NUH-003
Revision 10
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UPDATED FINAL SAFETY ANALYSIS REPORT FOR THE STANDARDIZED NUHOMS® HORIZONTAL MODULAR STORAGE SYSTEM FOR IRRADIATED NUCLEAR FUEL

PUBLIC

By

Transnuclear, Inc.

Columbia, MD

REVISION LOG SHEET

UFSAR Revision	Date	Record of Changes/FCNs	Changed Pages
9	2/3/06	FCNs 721004-045, 074, 171 R1, 172, 188, 218, 206 R1, 250, 276 R1, 294 R1, 301 R1, 309 R1, 313 R1, 317, 345, 373 and 377.	See List of Effective Pages
10	2/1/08	FCNs 721004-321 R2, 338 R1, 340, 347 R1, 352, 370, 401, 406, 410, 416, 417, 418, 428, 435, 437, 439, 445, 446, 447, 461, 467, 476 R1, 484, 494, 498, 509, 525, 528, 543	See List of Effective Pages

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8.2-72	10	February 2008
8.2-73	10	February 2008
8.2-74	9	January 2006

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8.2-76	10	February 2008
8.2-77	10	February 2008
8.2-78	8	June 2004
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9.3-2	6	October 2001
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9.5-1	6	October 2001
9.6-1	6	October 2001
9.7-1	6	October 2001
10-1	7	November 2003
10-2	6	October 2001
10-3	6	October 2001

Page or description	Rev.	Date
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11.1-2	7	November 2003
11.1-3	6	October 2001
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11.2-1 "Category A…"	7	November 2003
11.2-2	7	November 2003
11.2-3	6	October 2001
11.2-4	6	October 2001
11.3-1	7	November 2003
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A.3	6	October 2001
A.4	7	November 2003
A.5	7	November 2003
A.6	6	October 2001
A.7	6	October 2001
A.8	6	October 2001
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B.2-1	6	October 2001
B.2-2	6	October 2001
B.2-3	6	October 2001
B.2-4	6	October 2001
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B.3-7	6	October 2001
B.3-8	6	October 2001
B.3-9	6	October 2001
B.3-10	6	October 2001

Page or description	Rev.	Date
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B.3-13	6	October 2001
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C.2-1	6	October 2001
C.2-2	9	January 2006
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C.3-9	6	October 2001
C.3-10	6	October 2001
D.0	6	October 2001
D.1-1	6	October 2001
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D.1-3	6	October 2001
D.1-4	6	October 2001
D.1-5	6	October 2001
D.1-6	6	October 2001

Page or description	Rev.	Date
D.1-7	6	October 2001
D.1-8	6	October 2001
D.1-9	6	October 2001
E-1 "Appendix E"	7	November 2003
E.2 "This appendix…"	10	February 2008
E.1 "Appendix E.1"	9	January 2006
E.2 "Appendix E.1.1"	9	January 2006
DWG (sh. 1 of 3) NUH-03-1020NP-SAR	1	Not shown
DWG (sh. 2 of 3) NUH-03-1020NP-SAR	1	Not shown
DWG (sh. 3 of 3) NUH-03-1020NP-SAR	1	Not shown
DWG (sh. 1 of 1) NUH-03-1021NP-SAR	1	Not shown
DWG (sh. 1 of 2) NUH-03-1022NP-SAR	1	Not shown
DWG (sh. 2 of 2) NUH-03-1022NP-SAR	1	Not shown
DWG (sh. 1 of 3) NUH-03-1023NP-SAR	1	Not shown
DWG (sh. 2 of 3) NUH-03-1023NP-SAR	1	Not shown
DWG (sh. 3 of 3) NUH-03-1023NP-SAR	1	Not shown
E.3	9	January 2006
DWG (sh. 1 of 1) NUH-03-1029NP-SAR	1	Not shown
DWG (sh. 1 of 2) NUH-03-1030NP-SAR	1	Not shown
DWG (sh. 2 of 2) NUH-03-1030NP-SAR	1	Not shown
DWG (sh. 1 of 3) NUH-03-1031NP-SAR	1	Not shown
DWG (sh. 2 of 3) NUH-03-1031NP-SAR	1	Not shown
DWG (sh. 3 of 3) NUH-03-1031NP-SAR	1	Not shown
DWG (sh. 1 of 3) NUH-03-1032NP-SAR	1	Not shown
DWG (sh. 2 of 3) NUH-03-1032NP-SAR	1	Not shown
DWG (sh. 3 of 3) NUH-03-1032NP-SAR	1	Not shown
E.4	9	January 2006
DWG (sh. 1 of 3) NUH-03-1050NP-SAR	1	Not shown
DWG (sh. 2 of 3) NUH-03-1050NP-SAR	1	Not shown
DWG (sh. 3 of 3) NUH-03-1050NP-SAR	1	Not shown
DWG (sh. 1 of 2) NUH-03-1051NP-SAR	1	Not shown
DWG (sh. 2 of 2) NUH-03-1051NP-SAR	1	Not shown
DWG (sh. 1 of 2) NUH-03-1052NP-SAR	1	Not shown

Page or description	Rev.	Date
DWG (sh. 2 of 2) NUH-03-1052NP-SAR	1	Not shown
DWG (sh. 1 of 3) NUH-03-1053NP-SAR	1	Not shown
DWG (sh. 2 of 3) NUH-03-1053NP-SAR	1	Not shown
DWG (sh. 3 of 3) NUH-03-1053NP-SAR	1	Not shown
E.5	9	January 2006
E.6	9	January 2006
DWG (sh. 1 of 3) NUH-03-6008NP-SAR	1	Not shown
DWG (sh. 2 of 3) NUH-03-6008NP-SAR	1	Not shown
DWG (sh. 3 of 3) NUH-03-6008NP-SAR	1	Not shown
DWG (sh. 1 of 1) NUH-03-6009NP-SAR	1	Not shown
DWG (sh. 1 of 2) NUH-03-6016-SAR	9	Not shown
DWG (sh. 2 of 2) NUH-03-6016-SAR	9	Not shown
E.7	9	January 2006
E.8	9	January 2006
DWG (sh. 1 of 1) NUH-03-8000-SAR	4	Not shown
DWG (sh. 1 of 5) NUH-03-8001-SAR	8	Not shown
DWG (sh. 2 of 5) NUH-03-8001-SAR	8	Not shown
DWG (sh. 3 of 5) NUH-03-8001-SAR	8	Not shown
DWG (sh. 4 of 5) NUH-03-8001-SAR	8	Not shown
DWG (sh. 5 of 5) NUH-03-8001-SAR	8	Not shown
DWG (sh. 1 of 3) NUH-03-8002-SAR	8	Not shown
DWG (sh. 2 of 3) NUH-03-8002-SAR	8	Not shown
DWG (sh. 3 of 3) NUH-03-8002-SAR	8	Not shown
DWG (sh. 1 of 3) NUH-03-8003-SAR	8	Not shown
DWG (sh. 2 of 3) NUH-03-8003-SAR	8	Not shown
DWG (sh. 3 of 3) NUH-03-8003-SAR	8	Not shown
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G.0	6	October 2001
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H.3	6	October 2001
H.4	6	October 2001
H.5	6	October 2001
H.6	6	October 2001
H.7	6	October 2001

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H.9	6	October 2001
H.10	6	October 2001
H.11	6	October 2001
H.12	6	October 2001
H.13	6	October 2001
I-1	6	October 2001
"Appendix J"	6	October 2001
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J.10-1	6	October 2001
J.11-1	6	October 2001
J.12-1	6	October 2001
J.13-1	6	October 2001
J.14-1	6	October 2001
"Appendix K"	8	June 2004
Page i	10	February 2008
Page ii	10	February 2008
Page iii	10	February 2008
Page iv	8	June 2004
Page v	8	June 2004

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Page vi	8	June 2004
Page vii	8	June 2004
Page viii	10	February 2008
Page ix	8	June 2004
Page x	8	June 2004
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K.1-2	8	June 2004
K.1-3	8	June 2004
K.1-4	8	June 2004
K.1-5	8	June 2004
K.1-6	8	June 2004
K.1-7	8	June 2004
K.1-8	8	June 2004
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DWG (sh. 2 of 2) NUH-61B-1060-SAR	4	Not shown
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DWG (sh. 2 of 2) NUH-61B-1062-SAR	5	Not shown
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DWG (sh. 2 of 3) NUH-61B-1066NP-SAR	3	1/30/06
DWG (sh. 3 of 3) NUH-61B-1066NP-SAR	3	1/30/06
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K.2-6	8	June 2004
K.2-7	8	June 2004
K.2-8	8	June 2004

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K.2-24	10	February 2008
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Page or description	Rev.	Date
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Page or description	Rev.	Date
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K.3.7-46	8	June 2004

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V.4-6	10	February 2008

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W.3-3	10	February 2008
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EXECUTIVE SUMMARY

This Updated Final Safety Analysis Report (No. NUH-003, Revision 10, NRC Docket No. 72-1004) provides the generic safety analysis for the standardized NUHOMS®[1] system for storage of light water reactor spent nuclear fuel assemblies. This system provides for the safe dry storage of spent fuel in a passive Independent Spent Fuel Storage Installation (ISFSI) which fully complies with the requirements of 10CFR72 and ANSI 57.9. The related NUHOMS®-24P Topical Report (No. NUH-002, Revision 1A, NRC Project No. M-49) was approved by the U.S. Nuclear Regulatory Commission on April 21, 1989. The original NUHOMS®-07P Topical Report (No. NUH-001, Revision 1A, NRC Project No. M-39) was approved by the U.S. Nuclear Regulatory Commission on March 28, 1986.

This Updated Final Safety Analysis Report (UFSAR) formed the basis for generic NRC certification of the standardized NUHOMS® system and will be used by 10CFR50/10CFR72 general license holders in accordance with 10CFR72 Subparts K and L. It is also suitable for reference in 10CFR72 site specific license applications. In January 1995, the USNRC issued a generic Certificate of Compliance to VECTRA for the standardized NUHOMS® canister/module horizontal cask storage system. The Nuclear Regulatory Commission staff does not intend to repeat the review in order to authorize the use of a standardized NUHOMS® ISFSI by a general license holder.

The principal features of the standardized NUHOMS® system which differ from the previously approved NUHOMS®-24P system are:

1. A free-standing prefabricated horizontal storage module founded on an ISFSI basemat which is not important to safety.

2. A standardized dry shielded canister for on-site dry storage and eventual off-site shipment of spent PWR or BWR fuel assemblies.

3. Removal of site specific dependencies to allow direct implementation by 10CFR72 general license holders.

4. Design qualification for five-year cooled PWR and BWR spent fuel.

[1] NUHOMS® is a registered trademark of Transnuclear, Inc.

The NUHOMS® system provides long-term interim storage for spent fuel assemblies which have been out of the reactor for a sufficient period of time and which comply with the criteria set forth in this FSAR. The fuel assemblies are confined in a helium atmosphere by a canister containment pressure vessel. The canister is protected and shielded by a massive reinforced concrete module. Decay heat is removed from the canister and the concrete module by a passive natural draft convection ventilation system.

The canisterized spent fuel assemblies are transferred from the plant's spent fuel pool to the concrete storage modules located at the ISFSI in a transfer cask. The cask is aligned with the storage module and the canister is inserted into the module by means of a hydraulic ram. The NUHOMS® system is a totally passive installation that is designed to provide shielding and safe confinement of spent fuel for a range of postulated accident conditions and natural phenomena. As a condition of the USNRC Certificate of Compliance, temperature monitoring of the concrete module is required.

Revision 4A of this FSAR consists of a revision to the previously submitted report and incorporates the conditions of use specified by the Certificate and US NRC's Safety Evaluation Report that were not included in earlier revisions, along with revisions to reflect design modifications and utility comments.

Revision 5 of this FSAR incorporates all design modifications and supporting analysis implemented per Condition 9 of USNRC Certificate of Compliance (CoC) since issuance of Revision 4A. It also incorporates changes due to approval of Amendments 1 and 2 to the CoC.

Revision 6 of this FSAR incorporates all design modifications implemented per Condition 9 of CoC 1004 since issuance of FSAR Revision 5. It also incorporates changes implemented under CoC Amendment No. 3.

Revision 7 of this FSAR incorporates all design modifications implemented per 72.48 since the issuance of FSAR Revision 6. It also incorporates changes implemented due to approval of Amendment No. 4 to CoC 1004.

Revision 8 of this FSAR incorporates design modifications implemented per 72.48 since the issuance of FSAR Revision 7. It also incorporates changes implemented due to approval of Amendments 5, 6 and 7 to CoC 1004.

Revision 9 of this UFSAR incorporates design modifications implemented per 72.48 since the issuance of FSAR Revision 8. It also incorporates changes implemented due to approval of Amendment 8 CoC 1004.

Revision 10 of this UFSAR incorporates design modifications implemented per 72.48 since the issuance of FSAR Revision 9. It also incorporates changes implemented due to approval of Amendment 9 CoC 1004.

