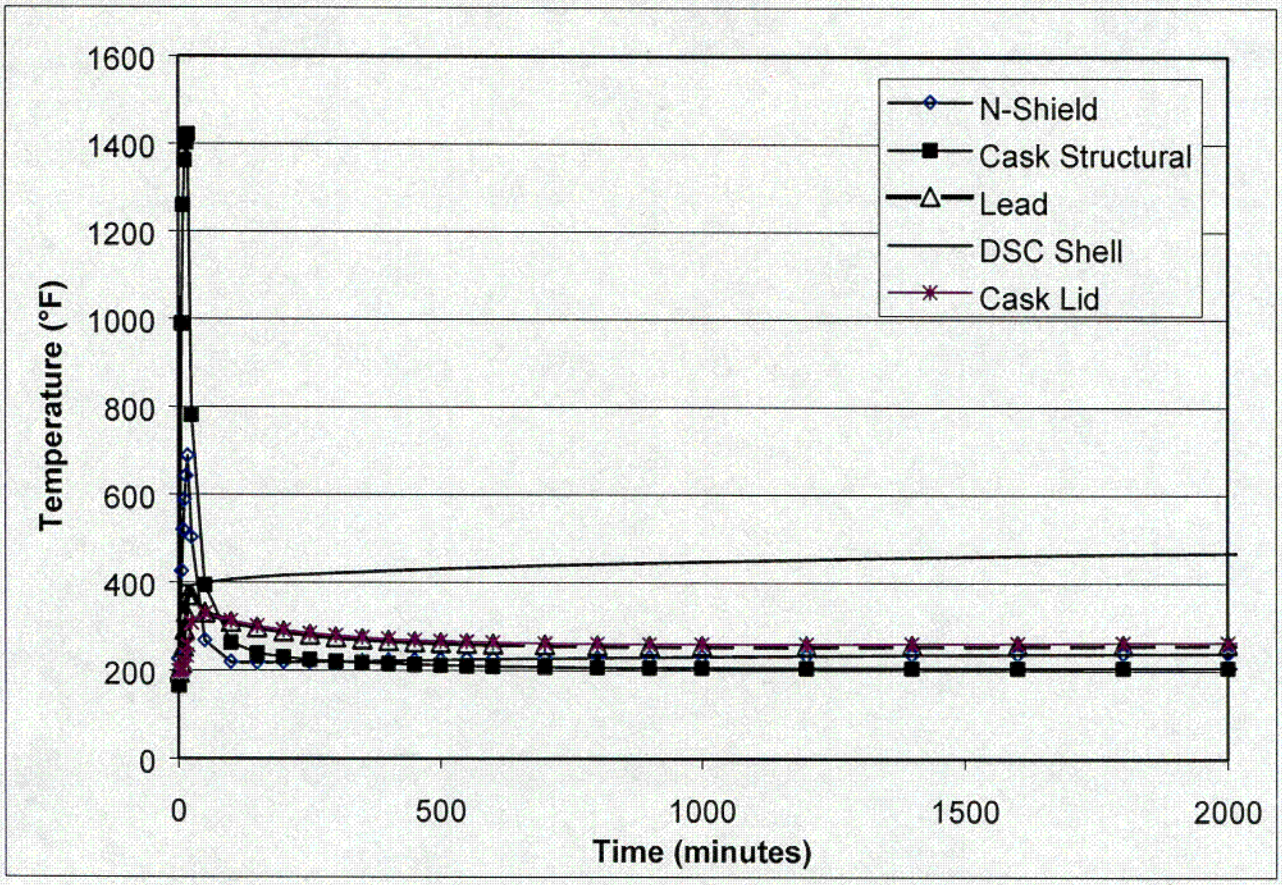


Figure M.4-14
NUHOMS®-32PT DSC and TC Temperature Response to
15 Minute Fire Accident Conditions