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LIST OF ABBREVIATIONS

10CFR	Code of Federal Regulations, Title 10
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ALARA	As Low as is Reasonably Achievable
ANF	Advanced Nuclear Fuels
ANS	American Nuclear Society
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
B&W	Babcock & Wilcox
BWR	Boiling Water Reactor
CE	Combustion Engineering
DBT	Design Basis Tornado
DSC	Dry Shielded Canister
GE	General Electric
HSM	Horizontal Storage Module
ISFSI	Independent Spent Fuel Storage Installation
MWD/MTU	Megawatt days per metric ton uranium
MWe	Megawatts electric
MWt	Megawatts thermal
NDE	Non-Destructive Examination
NDRC	National Defense Research Committee
NFPA	National Fire Protection Association
NRC	Nuclear Regulatory Commission
NUHOMS	Nuclear Horizontal Modular Storage
NUREG	Nuclear Regulatory Guide
OBE	Operating Basis Earthquake
OSHA	Occupational Health and Safety Administration
PI	Project Instruction
PWR	Pressurized Water Reactor
QP	Quality Procedure
R.G.	NRC Regulatory Guide
SFA	Spent Fuel Assembly
SSE	Safe Shutdown Earthquake
TC	Transfer Cask
TR	Topical Report
U.S.	United States
UFSAR	Updated Final Safety Analysis Report
W	Westinghouse
atm	Atmosphere
bar	Bar

LIST OF ABBREVIATIONS

°C	degrees Centigrade
Ci/cm^2	Curies per square centimeter
cm	centimeter
°F	degrees Fahrenheit
fps	feet per second
ft	foot
ft-lb	foot pounds
ft/s	feet per second
He	helium
Hg	Mercury
in	inch
k-in	kip inch
kg	kilogram
k_{eff}	neutron multiplication factor, effective
kips	thousand pounds
kN	kilonewton
ksi	kips per square inch
kW	kilowatt
lb	pound
lbf	pounds-force
m	meter
MeV	Megaelectron volt
mm	millimeter
mph	miles per hour
mrem/hr	millirem per hour
mR/hr	milliroentgen per hour
n	neutron
N	Newton
psf	pounds per square foot
psi	pounds per square inch
psia	pounds per square inch, absolute
psig	pounds per square inch, gauge
sec	second
sq. mi.	square mile
ton	ton
w/o	without
wt. %	weight %

The NUHOMS®-24PTH system adds a new canister with three alternate configurations (designated as DSC Type 24PTH-S, -24PTH-L, or -24PTH-S-LC), a new module designated as HSM-H, and a modified version of OS197/OS197H transfer cask designated as OS197FC/OS197H FC.

A detailed description of the 24PTH system, including drawings, authorized payload contents and supporting safety analyses for this system are provided in Appendix P of this UFSAR.

Amendment 8 to CoC also authorized storage of low enrichment and reconstituted fuel in the 32PT DSC. In addition, the authorized contents of the 24PHB DSC were revised to include additional fuel types. A detailed description of the changes implemented to the 32PT and 24PHB DSCs are provided in Appendices M and N, respectively.

TN has added two alternate HSMs, designated as HSM Model 152 and HSM Model 202, to the standardized NUHOMS® system. These alternate HSM designs provide enhanced shielding features while meeting the heat rejection requirements. A detailed description of the HSM Model 152 and HSM Model 202 and supporting analyses are provided in Appendices R and V, respectively.

Chapters 1 though 8 and Appendices A through H of this FSAR provide the supporting licensing basis for the Standardized NUHOMS®-24P and -52B systems only.

Appendix W has been added to the UFSAR to incorporate a light weight (75 ton) version of the OS197 onsite transfer cask.

A complete description of the new systems addressed by the above listed amendments, including supporting safety analysis, is located within self-contained Appendices to this FSAR as summarized in the following table:

Amendment No.	Description	Location of Supporting Licensing Basis
3	Addition of the NUHOMS®-61BT DSC to the contents of the Standardized NUHOMS® system	Appendix K
N/A	Addition of the NUHOMS®-24PT2 DSC to the contents of the Standardized NUHOMS® system	Appendix L
4	Addition of low burnup fuel to the contents of the NUHOMS®-24P DSC	Chapter 3
5	Addition of the NUHOMS®-32PT DSC to the Standardized NUHOMS® system	Appendix M
6	Addition of the NUHOMS®-24PHB DSC to the Standardized NUHOMS® system	Appendix N
7	Addition of damaged fuel to the contents of the NUHOMS®-61BT DSC	Appendix K
8	(a) Addition of the NUHOMS® 24PTH system to the Standardized NUHOMS® system (b) Revision of the authorized contents of the 32PT DSC to include low enrichment and reconstituted fuel (c) Revision of the authorized contents of the 24PHB DSC to include additional fuel types	Appendix P Appendix M Appendix N
N/A	Addition of an alternate version of the HSM, designated as HSM Model 152, to the Standardized NUHOMS® system	Appendix R
N/A	Addition of an alternate version of the HSM, designated as HSM Model 202, to the Standardized NUHOMS® system	Appendix V
N/A	Addition of an alternate version of the OS197 Transfer Cask, designated as OS197L, to the Standardized NUHOMS® system. Revised Technical Specifications to conform with NUREG 1745 format.	Appendix W

Table 1.2-2
Key Design Parameters for the Standardized NUHOMS® System
(concluded)

Category	Criteria or Parameter	Value
Horizontal Storage Module(1):	Capacity	One DSC per HSM
	Array Size	Single Module to 2xL Module Array. L may be any value.
	HSM Size:	
	Length	PWR: 5.8m (19.0 ft.) BWR: 6.0m (19.8 ft.)
	Height	4.6m (15 ft.)
	Width	2.9m (9.7 ft.)
	Surface Dose Rate	ALARA
	Heat Rejection Capacity	24.0 kW (5 yr. cooled)
	Heat Removal	Natural Circulation
	Materials of Construction	Reinforced Concrete and Structural Steel
	Service Life	50 years

(1) These are nominal dimensions. See Appendix E drawings for the HSM Model 80 and Model 102. See Appendix E drawings for actual dimensions. See Appendices R, P, and V for details on HSM Model 152, HSM-H and HSM Model 202, respectively.

The 61BT DSC basket structure consists of assemblies of stainless steel fuel compartments held in place by basket rails and holddown ring. The four and nine compartment assemblies are held together by welded stainless steel boxes wrapped around the fuel compartments, which also retain the neutron absorber plates between the compartments in the assemblies. The borated aluminum or boron carbide/aluminum metal matrix composite plates (neutron absorber plates) provide the necessary criticality control and provide the heat conduction paths from the fuel assemblies to the cask cavity wall.

The 32PT DSC basket structure is a box type assembly of high strength XM-19 stainless steel surrounded by transition rails. Inside the compartments, around the fuel assemblies, the borated aluminum or Boralyn® plates (neutron poison plates) provide the necessary criticality control and provide the heat conduction paths from the fuel assemblies to the cask cavity wall. This method of construction forms a very strong structure of compartment assemblies which provide for storage of 32 fuel assemblies. Appendix M provides the details of the 32PT DSC.

1.3.1.2 Horizontal Storage Module Model 80 and Model 102

An isometric view of the two alternate designs of a prefabricated HSM utilized to form an array of HSMs is shown in Figure 1.2-2 and 1.2-2a. Three additional alternate designs, designated as HSM-H, HSM Model 152, and HSM Model 202, are discussed in detail in Appendices P, R, and V, respectively.

Each HSM provides a self-contained modular structure for storage of spent fuel canisterized in a DSC as illustrated in Figure 1.3-4. The HSM is constructed from reinforced concrete and structural steel. The thick concrete roof and walls of the HSM provide substantial neutron and gamma shielding. Contact doses for the HSM are designed to be ALARA.

The nominal thickness of the HSM roof and exterior walls of an HSM array for biological shielding is about three feet. Separate shielding walls are utilized at the end of a module row to provide the required thickness. Similarly, an additional shield wall is used at the rear of the module if the ISFSI is configured as single module rows. Sufficient shielding between HSMs in an HSM array to prevent scatter in adjacent HSMs during loading and retrieval operations is provided by thick concrete side walls. The inlet and outlet vents are designed to take advantage of the self-shielding of adjacent HSMs.

The HSM provides a means of removing spent fuel decay heat by a combination of radiation, conduction and convection. Ambient air enters the HSM through ventilation inlet openings in the lower side walls of the HSM and circulates around the DSC and the heat shield. Air exits the HSM through outlet openings in the upper side walls of the HSM. Adjacent modules are spaced to provide a ventilation flow path between modules.

Decay heat is rejected from the DSC to the HSM air space by convection and then is removed from the HSM by a natural circulation air flow. Heat is also radiated from the DSC surface to the heat shield and HSM walls where again the natural convection air flow and conduction through the walls removes the heat. Figure 1.3-5 shows the ventilation flow paths for the DSC and the HSM. The passive cooling system for the HSM is designed to assure that peak cladding temperatures during long term storage remain below acceptable limits to ensure fuel cladding integrity.

controlled access. The necessary civil work required to prepare the ISFSI site is the same as that for an ISFSI utilizing vertical storage casks.

Two alternate designs of the standardized HSM are available for licensees' use: the original HSM, now designated as HSM Model 80 and HSM Model 102. HSM Model 102 design is similar to HSM Model 80 design except for the following two features:

- The steel encased composite door of HSM Model 80 design is replaced by a two foot thick reinforced concrete door with a steel liner on its inside surface. The steel liner mitigates DSC damage from spalled concrete due to tornado generated missile impact.
- The inlet and outlet vents, which are formed in concrete for HSM Model 80, are lined with 1½" steel plates.

The above features included with HSM Model 102 are improvements to the original HSM Model 80 design that increase the shielding capabilities of the HSM. The heat transfer capability (decay heat rejection from the DSC to the HSM and heat removal from the HSM by natural convection) of both HSM Model 80 and HSM Model 102 designs are equivalent. Appendix E drawings show both models. Each model can store a DSC with maximum weight up to 102 kips which includes 24P, 52B, 24PT2 and 61BT DSCs.

1.3.2 Transfer Systems Descriptions

1.3.2.1 On-Site TC

The transfer cask used in the NUHOMS® system provides shielding and protection from potential hazards during the DSC closure operations and transfer to the HSM. Four alternate configurations of the transfer cask are available for the licensees' use. The basic configuration, where the cask is provided with a solid neutron shield, is described herein as the "Standardized Cask." An alternate configuration, where a liquid neutron shield is provided instead, is described in this SAR as the "OS197, OS197H, or OS197L Cask."

The configuration of the OS197 is a slightly modified version of the NRC approved cask (with a liquid neutron shield) as described in the NUHOMS®–24P Topical Report (1.10). The standardized transfer cask documented in this SAR has a gross weight of less than 90.7 Te (100 tons) and is limited to on-site use under 10CFR72. The OS197 and OS197H transfer casks, which are also limited to on-site use under 10CFR72, have a maximum gross weight of 94.6 Te (104.25 tons) and 113.4 Te (125 Tons), respectively. In addition, the licensee may also elect to utilize a future transfer cask having a gross weight of about 113.4 Te (125 tons) which can be used on-site under 10CFR72, but is also suitable for future off-site shipment of intact NUHOMS® canisters under 10CFR71. Where applicable, any other NRC licensed NUHOMS® transfer or transportation cask is acceptable for use with the standardized NUHOMS® system subject to an application specific safety evaluation.

The third configuration of the transfer cask, designated as OS197FC/OS197H FC, is a modified version of OS197/OS197H equipped with a modified lid to allow air circulation through the TC/DSC annulus, and is described in Appendix P.

A fourth configuration of the transfer cask, designated as OS197L TC, is a lighter version of the OS197 TC. It is designed for use by facilities with a crane capacity of 75 tons and is described in Appendix W.

Table 1.3-1
Components, Structures and Equipment for the Standardized NUHOMS® System

Dry Shielded Canister[1] [2]

Internal Basket Assembly:

Guide Sleeves	(24 for 24P, 24PHB & 24PT2)
Oversleeves	(24P, 24PHB & 24PT2)
Fixed Neutron Absorbers	(88 for 52B; 72 for 24PT2)
Spacer Disks	(8 for 24P & 24PHB; 9 for 52B; 26 for 24PT2)
Support Rods	(4 for 24P & 24PHB; 6 for 52B; 4 for 24PT2)
Spacer Sleeves	(52B & 24PT2)

Cylindrical Shell

Shield Plugs (top and bottom)

Inner and Outer Cover Plates (top and bottom)

Siphon and Vent Port

Grapple Ring

Horizontal Storage Module Model 80 and Model 102[3]

Reinforced Concrete Walls, Roof, and Floor

DSC Support Structure

DSC Axial Retainer

Cask Docking Flange and Cask Restraint Eyes

Heat Shield

Shielded Access Door

Ventilation Air Openings (four inlets, four outlets)

(1) For the NUHOMS®-61BT DSC, see Appendix K.
(2) For the NUHOMS®-32PT DSC, see Appendix M.
(3) For the NUHOMS® HSM-H, HSM Model 152, and HSM Model 202, see Appendices P, R, and V, respectively.

Once inside the HSM, the DSC and its payload of SFAs is in passive dry storage. Safe storage in the HSM is assured by a natural convection heat removal system, and massive concrete walls and slabs which act as biological radiation shields. The storage operation of the HSMs and DSCs is totally passive. No active systems are required.

3.1.2.1 Handling and Transfer Equipment

The handling and transfer equipment required to implement the NUHOMS® system includes a cask handling crane at the reactor fuel pool, a cask lifting yoke, a transfer cask, a cask support skid and positioning system, a low profile heavy haul transport trailer and a hydraulic ram system. This equipment is designed and tested to applicable governmental and industrial standards and is maintained and operated according to the manufacturer's specifications. Performance criteria for this equipment, excluding the fuel/reactor building cask handling crane, is given in the following sections. The criteria are summarized in Table 3.1-7.

On-Site Transfer Cask: The on-site transfer cask used for the NUHOMS® system has certain basic features. The DSC is transferred from the plant's fuel pool to the HSM inside the transfer cask. The cask provides neutron and gamma shielding adequate for biological protection at the outer surface of the cask. The cask is capable of rotation, from the vertical to the horizontal position on the support skid. The cask has a top cover plate which is fitted with a lifting eye allowing removal when the cask is oriented horizontally. The cask is capable of rejecting the design basis decay heat load to the atmosphere assuming the most severe ambient conditions postulated to occur during normal, off-normal and accident conditions. For the NUHOMS®-24P, 24PHB DSC or the NUHOMS®-24PT2 DSC, the standardized transfer cask has a cylindrical cavity of 1.73m (68 inches) diameter and 4.75m (186.75 inches) in length and a maximum dry payload capacity of 42,321 Kg (93,300 pounds). For the NUHOMS®-52B or NUHOMS®-61BT, the standardized transfer cask is fitted with an extension collar to accommodate the longer BWR DSC and fuel. Alternatively, the OS197 and OS197H transfer casks with a full length cavity of 5.0m (196.75 inches) may be used for the NUHOMS®-24P, 24PHB (with cask spacer), NUHOMS®-52B, NUHOMS®-61BT DSCs, NUHOMS®-24PT2 DSC (with cask spacer) or NUHOMS®-32PT DSC (with cask spacer). The OS197 and OS197H casks can carry a maximum dry payload of 44,100 kg (97,250 lb) and 52,600 kg (116,000 lb), respectively. These payload capacities are based on a transfer cask weight of 111,250 pounds. The cask and the associated lifting yoke are designed and operated such that the consequences of a postulated drop satisfy the current 10CFR50 licensing bases for the vast majority of plants. Appendix W provides a detailed description of the OS197L transfer cask.

The NUHOMS® transfer cask is designed to meet the requirements of 10CFR72 (3.6) for normal, off-normal and accident conditions. The NUHOMS® transfer cask is designed for the following conditions:

A.	Seismic	Reg. Guide 1.60 (3.11) and 1.61 (3.12)

3.2 Structural and Mechanical Safety Criteria

The reinforced concrete HSM and its DSC support structure, the DSC and its internal basket assembly, and the transfer cask are the NUHOMS® system components which are important to safety. Consequently, they are designed and analyzed to perform their intended functions under the extreme environmental and natural phenomena specified in 10CFR72.122 (3.6) and ANSI-57.9 (3.36). Since the NUHOMS® ISFSI is an independent, passive system, no other components or systems contribute to its safe operation.

Table 3.2-1 summarizes the design criteria for the standardized NUHOMS® system components which are important to safety. This table also summarizes the applicable codes and standards utilized for design. The extreme environmental and natural phenomena design criteria discussed below comply with the requirements of 10CFR72.122 and ANSI-57.9. A description of the structural and mechanical safety criteria for the other design loadings listed in Table 3.2-1, such as thermal loads and cask drop loads, are provided in Chapter 8. The principal design criteria for the NUHOMS®-61BT system are provided in Appendix K.

The principal design criteria for the NUHOMS® HSM Model 80 and Model 102 described in this chapter are also applicable to HSM Model 152 and HSM Model 202. See Appendix R.2 and Appendix V.2, respectively, for details. For HSM-H design criteria, see Appendix P.2.

3.2.1 Tornado and Wind Loadings

The NUHOMS® ISFSI is designed to be located anywhere within the contiguous United States. Consequently, the most severe tornado and wind loadings specified by NRC Regulatory Guide 1.76 (3.7) and NUREG-0800, Section 3.5.1.4 (3.8) are selected as the design basis. The NUHOMS® reinforced concrete HSMs are designed to safely withstand 10CFR72.122 (b)(2) tornado missiles. Extreme wind effects are much less severe than tornado wind and missile loads or seismic effects and, therefore, are not evaluated in detail for the HSM.

Since the NUHOMS® on-site transfer cask is used infrequently and for short durations, the possibility of a tornado funnel cloud enveloping the cask/DSC during transit to the HSM is a low probability event. Nevertheless, the transfer cask is designed for the effects of tornados, in accordance with 10CFR72.122. This includes design for the effects of worst case tornado winds and missiles.

3.2.1.1 Applicable Design Parameters

The design basis tornado (DBT) intensities used for the NUHOMS® transfer cask and HSM design are obtained from NRC Regulatory Guide 1.76. Region I intensities are utilized since they result in the most severe loading parameters. For this region, the maximum wind speed is 160 m/sec (360 miles per hour), the rotational speed is 130 m/sec (290 miles per hour), the maximum translational speed is 31 m/sec (70 miles per hour), the radius of the maximum rotational speed is 45.7 m (150 feet), the pressure drop

Since the HSMs are located outdoors in generally open areas, there is no possibility of an adjacent building collapsing on an HSM. The possibility of blocking the ventilation air openings by a foreign object during a tornado event, however, is considered. The effects of ventilation opening blockage are presented in Section 8.2.7.

3.2.2 Water Level (Flood) Design

Flooding of the NUHOMS® ISFSI greater than 0.46 m (1'-6") above grade results in blockage of the HSM Model 80 and Model 102 inlet vents. Blockage of the HSM-H, HSM Model 152, and Model 202 inlet vents occurs for any flooding above grade. Flooding of the NUHOMS® ISFSI greater than 1.7 m (5'-8") above grade results in wetting of the DSC. Greater flood heights result in submersion of the DSC and blockage of the HSM outlet vents.

The DSC and HSM are conservatively designed for an enveloping design basis flood, postulated to result from natural phenomena such as a tsunami, and seiches, as specified by 10CFR72.122(b). For the purpose of this bounding generic evaluation, a 15 m (50 foot) flood height and water velocity of 4.6 m/sec (15 fps) is used. The HSM is evaluated for the effects of a water current of 4.6 m/sec (15 fps) impinging upon the side of a submerged HSM. The DSC is subjected to an external pressure equivalent to a 15 m (50 foot) head of water. These evaluations are presented in Section 8.2.4. The effects of water reflection on DSC criticality safety are addressed in Section 3.3.4. Due to its short term infrequent use, the on-site transfer cask is not explicitly evaluated for flood effects. ISFSI procedures should ensure that the transfer cask is not used for DSC transfer during flood conditions.

The calculated effects of the enveloping design basis flood are included in the load combinations and reported stresses presented in Section 8.2.10. The plant specific design basis flood (if the possibility for flooding exists at a particular ISFSI site) should be evaluated by the licensee and shown to be enveloped by the flooding conditions used for this generic evaluation of the NUHOMS® DSC and HSM.

3.2.3 Seismic Design Criteria

The design basis response spectra of NRC Regulatory Guide (R.G.) 1.60 (3.11) is selected for the NUHOMS® design earthquake as defined in 10CFR72.102 (a)(2). Since the DSC can be considered to act as a large diameter pipe for the purpose of evaluating seismic effects, the "Equipment and Large Diameter Piping System" category in NRC Regulatory Guide 1.61, Table 1 (3.12) is assumed to be applicable. Hence, a damping value of three percent of critical damping for the design bases safe shutdown earthquake is used. Similarly, from the same R.G. table, a damping value of seven percent of critical damping is used for the reinforced concrete HSM. The horizontal and vertical components of the design response spectra (in Figures 1 and 2, respectively, of the NRC Regulatory Guide 1.60) correspond to a maximum horizontal and vertical ground acceleration of 1.0g. The maximum ground displacement is taken to be proportional to

summarizes the stress criteria for DSC non-pressure boundary components (except for support rods). The spacer discs are designed using the component stress criteria from ASME Code Subsection NB (for Service Levels A, B, C) and ASME Code Appendix F (Service Level D, Elastic and Elastic/Plastic analysis). The support rods are designed using the criteria of ASME Code Subsection NF for linear type component supports (for Service levels A, B, C) and ASME Code Appendix F (for Service Level D stress or stability criteria). For Service Level A the limits of NF-3322 are used. For Service Levels B and C the factors of Table NF-3523(b)-1 are used. For Service Level D, the criteria from Appendix F is used. The 24P guide sleeves and oversleeves are designed using the stress criteria of ASME Code Subsection NB and ASME Code Appendix F, and the stability criteria of Subsection NF and Appendix F, as applicable. All non-pressure boundary partial penetration and fillet welds are designed using the stress criteria of ASME Code Subsection NF and ASME Code Appendix F.

Other components of the DSC include the support ring, the lifting lugs, the shield plugs, the grapple ring and grapple ring support plate, and all welds associated with these components. The support ring is designed using the ASME Code Subsection NB criteria. The associated weld to the DSC shell is a partial penetration weld evaluated to the ASME Code Subsection NF and Appendix F requirements, as applicable. The lifting lugs and associated welds are designed using Subsection NF allowables. The grapple ring, grapple ring support plates and associated welds are designed using the ASME Code Subsection NB design criteria. The shield plugs are non-pressure boundary components and need only to maintain their structural integrity. The shield plugs are evaluated using Subsection NB primary stress limits. The shield plugs stiffener welds in the long cavity basket are full penetration welds designed to Subsection NF.

3.2.5.3 On-site Transfer Cask

The on-site transfer cask is a non-pressure retaining component which conservatively is designed by analysis to meet the stress allowables of the ASME Code (3.14) Subsection NC for Class 2 components. The cask is conservatively designed by utilizing linear elastic analysis methods. The load combinations considered for the transfer cask normal, off-normal, and postulated accident loadings are shown in Table 3.2-7. Service Levels A and B allowables are used for all normal operating and off-normal loadings. Service Levels C and D allowables are used for load combinations which include postulated accident loadings. Allowable stress limits for the upper lifting trunnions and upper trunnion sleeves are conservatively developed to meet the requirements of ANSI N14.6-1993 (3.37) for a non-redundant lifting device for all cask movements within the fuel/reactor building. The maximum shear stress theory is used to calculate principal stresses in the cask structural shell. The appropriate dead load and thermal stresses are combined with the calculated drop accident scenario stresses to determine the worst case design stresses. The transfer cask structural design criteria are summarized in Table 3.2-11 and Table 3.2-12. The transfer cask accident analyses are presented in Section 8.2. The effects of fatigue on the transfer cask due to thermal cycling are addressed in Section 8.2.10. Appendices K, L, and N address the effects of handling the NUHOMS®-61BT, -24PT2, and 24PHB DSC in the transfer cask, respectively. The effects of handling the licensed (≤24.0 kW) DSCs (24P, 52B, 61BT, 24PT2, 32PT, and 24PHB) in the OS197L TC are addressed in Appendix W.

using records or tests to document initial enrichment and burnup of the selected fuel assemblies), the geometrical arrangement of the basket and the inherent neutron absorption in the stainless steel guide sleeve assemblies.

Credit for burnup is taken by calculating an initial enrichment equivalent to the fissile inventory of the spent fuel. The CSAS2 criticality analysis sequence included in the SCALE-3 package of computer codes (3.44) is used to demonstrate subcriticality during moderation by pure water having a wide density range. Credit is taken for negative reactivity due to stable fission products.

The DSC basket is shown by analysis in Chapter 8 to maintain its configuration and location of the fuel assemblies after a drop accident. The DSC shell is shown to maintain its integrity during the accident so that no credible accident exists whereby the DSC may be accidentally flooded with fresh water. Water intrusion is not feasible since the DSC has been qualified to be helium leak tight for all postulated events which is a much more limiting condition. ISFSI flooding does result in canister immersion and a water reflector for the spent fuel matrix. However, as has been shown for the NUHOMS®-52B DSC in Section 3.3.4.2, this case does not limit the design. Since moderator intrusion during storage is prevented, subcriticality of the DSC is assured during storage at the ISFSI.

B. Design Parameters for Criticality Model (NUHOMS®-24P)

The geometry and fuel characteristics of the NUHOMS®-24P DSC criticality model are shown in Table 3.3-3. A sensitivity analysis was performed with the guide tube and instrument tubes modeled with twice their design thicknesses. The results of this analysis demonstrates that the design details of the guide tube and instrument tube thicknesses and sub-components like "oversleeves" are not important for criticality and do not affect the conclusions of this evaluation. These results, therefore, cover for sub-components like "oversleeves" with thicknesses up to the design thickness of the guide tube or instrument tube. Figure 3.3-1 shows the actual geometry of the DSC and the geometry of the CSAS2 model. Figure 3.3-2 describes the modeling of the fuel assembly guide sleeves with the heterogeneous fuel assembly region inside.

The reactivity equivalence curve presented in Figure 3.3-3 is used to determine the acceptability of storing specific fuel assemblies in the NUHOMS®-24P DSC. The predetermined residual reactivity limit is selected to correspond roughly to a fuel assembly at 80 percent of what is typically considered full burnup. The concept of reactivity equivalency is used to develop a curve of constant reactivity through the enrichment/burnup space assuming the DSC was fully loaded with spent B&W 15x15 fuel assemblies. The resulting curve of reactivity equivalence for the DSC is presented in Figure 3.3-3. The reactivity equivalence curve extends from a zero burnup, initial enrichment equivalent point of 1.45 wt. % (weight percent) U-235 to a high enrichment endpoint corresponding to 4.0 wt. % U-235 initial enrichment irradiated for approximately 37,000 MWD/MTU.

The selection of a 15x15 fuel assembly for PWR criticality calculations has been shown by many analyses to be the most reactive under a variety of conditions when compared to other PWR fuel assemblies (i.e., 14x14, 16x16, and 17x17) (3.28, 3.29, 3.30, 3.31). Thus the B&W 15x15 fuel selected as the design basis for the NUHOMS®-24P canister forms a sufficient basis to permit storage of PWR fuel types which meet the requirements of Section 10.3.1.1.

shipping cask externals (3.22) Table V, 10CFR71.87(i)(1). Surface swipes of the DSC exterior are taken while in the cask decon area to assure that the maximum DSC removable contamination does not exceed:

Beta/Gamma Emitters	2,200 dpm/100 cm^2
Alpha Emitters	220 dpm/100 cm^2

Transfer cask external contamination is minimized by the use of smooth, easily decontaminated surface finishes to minimize personnel radiation exposures during cask handling operations outside the spent fuel pool. There are no explicit surface contamination limits in 10CFR72 for an on-site transfer cask, and the controlling values will be determined by the specific licensee's Radiation Protection (RP) program.

Containment of radioactive material associated with spent fuel assemblies is provided by fuel cladding, the DSC stainless steel shell, and double seal welded inner and outer closures.