C09

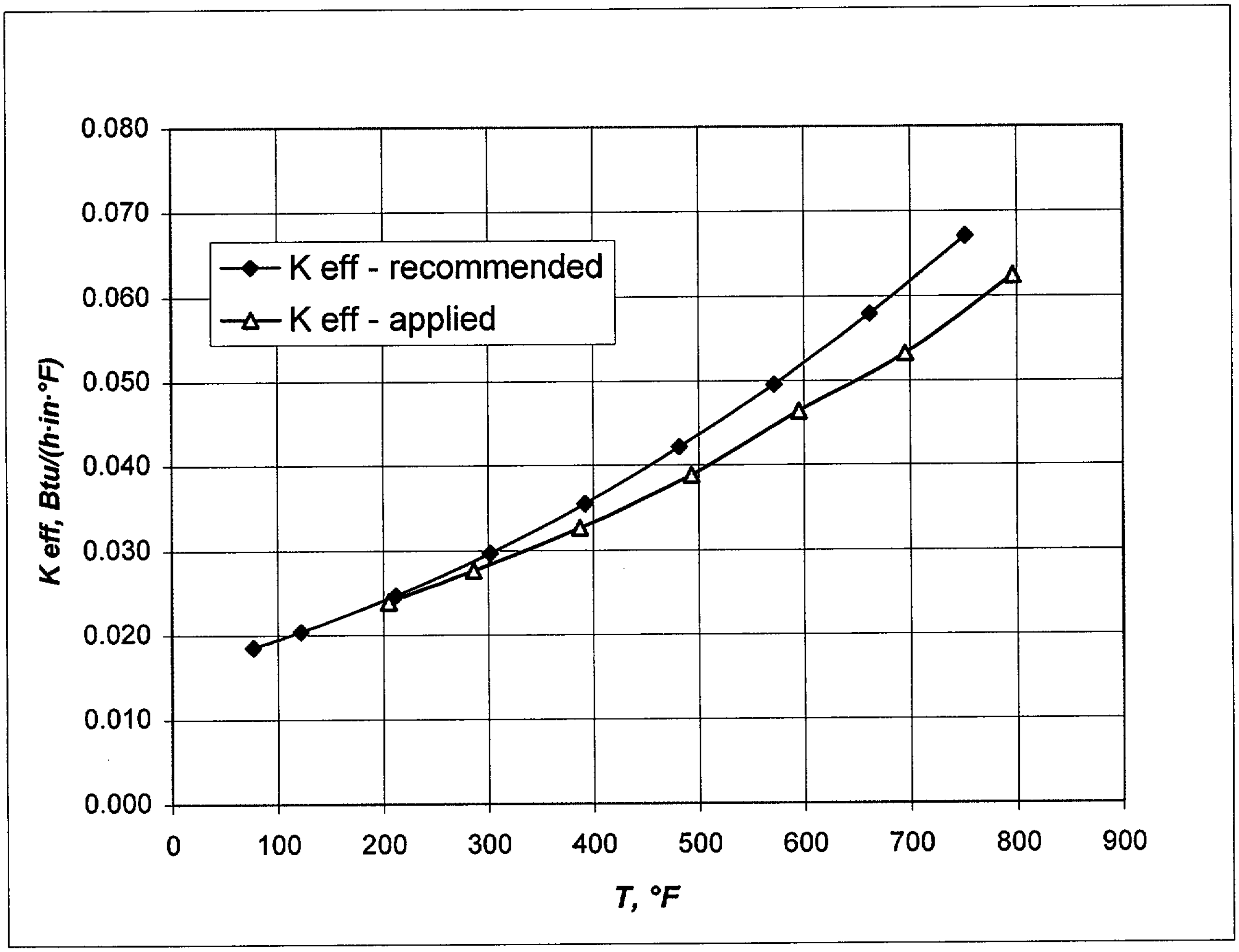


Figure M.4-15
Comparison of Fuel Thermal Conductivities