3.3.7.2 Radioactive Waste Treatment

No radioactive waste is generated during the storage period for the NUHOMS® DSC. Radioactive wastes generated during DSC loading operations (contaminated water from the spent fuel pool and potentially contaminated air and helium from the DSC cavity) are treated using existing plant system and procedures as described in Chapter 6.

3.3.7.3 On-site Waste Storage

The requirements for on-site waste storage are satisfied by existing plant facilities for handling and storage of waste from the spent fuel pool and dry active wastes as described in Chapter 6.

3.3.8 Industrial and Chemical Safety

No hazardous chemicals or chemical reactions are involved in the NUHOMS® system loading and storage operations. Industrial safety relating to handling of the cask and DSC are addressed by the licensee's procedures which meet the Occupational Safety and Health Administration (OSHA) requirements.

3.37 American National Standard, "For Radioactive Materials - Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4500 Kg) or More," ANSI N14.6-1986, American National Standards Institute, Inc., New York, New York (1993).

3.38 Malte Edenius, et. al., "CASMO-2 - A Fuel Assembly Burnup Program," STUDSVIK/NR-81/3, March 1981.

3.39 "Duke Power Company Oconee Nuclear Station Reload Design Methodology II," October 1985, DPC-NE-1002A.

3.40 T. L. Sanders, et. al., "Feasibility and Incentives for the Consideration of Spent Fuel Operating Histories in the Criticality Analysis of Spent Fuel Shipping Casks," SAND87-0151, August 1987.

3.41 (See Reference 3.58)

3.42 R. I. Smith and G. J. Konzak, "Clean Critical Experiment Benchmarks for Plutonium Recycle in LWRs," EPRI NP-196, April, 1976.

3.43 "Oconee Generic NODE and PDQ Setup from CASMO-2," OSC-2270, Duke Power Company Design Engineering, Revisions 0-2, 1986.

3.44 (See Reference 3.53)

3.45 American Institute of Steel Construction, (AISC), "Specification for Structural Steel Buildings," Ninth Edition, 1989, Chicago, Illinois.

3.46 American National Standard, "Design Requirements for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Plants," ANSI/ANS 57.2-1983, American National Standards Institute, Inc., New York, New York (1983).

3.47 American National Standard, "Criticality Safety Criteria for the Handling, Storage, and Transportation of LWR Fuel Outside Reactors," ANSI/ANS 8.17-1984, American National Standards Institute, Inc., New York, New York (1984).

3.48 M. Edenius, E. Hellstand, E. Johansson, "CASMO Benchmark Report," RF-78/6293, Studsvik (March 1978).

4. INSTALLATION DESIGN

4.1 Summary Description

This chapter provides a more detailed description of the NUHOMS® system including the HSM (Model 80 and Model 102), HSM, DSC, and on-site transfer cask. A detailed description of the HSM-H, HSM Model 152, and HSM Model 202 is provided in Appendices P, R, and V, respectively.

4.1.1 Location and Layout of Installation

The details of a NUHOMS® ISFSI layout with proximity to other plant features to be determined by the licensee is site specific. The following guidelines are provided for ISFSI site layout as a means of providing a basis for generic analysis of the anticipated HSM arrangements:

A. Prefabricated HSMs may be arranged in side-by-side arrays as a single module row ranging in size from a single stand alone HSM to a 1x10 array of HSMs or larger, as shown in Figure 1.3-12 Adjacent HSMs have a 6" inch space between them to permit ventilation air flow. The side walls of the HSM base units are 1'-6" thick. The outside end walls of the HSM array are shielded by 2'-0" thick shield walls. The rear walls of a single module row HSM array are also shielded by 2'-0" thick shield walls. Detailed requirements for the arrangement of HSMs in a single module row are defined on the Appendix E drawings.

B. Prefabricated HSMs may be arranged in side-by-side back-to-back arrays as a double module row ranging in size from a 2x1 array to a maximum array size of 2x10 HSMs or larger, as shown in Figure 1.3-11. Adjacent HSMs have a 6" inch space between them to permit ventilation air flow.

C. The outside end walls of an HSM array are shielded by 2'-0" thick shield walls. Detailed requirements for the arrangement of HSMs in a double module row are defined on the Appendix E drawings.

D. Combinations of the single module row and double module row arrangements are also permissible as shown in Figure 1.3-13.

E. A concrete basemat and approach slab with access space in front of the HSMs is needed which varies in size depending on the site specific ISFSI layout. Examples of these are shown in Figures 1.3-11 through 1.3-13.

Guidelines for selection of a suitable ISFSI site are provided in Section 1.2.6 and Chapter 2.

4.2 Storage Structures

4.2.1 Structural Specifications

The design bases for the NUHOMS® ISFSI are described in Chapter 3. Fabrication and construction specifications will be utilized in accordance with 10CFR72 (4.1) and industry codes and standards. The codes and standards used for fabrication and construction the NUHOMS® components, equipment, and structures are identified throughout the SAR. They are summarized as follows:

Component, Equipment, Structure	Code of Construction
DSC	ASME Code, Section III, Division 1, 1983 Edition with Winter 1985 Addenda (4.5) Subsection NB, Subsection NF, and Appendix F with exceptions as noted in Section 4.8 of this SAR.
Transfer Cask	ASME Code, Section III, Division 1, 1983 Edition with Winter 1985 Addenda (4.5) Subsection NC as applicable for non-pressure retaining vessels, with exceptions as noted in Section 4.9 of this SAR.
HSM (all models except HSM-H)	ACI-318-83 Code (4.10)
HSM-H	ACI 318-95 Code (see Appendix P)
DSC Supports	AISC Specification, 1989, Ninth Edition (4.11)
Transfer Equipment	AISC, ANSI, AWS and/or other applicable Standards

The ASME Code boundaries for the 24P and 52B DSCs and the transfer cask are identified on the corresponding Appendix E drawings. The code boundary for the NUHOMS®-61BT, 24PT2, 32PT, 24PHB and 24PTH DSCs are provided in Appendices K, L, M, N and P, respectively.

OR

- The coarse and fine aggregates to be one or a mix of the following: limestone, dolomite, marble, basalt, granite, rhyolite, gabbro. Determination of the aggregate constituents shall be done in accordance with the same methods described above.

For all PWR and BWR HSM components the above aggregate requirements can be waived if the criteria established by Appendix D for strength reduction is further validated by strength tests performed on the actual concrete mix to be used for construction subjected to elevated temperatures established by the design. Alternatively the minimum compressive strength requirements for the concrete may be increased to account for an appropriate reduction in concrete strength. This approach removes the need to reevaluate the HSM design analyses.

4.2.3.3 On-Site Transfer Cask

The on-site transfer cask is a nonpressure-retaining cylindrical vessel with a welded bottom assembly and bolted top cover plate. The transfer cask is designed for on-site transport of the DSC to and from the plant's spent fuel pool and the ISFSI as shown in Figure 4.2-10 and Figure 4.2-11. The transfer cask provides the principal biological shielding and heat rejection mechanism for the DSC and SFAs during handling in the fuel/reactor building, DSC closure operations, transport to the ISFSI, and transfer to the HSM. The transfer cask also provides primary protection for the loaded DSC during off-normal and drop accident events postulated to occur during the transport operations. The NUHOMS® transfer cask is illustrated in Figure 1.3-6. Drawings of the transfer cask are contained in Appendix E.

The transfer cask may be fitted with a shielded collar to extend the cask cavity length to accommodate the longer NUHOMS®-52B DSC as shown in Figure 4.2-12. The collar is a heavy forged steel ring with a bolt circle to match that of the transfer cask top flange and cover plate. Alternatively, a NUHOMS® transfer cask with a longer cavity length may be used for DSCs with PWR (with cask spacer) or BWR fuel.

The transfer cask to be used by a utility may be any one of the designs documented in Appendix E, including the standardized cask, OS197, OS197H, or OS197L. The licensee may also use any other previously NRC reviewed and approved design such as the transfer cask designs documented in the NUHOMS®-24P Topical Report [4.13], the Oconee Nuclear Station ISFSI Safety Analysis Report [4.16], and the Calvert Cliffs ISFSI Safety Analysis Report [4.17], provided it is demonstrated prior to use that the limiting conditions of use as described in CoC 1004 can be met.

The transfer cask is constructed from three concentric cylindrical shells to form an inner and outer annulus. These are filled with lead and a neutron absorbing material. The two inner shells are welded to heavy forged ring assemblies at the top and bottom ends of the

cask as shown in Figure 1.3-6. Rails fabricated from a hardened, non-galling, wear resistant material coated with a high contact pressure dry film lubricant are provided to facilitate DSC transfer. All surfaces exposed to fuel pool water are stainless steel. The transfer cask structural shell and the bolted top cover plate may be fabricated from carbon or stainless steel. The transfer cask carbon steel structural shell and top cover plate are coated with a durable epoxy paint which is shop applied in accordance with the manufacturer's standards. This coating system is suitable for immersion service with a continuous temperature of 250°F with intermittent temperatures to 400°F.

The method used to cast the transfer cask lead shielding will vary between fabricators. Only one transfer cask need be utilized for each ISFSI. Transfer casks for different ISFSIs may be supplied by different fabricators. Each fabricator is required to submit detailed procedures for the lead pour consistent with the requirements delineated on the Appendix E drawings. These procedures include specific locations and sealing of pour holes, temporary bracing, and controlled cooling methods for the lead, all of which must meet the applicable codes and standards.

The transfer cask neutron shield cavity is fabricated as a pressure vessel since it is desirable to have this cavity remain leak tight to prevent intrusion of contaminated spent fuel pool water. Also, the support members for the outer shell of the solid neutron shield are angled at 45° with respect to the transfer cask structural shell to further enhance shielding and decay heat removal. Solid neutron shielding materials are also incorporated into the top and bottom end closures to provide effective radiological protection.

Two trunnion assemblies are provided in the upper region of the cask for lifting of the transfer cask and DSC inside the plant's fuel/reactor building, and for supporting the cask on the skid for transport to and from the ISFSI. An additional pair of trunnions in the lower region of the cask are used to position the cask on the support skid, serve as the rotation axis during down-ending of the cask, and provide support for the bottom end of the cask during transport operations. The trunnion assemblies may be fabricated either as (1) a one solid forged piece or, (2) as a hollow trunnion piece welded to a trunnion sleeve assembly with the hollow space filled with NS-3 neutron shielding material. There are no testing requirements per the ASME Code for the transfer cask trunnions. Neither the transfer cask nor the trunnions are special lifting devices per ANSI N14.6. Nonetheless, for transfer casks fabricated under the General License, a one-time pre-service load test of the trunnions is performed at a load equal to 150% of the design load followed by an examination of all accessible trunnion welds. Trunnion testing is neither applicable nor required for existing NUHOMS® transfer casks previously licensed for site specific use (e.g., Calvert Cliffs and Oconee plants).

The cask bottom ram penetration cover plate is a water tight closure used during fuel loading in the fuel pool, during DSC closure operations in the cask decon area, and during cask handling operations in the fuel/reactor building. The circular projection on the transfer cask bottom cover plate is dimensioned to ensure that the DSC does not contact any surface of the bottom cover plate assembly. Prior to cask transport from the plant's fuel/reactor building to the HSM, the bottom cover plate of the cask is removed

4.10 References

4.1 U.S. Government, "Licensing Requirements for the Storage of Spent Fuel in an Independent Spent Fuel Storage Installation (ISFSI)," Title 10 Code of Federal Regulations, Part 72, Office of the Federal Register, Washington, D.C.

4.2 Deleted.

4.3 Deleted.

4.4 Deleted.

4.5 American Society of Mechanical Engineers, ASME Boiler and Pressure Vessel Code, Section III, Division 1, 1983 Edition, with Winter 1985 Addenda.

4.6 American Society for Testing and Materials, Annual Book of ASTM Standards, Section 4, Volume 04.02, 1990.

4.7 American Society for Testing and Materials, Annual Book of ASTM Standards, Section 1, Volume 01.04, 1990.

4.8 Deleted.

4.9 "American National Standard for Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4500 kg) or More for Nuclear Materials", ANSI N14.6-1993, American National Standards Institute, Inc., New York, New York.

4.10 American Concrete Institute, "Building Code Requirement for Reinforced Concrete," ACI-318, 1983.

4.11 American Institute of Steel Construction, (AISC), "Specification for Structural Steel Buildings," Ninth Edition 1989, Chicago, Illinois.

4.12 American National Standards Institute, "American National Standard for Radioactive Materials - Leakage Tests on Packages for Shipment," ANSI N14.5, 1977.

5. OPERATION SYSTEMS

This Chapter presents the operating procedures for the standardized NUHOMS® system described in previous chapters and shown on the drawings in Appendix E for the 24P and 52B systems. The operating procedures for the 61BT, 24PT2, 32PT, 24PHB and 24PTH systems are described in Appendices K. L, M, N and P, respectively. The procedures include preparation of the DSC and fuel loading, closure of the DSC, transport to the ISFSI, DSC transfer into the HSM Model 80 and Model 102, monitoring operations, and DSC retrieval from the HSM Model 80 and Model 102. The operating procedures involving the HSM-H, HSM Model 152, and HSM Model 202 are described in Appendices P, R, and V, respectively. The standardized NUHOMS® transfer equipment, and the existing plant systems and equipment are used to accomplish these operations. Procedures are delineated here to describe how these operations are to be performed and are not intended to be limiting. Standard fuel and cask handling operations performed under the plant's 10CFR50 operating license are described in less detail. Existing operational procedures may be revised by the licensee and new ones may be developed according to the requirements of the plant, provided that the limiting conditions of operation specified in Technical Specifications, Functional and Operating Limits of the NUHOMS® CoC (5.6) are not exceeded.

Appendix W.8 provides a description of the changes in operational sequences when each of the licensed DSCs ≤24.0 kW (24P, 52B, 61BT, 24PT2, 32PT and 24PHB) are transferred in an OS197L TC.

5.1 Operation Description

The following sections outline the typical operating procedures for the standardized NUHOMS® system. These generic NUHOMS® procedures have been developed to minimize the amount of time required to complete the subject operations, to minimize personnel exposure, and to assure that all operations required for DSC loading, closure, transfer, and storage are performed safely. Plant specific ISFSI procedures are to be developed by each licensee in accordance with the requirements of 10CFR72.24 (h) and the guidance of Regulatory Guide 3.61 (5.7). The generic procedures presented here are provided as a guide for the preparation of plant specific procedures and serve to point out how the NUHOMS® system operations are to be accomplished. They are not intended to be limiting, in that the licensee may judge that alternate acceptable means are available to accomplish the same operational objective.

The generic operating procedures presented herein also do not address the use of auxiliary equipment which is optional or represents a level of detail which a licensee may choose to implement based on licensee preference. Examples of such auxiliary items are the Neutron Shield Overflow Tank (used with OS197 or OS197H Cask only), TC/DSC Annulus Pressurization Tank, and the Shield Plug Restraints.

5.1.1 Narrative Description

The following steps describe the recommended generic operating procedures for the standardized NUHOMS® system. Flowcharts of NUHOMS® system loading and retrieval operations are provided in Figure 5.1-1 and Figure 5.1-2, respectively.

5.1.1.1 Preparation of the Transfer Cask and DSC

1. Prior to placement in dry storage, the candidate fuel assemblies are to be visually examined to insure that no known or suspected gross cladding breaches exist. Pinholes and hairline cracks are acceptable. Verification of fuel integrity may also be accomplished using suitable existing plant records. The assemblies shall be evaluated (by plant records or other means) to verify that they meet the physical, thermal and radiological criteria specified in Technical Specification 1.2.1. Depending on the length of the authorized fuel assemblies to be loaded, fuel spacers may be placed within the DSC to reduce the fuel assembly/DSC cavity gap in consideration of Part 71 requirements. There are no requirements for fuel spacers under Part 72. Fuel spacers, if used, may be placed below the assembly, above the assembly, or both, and shall be evaluated for any adverse impact.

2. Prior to being placed in service, the transfer cask is to be cleaned or decontaminated as necessary to insure a surface contamination level of less than those specified in Technical Specification 1.2.12.

3. Place the transfer cask in the vertical position in the cask decon area using the cask handling crane and the transfer cask lifting yoke.

4. Place scaffolding around the cask so that the top cover plate and surface of the cask are easily accessible to personnel.

5. Remove the transfer cask top cover plate and examine the cask cavity for any physical damage and ready the cask for service.

6. Examine the DSC for any physical damage which might have occurred since the receipt inspection was performed. The DSC is to be cleaned and any loose debris removed.

7. Using a crane, lower the DSC into the cask cavity by the internal lifting lugs and rotate the DSC to match the cask and DSC alignment marks.

8. Fill the cask-DSC annulus with clean, demineralized water. Place the inflatable seal into the upper cask liner recess and seal the cask-DSC annulus by pressurizing the seal with compressed air.

9. Fill the DSC cavity with water from the fuel pool or an equivalent source which meets the requirements of Technical Specification 1.2.15. For PWR fuel, the

opening) that would be needed in order to downend the TC with the trailer/skid in a stationary position. For these situations, alternate procedures are to be developed on a plant-specific basis, with detailed steps for downending.

1. Verify neutron shield is filled. Re-attach the transfer cask lifting yoke to the crane hook, as necessary. Ready the transport trailer and cask support skid for service.
2. Move the scaffolding away from the cask as necessary. Engage the lifting yoke and lift the cask over the cask support skid on the transport trailer.
3. The transport trailer should be positioned so that cask support skid is accessible to the crane with the trailer supported on the vertical jacks.
4. Position the cask lower trunnions onto the support skid lower trunnion pillow blocks.
5. Move the crane forward while simultaneously lowering the cask until the cask upper trunnions are just above the support skid upper trunnion pillow blocks.
6. Inspect the positioning of the cask to insure that the cask and trunnion pillow blocks are properly aligned.
7. Lower the cask onto the skid until the weight of the cask is distributed to the trunnion pillow blocks.
8. Inspect the trunnions to insure that they are properly seated onto the skid and install the trunnion tower closure plates.
9. Remove the bottom ram access cover plate from the cask. Install the two-piece temporary neutron/gamma shield plug to cover the bottom ram access. Install the ram trunnion support frame on the bottom of the transfer cask. (When using the integral ram/trailer, the temporary shield plug and ram trunnion support frame are not required, and this step is therefore optional.)

5.1.1.6 DSC Transfer to the HSM

1. Prior to transporting the cask to the ISFSI, or prior to positioning the transfer cask at the HSM designated for storage, remove the HSM door, inspect the cavity of the HSM, removing any debris and ready the HSM to receive a DSC. The doors on adjacent HSMs should remain in place.

   Caution: The insides of empty modules have the potential for high dose rates due to adjacent loaded modules. Proper ALARA practices should be followed for operations inside these modules and in the areas outside these modules whenever the door from the empty HSM has been removed.

2. Inspect the HSM air inlet and outlets to ensure that they are clear of debris. Inspect the screens on the air inlet and outlets for damage.

CAUTION: Verify that the requirements of Technical Specification 1.2.14, "TC/DSC Transfer Operations at High Ambient Temperatures" are met prior to next step.

3. Using a suitable heavy haul tractor, transport the cask from the plant's fuel/reactor building to the ISFSI along the designated transfer route.

4. Once at the ISFSI, position the transport trailer to within a few feet of the HSM.

5. Check the position of the trailer to ensure the centerline of the HSM and cask approximately coincide. If the trailer is not properly oriented, reposition the trailer, as necessary.

6. Back the cask to within a few inches of the HSM, set the trailer brakes and disengage the tractor. Drive the tractor clear of the trailer. Extend the transfer trailer vertical jacks.

7. Unbolt and remove the cask top cover plate.

8. Connect the skid positioning system hydraulic power unit to the positioning system via the hose connector panel on the trailer, and power it up. Remove the skid tie-down bolts and use the skid positioning system to bring the cask into approximate vertical and horizontal alignment with the HSM. Using optical survey equipment and the alignment marks on the cask and the HSM, adjust the position of the cask until it is properly aligned with the HSM.

9. Using the skid positioning system, fully insert the cask into the HSM access opening docking flange.

10. Secure the cask trunnions to the front wall embedments of the HSM using the cask restraints.

11. After the cask is docked with the HSM, verify the alignment of the transfer cask using the optical survey equipment.

12. Position the hydraulic ram behind the cask in approximate horizontal alignment with the cask and align the ram. Remove either the bottom ram access cover plate or the outer plug of the two-piece temporary shield plug. Power up the ram hydraulic power supply and extend the ram through the bottom cask opening into the DSC grapple ring.

13. Activate the hydraulic cylinder on the ram grapple and engage the grapple arms with the DSC grapple ring.

14. Recheck all alignment marks in accordance with the Technical Specification 1.2.9 limits and ready all systems for DSC transfer.

15. Activate the hydraulic ram to initiate insertion of the DSC into the HSM. Stop the ram when the DSC reaches the support rail stops at the back of the module.

16. Disengage the ram grapple mechanism so that the grapple is retracted away from the DSC grapple ring.

17. Retract and disengage the hydraulic ram system from the cask and move it clear of the cask. Remove the cask restraints from the HSM.

18. Using the skid positioning system, disengage the cask from the HSM access opening. Insert DSC axial retainer.

19. The trailer may be moved as necessary to install the HSM door. Install the HSM door and secure it in place.

20. Replace the transfer cask top cover plate (optional, may be done later away from the ISFSI). Secure the skid to the trailer, retract the vertical jacks and disconnect the skid positioning system.

21. Tow the trailer and cask to the designated equipment storage area. Return the remaining transfer equipment to the storage area.

22. Close and lock the ISFSI access gate and activate the ISFSI security measures.

5.1.1.7 Monitoring Operations

1. Perform routine security surveillance in accordance with the licensee's ISFSI security plan.

2. Perform a daily visual surveillance of the HSM air inlets and outlets (end wall and roof birdscreens) to insure that no debris is obstructing the HSM vents in accordance with Technical Specification 1.3.1 requirements
OR
Perform a temperature measurement of the thermal performance, for each HSM, on a daily basis in accordance with Technical Specification 1.3.2 requirements.

5.1.1.8 DSC Retrieval from the HSM

1. Ready the transfer cask, transport trailer, and support skid for service and tow the trailer to the HSM.

2. Back the trailer as close to the HSM as compatible with HSM door removal, remove the cask top cover plate. Remove the HSM door. Remove the DSC axial retainer.

3. Using the skid positioning system align the cask with the HSM and position the skid until the cask is docked with the HSM access opening.

4. Using optical survey equipment verify alignment of the cask with respect to the HSM. Install the cask restraints.

5. Install and align the hydraulic ram with the cask.

6. Extend the ram through the cask into the HSM until it is inserted in the DSC grapple ring.

7. Activate the arms on the ram grapple mechanism with the DSC grapple ring.

8. Retract ram and pull the DSC into the cask.

9. Retract the ram grapple arms.

10. Disengage the ram from the cask.

11. Remove the cask restraints.

12. Using the skid positioning system, disengage the cask from the HSM.

13. Install the cask top cover plate and ready the trailer for transport.

14. Replace the door on the HSM.

5.1.1.9 Removal of Fuel from the DSC

When the DSC has been removed from the HSM, there are several potential options for off-site shipment of the fuel. It is preferred to ship the DSC intact to a reprocessing facility, monitored retrievable storage facility or permanent geologic repository in a compatible shipping cask licensed under 10CFR71.

If it becomes necessary to remove fuel from the DSC prior to off-site shipment, there are two basic options available at the ISFSI or reactor site. The fuel assemblies could be removed and reloaded into a shipping cask using dry transfer techniques, or if the applicant so desires, the initial fuel loading sequence could be reversed and the plant's spent fuel pool utilized. Procedures for unloading of the DSC in a fuel pool are presented here, however wet or dry

7. RADIATION PROTECTION

The analysis presented in this Chapter is specifically applicable to the storage of the NUHOMS®-24P and –52B and transfer in the standardized cask, OS197 or OS197H TCs DSCs in the HSM Model 80 and Model 102. Appendices J, K and L provide a similar evaluation for the NUHOMS®-24P long cavity, -61BT and -24PT2 systems, respectively. Appendices R and V provide an evaluation of these various DSCs stored in the HSM Model 152 and HSM Model 202, respectively.

Shielding analysis of the licensed DSCs (≤24.0 kW) (24P, 52B, 61BT, 24PT2, 32PT and 24PHB) when transferred in OS197L TC are provided in Appendix W.

7.1 Ensuring That Occupational Radiation Exposures Are As-Low-As-Reasonably-Achievable (ALARA)

7.1.1 Policy Considerations

The licensee's existing radiation safety and ALARA policies for the plant should be applied to the ISFSI. The ALARA program should follow the general guidelines of Regulatory Guides 1.8, 8.8, 8.10 and 10CFR20. ISFSI personnel should be trained and updated on ALARA practices and dose reduction techniques. Implementation of ISFSI systems and equipment procedures should be reviewed by the licensee to ensure ALARA exposure during all phases of operations, maintenance and surveillance.

7.1.2 Design Considerations

The design of the NUHOMS® DSC and HSM comply with 10CFR72 ALARA requirements. Features of the NUHOMS® system design that are directed toward ensuring ALARA are:

A. Thick concrete walls and roof on the HSM to minimize the on-site and off-site dose contribution from the ISFSI.

B. A thick shield plug on each end of the DSC to reduce the dose to plant workers performing drying and sealing operations, and during transfer and storage of the DSC in the HSM.

C. Use of a heavy shielded transfer cask for DSC handling and transfer operations to ensure that the dose to plant and ISFSI workers is minimized.

D. Fuel loading procedures which follow accepted practice and build on existing experience.

8. ANALYSIS OF DESIGN EVENTS

In previous chapters of this SAR, the features of the standardized NUHOMS® system which are important to safety have been identified and discussed. The purpose of this chapter is to present the engineering analyses for normal and off-normal operating conditions, and to establish and qualify the system for a range of credible and hypothetical accidents. As stated in Chapter 1, the analyses presented in this section are applicable to the standard length 24P and 52B canisters. An evaluation of the long cavity 24P canister, for the same design criteria, is provided in Appendix H and J. Appendices K, L, M, N and P provide the evaluation for the NUHOMS®-61BT 24PT2, 32PT, 24PHB and 24PTH DSC, respectively. Also, as noted in Chapter 1, the structural, thermal, and shielding evaluations for the HSM-H, HSM Model 152, and HSM Model 202 are provided in Appendices P, R, and V, respectively. Evaluations for other canisters and modules may be included as additional appendices at a later time.

The structural and thermal analysis of the licensed DSCs (≤24.0 kW) (24P, 52B, 61BT, 24PT2, 32PT and 24PHB) when transferred in OS197L TC are provided in Appendix W.3 and W.4, respectively.

In accordance with NRC Regulatory Guide 3.48 (8.1), the design events identified by ANSI/ANS 57.9-1984, (8.2) form the basis for the accident analyses performed for the standardized NUHOMS® system. Four categories of design events are defined. Design event Types I and II cover normal and off-normal events and are addressed in Section 8.1. Design event Types III and IV cover a range of postulated accident events and are addressed in Section 8.2. These events provide a means of establishing that the NUHOMS® system design satisfies the applicable operational and safety acceptance criteria as delineated herein.

It is important to note that, given the generic nature of this SAR, the majority of the analyses presented throughout this chapter are based on bounding conservative assumptions and methodologies, with the objective of establishing upper bound values for the responses of the primary components and structures of the standardized NUHOMS® system for the design basis events. Because of the conservative approach adopted herein, the reported temperatures and stresses in this chapter envelope the actual temperatures or states of stress for the various operating and postulated accident conditions. More rigorous and detailed analyses and/or more realistic assumptions and loading conditions would result in temperatures and states of stress which are significantly lower than the reported values.