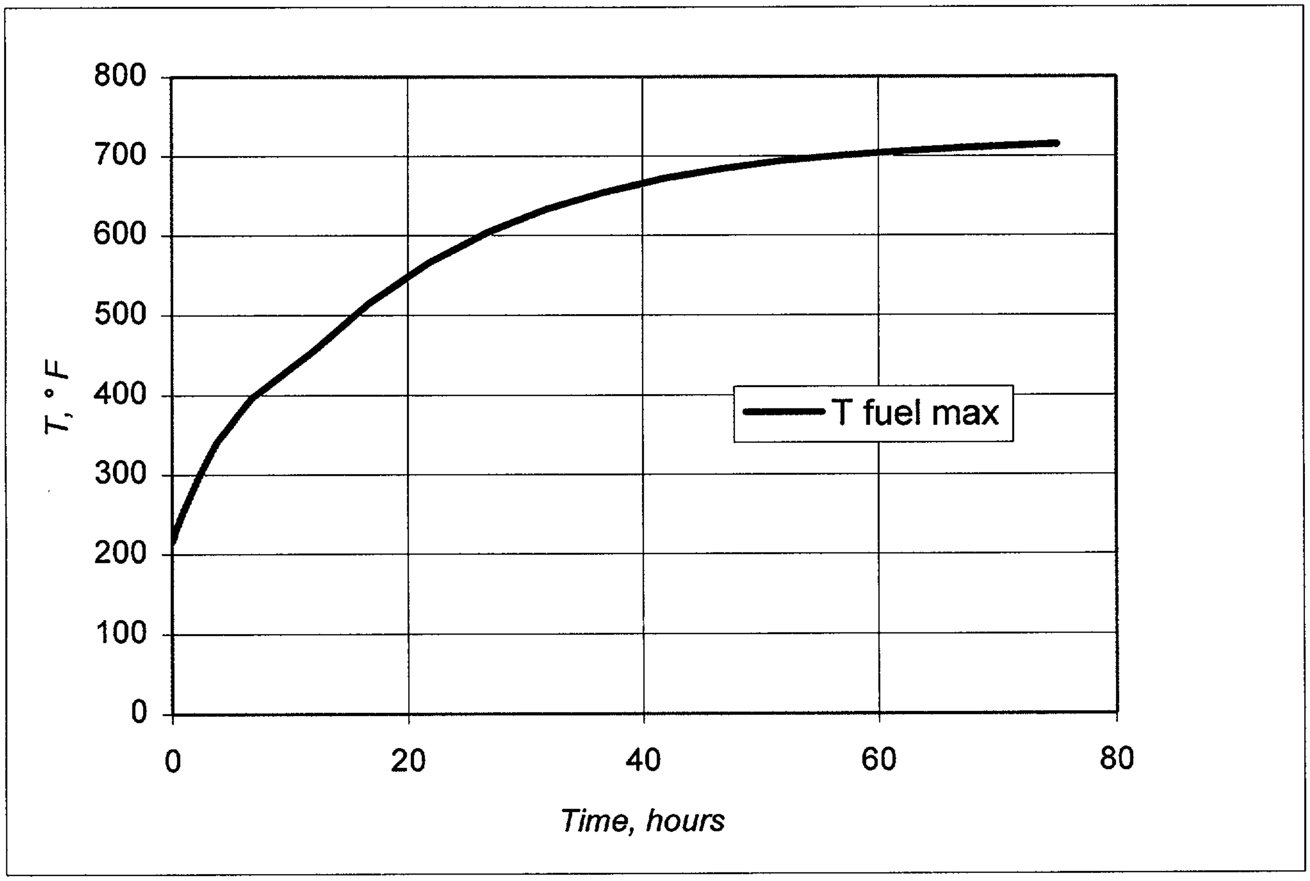


Figure M.4-16
Maximum Fuel Temperature during Vacuum Drying with Heat Load Zoning Configuration 1

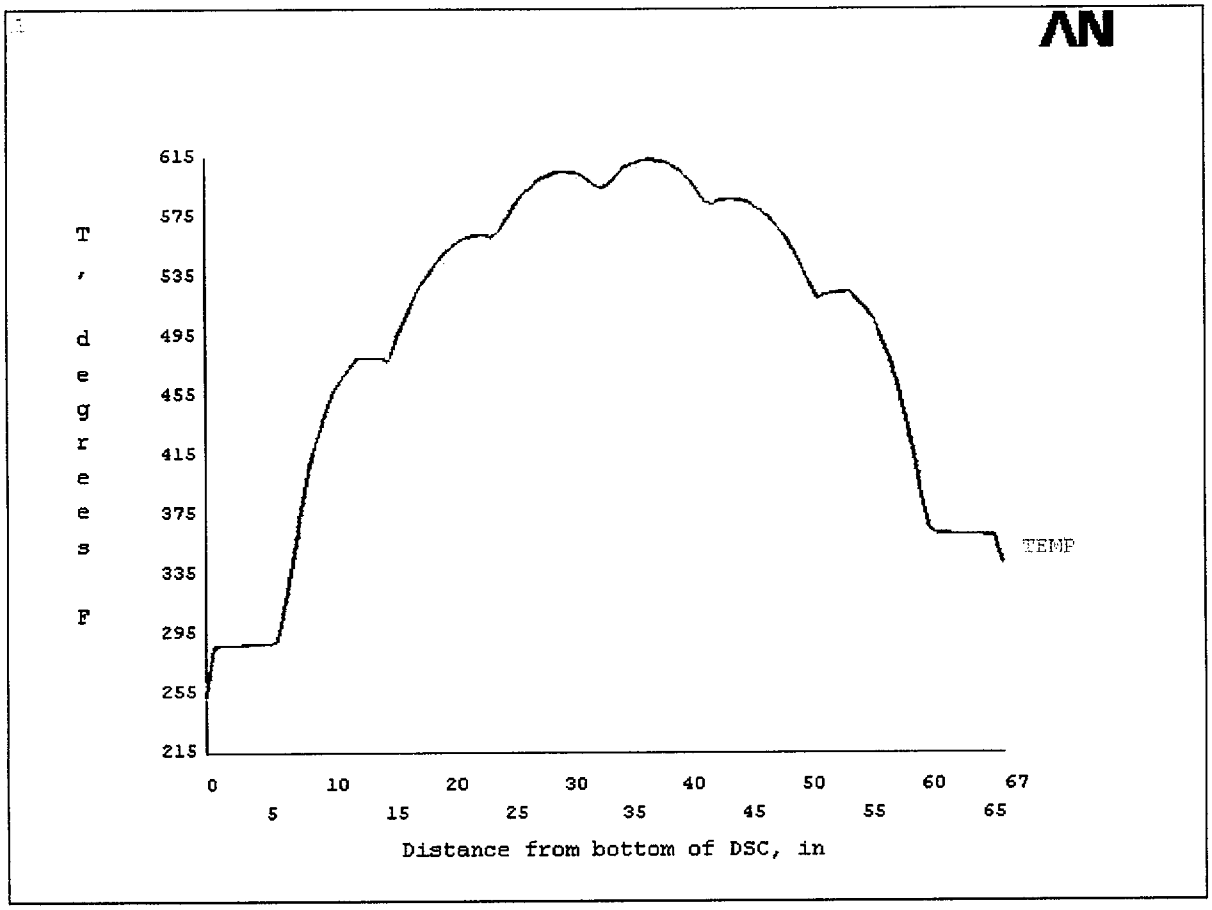


Figure M.4-17
Temperature Distribution from Bottom to Top of DSC at Cross-Section with Highest Temperatures, 70 °F HSM Storage Case

For the case of a liquid neutron shield, a complete loss of neutron shield was evaluated at the 100°F ambient condition with full solar load. It is conservatively assumed that the neutron shield jacket is still present but all the liquid is lost. The maximum DSC shell temperature is *520*°F. The maximum cask inner shell, cask outer shell, and cask neutron shield jacket temperatures are bounded by analyses presented in Section 8.1.3.3 which are 393°F, 384°F and 238°F respectively. The DSC shell temperatures and hence fuel cladding temperature are bounded by the HSM plugged vent case shown in Table M.4-14. Accident thermal conditions, such as loss of the liquid neutron shield, need not be considered in the load combination evaluation. Rather the peak stresses resulting from the accident thermal conditions must be less than the allowable fatigue stress limit for 10 cycles from the appropriate fatigue design curves in Appendix I of the ASME Code. Similar analyses of other NUHOMS® TCs have shown that fatigue is not a concern. Therefore, these stresses in a TC with a liquid neutron shield need not be evaluated for the accident condition.

M.11.2.5.3 Accident Dose Calculations for Loss of Neutron Shield

The postulated accident condition for the on-site TC assumes that after a drop event, the water in the neutron shield is lost. The loss of neutron shield is modeled using the normal operation models described in Section M.5.4 by replacing the neutron shield with air.

The accident condition dose rates are summarized in Table M.11-2 and Figure M.11-1 for the bounding 100-ton 32PT-L100 DSC loaded with design basis fuel plus BPRAs.

A comparison of the results in Table M.11-2 and Table M.5-4, demonstrates a maximum cask surface contact dose rate increase from 9.47E+02 mrem/hr to 4.63E+03 mrem/hr. These dose rates are approximately 2.2 times those reported in Section 8.2.5.3.2. Therefore, one would expect that the additional dose rate to an average on-site worker at an average distance of fifteen feet would also increase from 310 mrem/hr to 700 mrem/hr. Similarly the exposure to off-site individuals at a distance of 2000 feet would also be expected to increase from 0.04 mrem for an assumed eight hour exposure to 0.09 mrem. This exposure is still well within the limits of 10CFR72 for an accident condition.

M.11.2.5.4 Corrective Action

No change. See Section 8.2.5.4.

M.11.2.6 Lightning

No change. The evaluation presented in Section 8.2.6 is not affected by the addition of the NUHOMS®-32PT DSC to the NUHOMS® System.

M.11.2.7 Blockage of Air Inlet and Outlet Openings

This accident conservatively postulates the complete blockage of the HSM ventilation air inlet and outlet openings on the HSM side walls.