8.1 Normal and Off-Normal Operations

Normal operating design conditions consist of a set of events that occur regularly, or frequently, in the course of normal operation of the NUHOMS® system. These normal operating conditions are addressed in Section 8.1.1. Off-normal operating design conditions are events that could occur with moderate frequency, possibly once during any calendar year of operation. These off-

transfer casks are discussed in this SAR. Table 8.1-20, Table 8.1-20a, and Table 8.1.20b summarize the calculated stresses for the normal operating loads for the standardized, OS197, and OS197H transfer casks, respectively. The methodology used to evaluate the transfer cask for the effects of normal operating loads is described in the following paragraphs. The analytical results and comparisons with the acceptance criteria defined in Section 3.2 are also presented in this section.

A. Transfer Cask Dead Weight Analysis

The effects of dead weight for a loaded transfer cask are evaluated for two cases. The first case evaluated is for the transfer cask hanging vertically by the two lifting trunnions, and loaded with its maximum payload. A maximum wet payload of 97,950 pounds is used in the analysis of the standardized cask, while a load of 102,410 pounds and 126,000 pounds is used for the OS197 and OS197H transfer casks, respectively.

The second dead weight load case evaluated for the transfer cask includes the loaded transfer cask resting in a horizontal position on the support skid transport trailer. In this orientation, the weight of the cask is shared between the lower support trunnions and the upper lifting trunnions resting in the pillow block supports of the support skid. The maximum dead load stresses are shown in Table 8.1-20, Table 8.1-20a, and Table 8.1-20b for the standardized, OS197, and OS197H transfer casks, respectively. The local stresses around the trunnions are included in the normal handling load case described in Paragraph B.

B. Transfer Cask Normal Handling Loads Analysis

The major components of the transfer cask affected by the normal handling loads are the structural shell including the top and bottom cover plates, the upper and lower trunnions, the upper trunnion assembly insert plates, and the structural shell local to the trunnions. As described for the dead weight analysis, there are two normal operating cask handling cases which form the design basis for the transfer cask. These cases are illustrated in Figure 8.1-30 and are summarized as follows:

(i) The transfer cask is oriented in the vertical position, loaded to its maximum estimated weight of 200,000 lbs, 208,500 lbs and 250,000 lbs for the standardized, OS197, and OS197H transfer casks, respectively, hanging by the upper lifting trunnions, and present in an area of the plant which requires conformance with the requirements of NUREG-0612. Accordingly, the allowable design stresses for the upper trunnions (and their attachment welds to the trunnion sleeve for the multiple piece trunnion assembly option) are restricted to the smaller of one sixth of the material yield strength, or one tenth of the material ultimate strength for critical lifts. Allowable stresses for the remaining transfer cask components including the lower support trunnions are governed by the requirements of the ASME Code. The cask handling load is assumed to be shared equally between the two upper trunnions. An additional load factor of 15% is conservatively applied to account for the inertial effects of crane hoist motions in accordance with CMAA #70 recommendations. The transfer cask is designed so that the cask lifting yoke engages the

outer most portion of the upper trunnion assembly. During the heaviest lift from the fuel pool, the cask/DSC contains water, the DSC top shield plug is in place, and the DSC and cask top cover plates are removed. For this condition the maximum ANSI N14.6 design load for the two upper trunnions of the standardized cask due to a vertical lift is conservatively assumed to be 100 kips per trunnion plus the 15% allowance, or 115 kips, acting vertically, with a moment arm measured from the center of the yoke lifting hook to the middle surface of the transfer cask structural shell. For the OS197 and OS197H transfer casks, the maximum load considered for the vertical lift per trunnion is 120 kips and 144 kips, respectively.

The maximum calculated upper trunnion stress for the standardized transfer cask under this load case is 5.5 ksi at the junction between the trunnion shoulder and the trunnion sleeve attached to the structural shell plate. This compares with the ANSI N14.6 allowable stress of 13.5 ksi for the trunnion material. The maximum weld stress is 6.7 ksi. The ANSI N14.6 allowable weld stress is 8.0 ksi. The maximum calculated stress intensity in the lower trunnion is 9.5 ksi, and the maximum weld stress is 12.6 ksi. These stresses compare with the ASME Code allowable value of 20 ksi.

For the critical lift of the OS197 transfer cask, the limiting stress occurs at the junction between the trunnion shoulder and the trunnion sleeve weld. The maximum weld stress ratio is 0.98 based on a stress of 5.08 ksi versus an allowable of 5.21 ksi.

The upper trunnion assembly of the OS197H cask is designed to accommodate a lifted load of 250,000 lbs. The limiting stress occurs in the upper trunnion sleeve. The maximum trunnion sleeve stress ratio is 0.87 based on a stress of 3.34 ksi versus an allowable of 3.82 ksi.

For the OS197/OS197H transfer casks with the single piece solid trunnion options, the evaluation is performed using a lifted load of 250,000 lbs. The maximum critical lift stress ratio in the upper trunnion is 0.68 based on a stress of 4.90 ksi versus an ANSI N14.6 based allowable stress of 7.23 ksi.

The maximum stress in the standardized transfer cask structural shell occurs in the thickened plate at the junction with the upper trunnion sleeves. Stresses in the structural shell are calculated using the WRC Bulletin No. 107 (8.54) method for the standardized transfer cask and an ANSYS finite element analysis for the OS197 and OS197H transfer casks. The maximum calculated stress intensity in the standardized transfer cask structural shell is 42.6 ksi compared with an ASME Code allowable stress intensity value of 67.5 ksi. The maximum calculated stress intensity in the cask structural shell for the critical lift combinations using finite element analysis is 23.5 ksi (envelope of OS197/OS197H, hollow solid trunnions) versus an allowable of 60 ksi for 24 kW max. heat load. See Appendix P for up to 40.8 kW heat load.

(ii) During transport of the DSC from the plant's fuel/reactor building to the ISFSI, the transfer cask is oriented in a horizontal position, and is firmly secured to the support skid/transport trailer. During this operation the cask/DSC is loaded with fuel with theDSC top shield plug and the DSC and cask top cover plates in place. The resulting trunnion loads are developed by taking the summation of moments about a horizontal axis to account for the fact that the upper trunnions are closer to the horizontal center of gravity of the cask and thus carry a greater part of the total cask weight compared with the lower support trunnions. The transfer cask is supported in pillow block supports at

two locations; the lower support trunnions near the bottom end of the cask, and the lifting upper trunnions supports near the top end of the cask. The allowable stresses for the on-site transfer load cases are governed by the ASME Code. For the standardized cask the maximum postulated ASME Code upper lifting trunnion load is 118 kips while the critical load for the structural shell plate is a combination of the 58 kips dead load acting vertically, plus a postulated lateral load of ± 1g or 116 kips acting radial to the shell. The loads from this case envelope the design basis transport operation loads of ± 0.5g simultaneously applied in three directions to account for vibratory motion loads and start/stop loads which may occur during transport. The design loads for the lower support trunnion are developed in a similar manner.

The OS197 transfer cask upper lifting trunnions are evaluated for a combined vertical and dead weight handling loads of 146.3 kips and a radial load of 146.3 kips (163.8 kips each for the OS197H). The lower trunnions are evaluated for 112.5 kips each for the radial and axial directions and 112.5 kips for the combined effects of vertical and dead weight loading (126 kips each for the OS197H).

During transfer of a DSC from the transfer cask to and from the HSM, the transfer cask is restrained to the HSM to prevent any relative motion. The restraint device functions by firmly securing the transfer cask lifting trunnions to embedded anchor points in the HSM front wall. The maximum load exerted on the transfer cask lifting trunnions is equal to the maximum hydraulic ram load, or 80 kips. This load magnitude is much less than the design basis handling loads described above and is therefore enveloped by the calculated stresses reported for that case. During transfer, the cask rail welds are loaded in shear by the friction of the sliding DSC. At an assumed shear of 80 kips, the stress on the rail welds is 5.8 ksi compared to an allowable value of 9.4 ksi.

For the standardized cask, the maximum calculated upper lifting trunnion stress intensity for the transport load case is 5.7 ksi and occurs at the junction of the sleeve to the cask shell. This compares with an ASME Code allowable stress of 33.8 ksi. The maximum calculated weld stress intensity is 7.1 ksi compared with an ASME Code allowable stress, of 45 ksi. The maximum calculated lower support trunnion stress intensity is 9.5 ksi compared to the ASME Code allowable of 20 ksi. The maximum weld stress intensity is 12.6 ksi and the maximum cask structural shell stress intensity is 42.6 ksi compared with ASME Code allowable values of 20.0 ksi and 67.5 ksi respectively.

For the OS197 transfer cask the maximum calculated upper lifting trunnion stress for the transport case is 6.46 ksi at the junction of the shoulder of the trunnion and the trunnion sleeve (7.23 ksi for the OS197H). This compares with an ASME allowable stress of 45.0 ksi. The maximum calculated weld stress is 3.56 ksi (3.98 ksi for the OS197H) versus an ASME allowable of 11.25 ksi. The maximum lower trunnion stress for the transport case is 9.41 ksi (10.53 ksi for the OS197H) compared to an allowable of 22.9 ksi. The maximum weld stress for this load case is 8.21 ksi (9.20 ksi for the OS197H) versus an allowable of 11.45 ksi. The maximum OS197 cask structural shell stress intensity is 41.4 (46.8 ksi for the OS197H) ksi compared with an allowable of 60 ksi.

For the OS 197/OS 197H transfer casks with the single piece solid trunnion option, the evaluation is performed based on a total cask weight of 250,000 lbs. The results summarized below are for thermal analysis with 24 kW heat load. For heat loads of up to 40.8 kW, see Appendix P.

The maximum calculated upper trunnion stress for the transfer case is 3.19 ksi versus a general membrane (P_m) allowable of 31.4 ksi. The maximum lower trunnion stress for the transport case is 5.10 ksi versus a P_m allowable of 22.5 ksi. The maximum structural shell stress ratio is 0.76 based on a primary ($P_m + P_b$) stress intensity of 22.8 ksi versus an allowable of 30 ksi. The maximum primary plus secondary stress ratio is 0.76 based on a stress intensity of 45.7 ksi versus an allowable of 60 ksi.

Table 8.1-3
Mechanical Properties of Materials

Material	Temperature (°F)	Stress Properties[(1)] (ksi) Stress Intensity (S_m)	Yield Strength (S_y)	Ultimate Strength (S_u)	Elastic Modulus[(1)] (x1.0E3 ksi) (E)	Average Coefficient of Thermal Expansion[(1)] (x10^{-6} in./in.-°F)
Stainless Steel ASME SA240 Type 304	70	-	30.0	75.0	28.3	--
	100	20.0	30.0	75.0	--	8.55
	200	20.0	25.0	71.0	27.6	8.79
	400	18.7	20.7	64.4	26.5	9.19
	500	17.5	19.4	63.5	25.8	9.37
	600	16.4	18.2	63.5	25.3	9.53
	700	16.0	17.7	63.5	24.8	9.69
Stainless Steel ASME SA479 Type XM-19[(10)] ASME SA182 Type FXM-19[(10)]	-100	33.3	55.0	100.0	29.1	--
	-20	33.3	55.0	100.0	--	--
	70	--	--	--	28.3	--
	100	33.3	55.0	100.0	--	8.30
	200	33.2	47.0	99.5	27.6	8.48
	400	30.2	40.8	90.7	26.5	8.79
	500	29.7	38.8	89.1	25.8	8.92
	600	29.2	37.3	87.8	25.3	9.03
	700	28.8	36.3	86.5	24.8	9.15

Table 8.1-4
Estimated NUHOMS®-24P Component Weights

Component Description		Calculated Weight (Pounds)
1.	Dry Shielded Canister Shell Assembly	15,778
2.	DSC Top Shield Plug	7,859
3.	DSC Internal Basket Assembly	12,189
4.	DSC Inner and Outer Top Cover Plates	1,934
5.	24 PWR Spent Fuel Assemblies	≤40,368(4)
6.	Weight of Water in DSC Cavity	14,843
	Total Wet DSC Loaded Weight (w/o DSC inner and outer top cover plates.)	91,038
	Total Dry DSC Loaded Weight (w/ DSC inner and outer top cover plates.)	78,129
7.	Standardized Transfer Cask Empty Weight	107,091(1)(3)
8.	Standardized Transfer Cask Max. Loaded Weight	193,642(2)(5)
9.	HSM Single Module Weight, Model 80 (empty)	243,000
10.	HSM Single Module Weight, Model 102 (empty)	253,000

(1) Includes weight of cask top cover plate assembly.
(2) Weight includes: DSC dry weight plus fuel, plus water in DSC and cask less DSC and cask top cover plate assemblies.
(3) The as-built empty weight for the OS197 transfer cask is 111,250 lbs, including neutron shield water. The as-built empty weight of the standardized cask is 106,700 lbs including solid neutron shield and top cover. The as-built weights of each individual OS197 transfer cask may vary slightly.
(4) The standard design DSC fuel assembly weight of 1,682 lbs/assembly is used.
(5) The maximum loaded weight for the OS197 transfer cask without 24P DSC and OS197 top cover plates is 199,372 lbs.

Table 8.1-5
Estimated NUHOMS®-52B Component Weights

	Component Description	Calculated Weigh (Pounds)
1.	Dry Shielded Canister Shell Assembly	15,658
2.	DSC Top Shield Plug	7,621
3.	DSC Internal Basket Assembly	12,012
4.	DSC Inner and Outer Top Cover Plates	1,934
5.	52 BWR Spent Fuel Assemblies	≤37,700
6.	Weight of Water in DSC Cavity	16,211
	Total Wet DSC Loaded Weight (w/o DSC inner and outer top cover plates.)	89,202
	Total Dry DSC Loaded Weight (w/ DSC inner and outer top cover plates.)	74,925
7.	Standardized Transfer Cask Empty Weight (w/collar)	113,501(1)(3)
8.	Standardized Transfer Cask Max. Loaded Weight	198,294(2)(4)
9.	HSM Single Module Weight, Model 80 (empty)	252,000
10.	HSM Single Module Weight, Model 102 (empty)	263,000

(1) Includes weight of cask top cover plate assembly.
(2) Weight includes: DSC dry weight plus fuel, plus water in DSC and cask less DSC and cask top cover plate assemblies.
(3) The as-built empty weight of the OS197 transfer cask is 111,250 pounds, including water in the neutron shield. The as-built empty weight of the standardized cask is 106,700 lbs including solid neutron shield and top cover. The as-built weights of each individual OS197 transfer cask may vary slightly.
(4) The maximum loaded weight for the OS197 transfer cask without 52B DSC and cask top cover plates is 196,197 lb.

Table 8.2-9
Maximum Standardized Transfer Cask Stresses for Drop Accident Loads

Transfer Cask Components	Stress Type	Stress (ksi)[1]		
		Vertical	Horizontal	Corner[2]
Cylindrical Structural Shell	Primary Membrane	9.6	3.8	6.0
	Membrane + Bending	10.2	15.5	18.0
Top Cover Plate	Primary Membrane	32.4	5.8	3.5
	Membrane + Bending	32.4	5.8	18.3
Bottom End Plate	Primary Membrane	30.7	5.8	0.0
	Membrane + Bending	30.7	5.8	42.9
Transfer Cask Collar	Primary Membrane	26.2	12.2	2.3
	Membrane + Bending	26.2	12.2	3.2

(1) Values shown are maximums irrespective of location

(2) DSC was also included in corner drop analysis. DSC stresses for this case are enveloped by those for horizontal and vertical drop loads shown in Tables 8.2-7 and 8.2-8.

Table 8.2-21a
OS197 Transfer Cask Enveloping Load Combination Results
for Normal and Off-Normal Loads (ASME Service Levels A and B)

Transfer Cask Component	Stress Type	Stress (ksi)(1)	
		Calculated(1)	Allowable(2)
Structural Shell	Primary Membrane	1.8/9.08(4)(5)	20.0
	Membrane + Bending	14.0/22.8(4)(5)	30.0
	Primary + Secondary	25.4/45.7(4)(5)	60.0
Top Cover Plate (3)	Primary Membrane	0.61	18.7
	Membrane + Bending	4.5	28.1
	Primary + Secondary	10.8	56.1
Bottom End Plate	Primary Membrane	0.56	18.7
	Membrane + Bending	7.2	28.1
	Primary + Secondary	14.0	56.1

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(1) The load combination for Levels A and B is dead weight plus thermal plus handling loads.

(2) See Table 3.2-11 for allowable stress criteria. Material properties for all components except the cask structural shell were obtained from Table 8.1-3 at a design temperature of 400°F. The cask structural shell allowables are based on a temperature of 250°F.

(3) Allowable stress values and calculated stress intensities are tabulated for the stainless steel cover plate.

(4) The leftmost stress value listed is for locations remote from the trunnions, while the rightmost stress value occurs in the region of the trunnions.

(5) Envelop of results with multiple piece and single solid piece trunnion analyses.

Table 8.2-21b
OS197H Transfer Cask Enveloping Load Combination Results
for Normal and Off-Normal Loads (ASME Service Levels A and B)

Transfer Cask Component	Stress Type	Stress (ksi)[1]	
		Calculated[1]	Allowable[2]
Structural Shell	Primary Membrane	2.1/9.45[4][5]	20.0
	Membrane + Bending	14.9/22.8[4][5]	30.0
	Primary + Secondary	25.1/46.8[4][5]	60.0
Top Cover Plate[3]	Primary Membrane	0.7	18.7
	Membrane + Bending	5.3	28.1
	Primary + Secondary	11.2	56.1
Bottom End Plate	Primary Membrane	1.2	18.7
	Membrane + Bending	8.6	28.1
	Primary + Secondary	14.6	56.1

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(1) The load combination for Levels A and B is dead weight plus thermal plus handling loads.

(2) See Table 3.2-11 for allowable stress criteria. Material properties for all components except the cask structural shell were obtained from Table 8.1-3 at a design temperature of 400°F. The cask structural shell allowables are based on a temperature of 250°F.

(3) Allowable stress values and calculated stress intensities are tabulated for the stainless steel cover plate.

(4) The leftmost stress value listed is for locations remote from the trunnions, while the rightmost stress value occurs in the region of the trunnions.

(5) Envelop of results with multiple piece and single solid piece trunnion analyses.

Table 8.2-22a
OS197 Transfer Cask Enveloping Load Combination Results for Accident Loads (ASME Service Level C)

Transfer Cask Component	Stress Type	Stress (ksi)	
		Calculated[1]	Allowable[2]
Structural Shell	Primary Membrane	3.4/9.08[4][5]	24.0
	Membrane + Bending	27.6/22.8[4][5]	36.0
Top Cover Plate[3]	Primary Membrane	0.61	22.4
	Membrane + Bending	4.8	33.7
Bottom End Plate	Primary Membrane	1.1	22.4
	Membrane + Bending	15.4	33.7

(1) The load combination for Level C include dead weight, thermal, handling and seismic loads

(2) See Table 3.2-11 for allowable stress criteria. Material properties for all components except the cask structural shell were obtained from Table 8.1-3 at a design temperature of 400°F. The cask structural shell allowables are based on a temperature of 250°F.

(3) Allowable stress values and calculated stress intensities are tabulated for the stainless steel cover plate.

(4) The lower stress value listed is for locations remote from the trunnions, while the higher stress value occurs in the region of the trunnions.

(5) Envelop of results with multiple piece and single solid piece trunnion analyses.

Table 8.2-22b
OS197H Transfer Cask Enveloping Load Combination Results for Accident Loads (ASME Service Level C)

Transfer Cask Component	Stress Type	Stress (ksi)	
		Calculated(1)	Allowable(2)
Structural Shell	Primary Membrane	3.9/9.45(4)(5)	24.0
	Membrane + Bending	28.6/22.8(4)(5)	36.0
Top Cover Plate(3)	Primary Membrane	0.7	22.4
	Membrane + Bending	5.8	33.7
Bottom End Plate	Primary Membrane	2.9	22.4
	Membrane + Bending	22.3	33.7

(1) The load combination for Level C include dead weight, thermal, handling and seismic loads.

(2) See Table 3.2-11 for allowable stress criteria. Material properties for all components except the cask structural shell were obtained from Table 8.1-3 at a design temperature of 400°F. The cask structural shell allowables are based on a temperature of 250°F.

(3) Allowable stress values and calculated stress intensities are tabulated for the stainless steel cover plate.

(4) The leftmost stress value listed is for locations remote from the trunnions, while the rightmost stress value occurs in the region of the trunnions. The maximum stresses in the shell near the trunnions for Service Level C were evaluated against Service Level A/B allowables in Table 8.2-21a.

(5) Envelop of results with multiple piece and single solid piece trunnion analyses.

Table 8.2-23

Standardized Transfer Cask Enveloping Load Combination Results for Accident Loads (ASME Service Level D)

Transfer Cask Component	Stress Type	Controlling Load Combination[1]	Stress (ksi)	
			Calculated	Allowable[2]
Structural Shell	Primary Membrane	D1	9.7	49.0
	Membrane + Bending	D2	18.4	70.0
Top Cover Plate	Primary Membrane	D1	32.6	49.0
	Membrane + Bending	D1	32.6	70.0
Bottom End Plate	Primary Membrane	D1	30.9	49.0
	Membrane + Bending	D2	44.2	70.0

(1) See Table 3.2-7 for load combination nomenclature.

(2) See Table 3.2-11 for allowable stress criteria. Material properties were obtained from Table 8.1-3 at a design temperature of 400°F.

This appendix contains the following items:

E.1 Drawings for NUHOMS® Dry Shielded Canisters(1)

E.1.1 Standardized NUHOMS®-24P DSC Drawings

E.1.2 Standardized NUHOMS®-52B DSC Drawings

E.1.3 Standardized NUHOMS®-24P Long Cavity DSC Drawings

E.2 Drawings for NUHOMS® Horizontal Storage Module(2) (HSM Model 80 and Model 102 only)

E.3 Drawings for NUHOMS® On-Site Transfer Cask(3)

(1) The drawings for the NUHOMS®-61BT, 24PT2 and 32PT DSCs are contained in Appendices K, L and M, respectively. The drawings for the NUHOMS®-24PHB DSCs are contained in Appendices E and N. The drawings for the NUHOMS®-24PTH system (24PTH DSC, HSM-H and OS197FC transfer cask) are contained in Appendix P.

(2) The drawings for the NUHOMS® HSM Model 152 and Model 202 are contained in Section R.1.5 of Appendix R and V.1.5 of Appendix V, respectively.

(3) The drawings for the NUHOMS® OS197L transfer cask are contained in Section W.1.5 of Appendix W.

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

ALL DIMENSIONS ARE NOMINAL UNLESS A SPECIFIC TOLERANCE IS INDICATED WITH THE DRAWING DIMENSION
DIMENSIONS ARE IN INCHES AND DEGREES UNLESS OTHERWISE SPECIFIED. DIMENSIONING IN ACCORDANCE WITH ASME Y14.5M
INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4

TRANSNUCLEAR
AN AREVA COMPANY

SAFETY ANALYSIS REPORT
STANDARDIZED NUHOMS® ISFSI
HORIZONTAL STORAGE MODULE
DSC SUPPORT STRUCTURE

DRAWING NO.	SCALE	SHEET	REVISION
NUH-03-6016-SAR	NONE	1 OF 2	9

8 | 7 | 6 | 5 | 4 | 3 | 2 | 1

NUH-03-6016-SAR 2 OF 2

H G F E D C B A

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO. NUH-03-6016-SAR SHEET 2 OF 2 REVISION 9

8 | 7 | 6 | 5 | 4 | 3 | 2 | 1

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

ALL DIMENSIONS ARE NOMINAL UNLESS A SPECIFIC TOLERANCE IS INDICATED WITH THE DRAWING DIMENSION

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INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4

TRANSNUCLEAR
AN AREVA COMPANY

SAFETY ANALYSIS REPORT

GENERAL LICENSE NUHOMS® ISFSI ONSITE TRANSFER CASK OVERVIEW

DRAWING NO.	SCALE	SHEET	REVISION
NUH-03-8000-SAR	NONE	1 OF 1	4

DRAWING NO. NUH-03-8000-SAR SHEET 1 OF 1

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

ALL DIMENSIONS ARE NOMINAL UNLESS A SPECIFIC TOLERANCE IS INDICATED WITH THE DRAWING DIMENSION

DIMENSIONS ARE IN INCHES AND DEGREES UNLESS OTHERWISE SPECIFIED. DIMENSIONING IN ACCORDANCE WITH ASME Y14.5M

INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4

TRANSNUCLEAR
AN AREVA COMPANY

SAFETY ANALYSIS REPORT
GENEERAL LICENSE NUHOMS® ISFSI
ONSITE TRANSFER CASK
STRUCTRUAL SHELL ASSEMBLY

DRAWING NO.	SCALE	SHEET	REVISION
NUH-03-8001-SAR	NONE	1 OF 5	8

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO.	SHEET	REVISION
NUH-03-8001-SAR	2 OF 5	8

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO.	SHEET	REVISION
NUH-03-8001-SAR	3 OF 5	8

8 7 6 5 4 3 2 1

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PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO.	SHEET	REVISION
NUH-03-8001-SAR	4 OF 5	8

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

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ALL DIMENSIONS ARE NOMINAL UNLESS A SPECIFIC TOLERANCE IS INDICATED WITH THE DRAWING DIMENSION

DIMENSIONS ARE IN INCHES AND DEGREES UNLESS OTHERWISE SPECIFIED. DIMENSIONING IN ACCORDANCE WITH ASME Y14.5M

INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4

TRANSNUCLEAR
AN AREVA COMPANY

SAFETY ANALYSIS REPORT
GENERAL LICENSE NUHOMS® ISFSI
ONSITE TRANSFER CASK
INNER & OUTER SHELL ASSEMBLY

DRAWING NO.	SCALE	SHEET	REVISION
NUH-03-8002-SAR	NONE	1 OF 3	8

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO. NUH-03-8002-SAR | SHEET 2 OF 3 | REVISION 8

8 7 6 5 4 3 2 1

H G F E D C B A

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO.	SHEET	REVISION
NUH-03-8002-SAR	3 OF 3	8

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ALL DIMENSIONS ARE NOMINAL UNLESS A SPECIFIC TOLERANCE IS INDICATED WITH THE DRAWING DIMENSION

DIMENSIONS ARE IN INCHES AND DEGREES UNLESS OTHERWISE SPECIFIED. DIMENSIONING IN ACCORDANCE WITH ASME Y14.5M

INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4

TRANSNUCLEAR
AN AREVA COMPANY

SAFETY ANALYSIS REPORT
GENERAL LICENSE NUHOMS® ISFSI
ONSITE TRANSFER CASK
MAIN ASSEMBLY

DRAWING NO.	SCALE	SHEET	REVISION
NUH-03-8003-SAR	NONE	1 OF 3	8

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

8 7 6 5 4 3 2 1

H G F E D C B A

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO.	SHEET	REVISION
NUH-03-8003-SAR	3 OF 3	8

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ALL DIMENSIONS ARE NOMINAL UNLESS A SPECIFIC TOLERANCE IS INDICATED WITH THE DRAWING DIMENSION

DIMENSIONS ARE IN INCHES AND DEGREES UNLESS OTHERWISE SPECIFIED. DIMENSIONING IN ACCORDANCE WITH ASME Y14.5M

INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4

TRANSNUCLEAR
AN AREVA COMPANY

SAFETY ANALYSIS REPORT
NUHOMS® 61BT TRANSPORTABLE CANISTER FOR BWR FUEL GENERAL ARRANGEMENT

DRAWING NO.	SCALE	SHEET	REVISION
NUH-61B-1060-SAR	NONE	1 OF 2	4

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO.	SHEET	REVISION
NUH-61B-1060-SAR	2 OF 2	4

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

NUH-61B-1062-SAR 1 OF 2

ALL DIMENSIONS ARE NOMINAL UNLESS A SPECIFIC TOLERANCE IS INDICATED WITH THE DRAWING DIMENSION
DIMENSIONS ARE IN INCHES AND DEGREES UNLESS OTHERWISE SPECIFIED. DIMENSIONING IN ACCORDANCE WITH ASME Y14.5M
INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4

TRANSNUCLEAR
AN AREVA COMPANY

SAFETY ANALYSIS REPORT
NUHOMS® 61BT TRANSPORTABLE CANISTER FOR BWR FUEL
CANISTER DETAILS

DRAWING NO.	SCALE	SHEET	REVISION
NUH-61B-1062-SAR	NONE	1 OF 2	5

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO. NUH-61B-1062-SAR | SHEET 2 OF 2 | REVISION 5

Table K.1-1
Nominal Dimensions and Weight of the NUHOMS®-61BT DSC

Overall length (with grapple, in)	199.7
Outside diameter (in)	67.25
Cavity diameter (in)	66.25
Cavity length (in)	179.5
Nominal DSC weight:	
Loaded on storage pad (kips)	88.5

Table K.2-1
Intact BWR Fuel Assembly Characteristics

PHYSICAL PARAMETERS: Fuel Design:	7x7, 8x8, 9x9, or 10x10 intact BWR fuel assemblies manufactured by General Electric or Exxon/ANF or equivalent reload fuel that are enveloped by the Fuel assembly design characteristics listed in Table K.2-3.
Cladding Material:	Zircaloy
Fuel Damage:	Cladding damage in excess of pinhole leaks or hairline cracks is not authorized to be stored as "Intact BWR Fuel."
Channels:	Fuel may be stored with or without fuel channels
Maximum Assembly length (Unirradiated)	176.2 in
Nominal Assembly Width (excluding channels)	5.44 in
Maximum Assembly Weight	705 lbs
RADIOLOGICAL PARAMETERS(1): *Group 1:* Maximum Burnup:	27,000 MWd/MTU
Minimum Cooling Time:	5-years
Maximum Initial Enrichment:	See Table K.2-4
Minimum Initial Bundle Average Enrichment:	2.0 wt. % U-235
Maximum Initial Uranium Content:	198 kg/assembly
Maximum Decay Heat:	300 W/assembly(2)
Group 2: Maximum Burnup:	35,000 MWd/MTU
Minimum Cooling Time:	8-years
Maximum Initial Enrichment:	See Table K.2-4
Minimum Initial Bundle Average Enrichment:	2.65 wt. % U-235
Maximum Initial Uranium Content:	198 kg/assembly
Maximum Decay Heat:	300 W/assembly(2)
Group 3: Maximum Burnup:	37,200 MWd/MTU
Minimum Cooling Time:	6.5-years
Maximum Initial Enrichment:	See Table K.2-4
Minimum Initial Bundle Average Enrichment:	3.38 wt. % U-235
Maximum Initial Uranium Content:	198 kg/assembly
Maximum Decay Heat:	300 W/assembly(2)
Group 4: Maximum Burnup:	40,000 MWd/MTU
Minimum Cooling Time:	10-years
Maximum Initial Enrichment:	See Table K.2-4
Minimum Initial Bundle Average Enrichment:	3.4 wt. % U-235
Maximum Initial Uranium Content:	198 kg/assembly
Maximum Decay Heat:	300 W/assembly(2)
Alternate Radiological Parameters: Maximum Initial Enrichment:	See Table K.2-4
Fuel Burnup, Initial Bundle Average Enrichment, and Cooling Time:	See Table K.2-11
Maximum Initial Uranium Content:	198 kg/assembly
Maximum Decay Heat:	300 W/assembly(2)

(1) Fuel assemblies fully complying with any of the four groups of parameters or alternate radiological parameters are suitable for storage in the NUHOMS®-61BT DSC. No interpolation of Radiological Parameters is permitted between groups 1 to 4.

(2) For FANP9 9x9-2 fuel assemblies, the maximum decay heat is limited to 0.21 kW/assembly.

Table K.2-3
BWR Fuel Assembly Design Characteristics[(1)(2)]

Transnuclear, ID	7 x 7-49/0[(5)]	8 x 8-63/1[(5)]	8 x 8-62/2[(5)]	8 x 8-60/4[(5)]	8 x 8-60/1[(5)]	9 x 9-74/2	10x10-92/2	7x7 – 49/0[(5)]	7x7 48/1Z[(5)]	8x8 – 60/4Z[(5)]	9x9-79/2
Fuel Type	GE1 GE2 GE3	GE4	GE-5 GE-Pres GE-Barrier GE8 Type I	GE8 Type II	GE9 GE10	GE11 GE13	GE12	ENC III-A	ENC III[(3)]	ENC Va & ENC Vb	FANP9 9x9-2
Nominal Width (in) (excluding channels)	5.44	5.44	5.44	5.44	5.44	5.44	5.44	5.44	5.44	5.44	5.44
Channel Internal Width (in)	5.278	5.278	5.278	5.278	5.278	5.278	5.278	5.278	5.278	5.278	5.278
Fissile Material	UO_2	UO_2	UO_2	UO_2	UO_2	UO_2	UO_2	UO_2	UO_2	UO_2	UO_2
Number of Fuel Rods	49	63	62	60	60	66 – Full 8 – Partial	78 – Full 14 – Partial	49	48	60	79
Number of Water Holes	0	1	2	4	1	2	2	0	1[(4)]	4[(4)]	2

(1) Any fuel channel thickness from 0.065 to 0.120 inch is acceptable on any of the fuel designs.
(2) Maximum fuel assembly weight with channel is 705 lb.
(3) Includes ENC III-E and ENC III-F.
(4) Solid Zirc rods instead of water holes.
(5) May be stored as damaged fuel.

Table K.2-5
Summary of Canister Load Combinations

LOAD CASE	Horizontal DW		Vertical DW		Internal Pressure(9)	External Pressure	Thermal Condition	Liting Loads	Other Loads	Service Level	Enveloped By
	61BT DSC	Fuel	61BT DSC	Fuel							
Non-Operational Load Cases											
NO-1 Fab. Leak Testing	--	--	--	--	--	14.7 psi (101kpa)	70°F (21°C)	--	155 kip axial (689KN)	Test	
NO-2 Fab. Pressure Testing (13)	--	--	--	--	16 psi (110kpa)	--			155 kip axial	Test	
NO-3 DSC Uprighting	x	--	--	--	--	--	70°F	x	--	A	
NO-4 DSC Vertical Lift	--	--	x	--	--	--	70°F	x	--	A	
Fuel Loading Load Cases											
FL-1 DSC/Cask Filling	--	--	Cask	--	--	Hydrostatic	100°F Cask (38°C)	x	x	A	DD-2
FL-2 DSC/Cask Filling	--	--	Cask	--	Hydrostatic	Hydrostatic	100°F Cask	x	x	A	DD-2
FL-3 DSC/Cask Xfer	--	--	Cask	--	Hydrostatic	Hydrostatic	100°F Cask	--	--	A	
FL-4 Fuel Loading	--	--	Cask	x	Hydrostatic	Hydrostatic	100°F Cask	--	--	A	
FL-5 Xfer to Decon	--	--	Cask	x	Hydrostatic	Hydrostatic	100°F Cask	--	--	A	
FL-6 Inner Cover plate Welding	--	--	Cask	x	Hydrostatic	Hydrostatic	100°F Cask	--	--	A	
FL-7 Fuel Deck Seismic Loading	--	--	Cask	x	Hydrostatic	Hydrostatic	100°F Cask	--	Note 10	C	
Draining/Drying Load Cases											
DD-1 DSC Blowdown	--	--	Cask	x	Hydrostatic + 20 psi (138kpa)	Hydrostatic	100°F Cask	--	--	A	DD-2
DD-2 Vacuum Drying	--	--	Cask	x	0 psia	Hydrostatic + 14 psi (97kpa)	100°F Cask	--	--	A	
DD-3 Helium Backfill	--	--	Cask	x	12 psi (83kpa)	Hydrostatic	100°F Cask	--	--	A	
DD-4 Final Helium Backfill	--	--	Cask	x	3.5 psi (24kpa)	Hydrostatic	100°F Cask	--	--	A	DD-3
DD-5 Outer Cover Plate Weld	--	--	Cask	x	3.5 psi (24kpa)	Hydrostatic	100°F Cask	--	--	A	DD-3
Transfer Trailer Loading											
TL-1 Vertical Xfer to Trailer	--	--	Cask	x	10 psi (69kpa)	--	0°F Cask (-17°C)	--	--	A	
TL-2 Vertical Xfer to Trailer	--	--	Cask	x	10 psi	--	100°F Cask	--	--	A	
TL-3 Laydown	Cask	X	--	--	10 psi	--	0°F Cask	--	--	A	TR-1-TR-4
TL-4 Laydown	Cask	X	--	--	10 psi	--	100°F Cask	--	--	A	TR-5-TR-6

Table K.2-5
Summary of Canister Load Combinations
(Concluded)

1. 75g drop acceleration includes gravity effects. Therefore, it is not necessary to add an additional 1.0g load.
2. For Level D events, only maximum temperature case is considered. (Thermal stresses are not limited for level D events and maximum temperatures give minimum allowables).
3. Flood load is an external pressure equivalent to 50 feet (164m) of water.
4. BV = HSM Vents are blocked.
5. At temperature over 100°F (38°C) a sunshade is required over the TC. Temperatures for these cases are enveloped by the 100° F (without sunshade) case.
6. As described in Section K.4.1.2, this pressure assumes release of the fuel cover gas and 30% of the fission gas. Since unloading requires the HSM door to be removed, the pressure and temperatures are based on the normal (unblocked vent) condition. Pressure is applied to the confinement boundary.
7. As described in Section K.4.1.2, this pressure assumes release of the fuel cover gas and 30% of the fission gas. Although unloading requires the HSM door to be removed, the pressure and temperatures are based on the blocked vent condition. Pressure is applied to the shell, inner bottom cover plate and outer top cover plate.
8. This pressure is applied to the shell, inner bottom cover plate and outer top cover plate.
9. Unless noted otherwise, pressure is applied to the confinement boundary.
10. Fuel deck seismic loads are assumed enveloped by handling loads.
11. Load Cases UL-7 and UL-8 envelop loading cases where the insertion loading of 80 kips (356KN) is considered with an accident pressure (the insertion force is opposed by internal pressure).
12. The 75g top end drop and bottom end drop are not credible events, therefore these drop analyses are not required.
13. For transport condition test pressure is 1.5 times maximum normal operating pressure and for storage condition test pressure is 1.25 times design pressure. This fabrication test pressure meets both conditions.

Table K.2-9
Additional Design Criteria for NUHOMS®-61BT DSC

The gross weight of the NUHOMS®-61BT DSC:	88.5 kips
NUHOMS®-61BT DSC Type:	A, B or C
Payload Capacity:	61 intact BWR assemblies 61 BWR assemblies (up to 16 damaged and remainder intact) (acceptable assemblies listed in Table K.2-3)
Spent Fuel Characteristics:	See Tables K.2-1, K.2-2, K.2-4

Table K.3.1-2
ASME Code Exceptions for the NUHOMS®-61BT DSC Confinement Boundary

Reference ASME Code Section/Article	Code Requirement	Exception, Justification & Compensatory Measures
NCA	All	Not compliant with NCA
NB-1100	Requirements for Code Stamping of Components	The NUHOMS®-61BT DSC shell is designed & fabricated in accordance with the ASME Code, Section III, Subsection NB to the maximum extent practical. However, Code Stamping is not required. As Code Stamping is not required, the fabricator is not required to hold an ASME "N" or "NPT" stamp, or to be ASME Certified.
NB-1132	Attachments with a pressure retaining function, including stiffeners, shall be considered part of the component.	Bottom shield plug and outer bottom cover plate are outside code jurisdiction; these components together are much larger than larger than required to provide stiffening for the inner bottom cover plate; the weld that retains the outer bottom cover plate and with it the bottom shield plug is subject to root and final PT examination.
NB-2130	Material must be supplied by ASME approved material suppliers	Material is certified to meet all ASME Code criteria but is not eligible for certification or Code Stamping if a non-ASME fabricator is used. As the fabricator is not required to be ASME certified, material certification to NB-2130 is not possible. Material traceability & certification are maintained in accordance with TN's NRC approved QA program.
NB-4121	Material Certification by Certificate Holder	
NB-4243 and NB-5230	Category C weld joints in vessels and similar weld joints in other components shall be full penetration joints. These welds shall be examined by UT or RT and either PT or MT	The joints between the top outer and inner cover plates and containment shell are designed and fabricated per ASME Code Case N-595-1. This includes the inner top cover plate weld around the vent and siphon block. The welds are partial penetration welds and the root and final layer are PT examined. The weld between the vent and siphon block and the shell is made at the fabricator's shop and receives a final PT examination.
NB-6100 and 6200	All completed pressure retaining systems shall be pressure tested	The vent and siphon block is not pressure tested due to the manufacturing sequence. The siphon block weld is helium leak tested when fuel is loaded and then covered with the outer top closure plate.
NB-7000	Overpressure Protection	No overpressure protection is provided for the NUHOMS® -61BT DSC . The function of the NUHOMS®-61BT DSC is to contain radioactive materials under normal, off-normal and hypothetical accident conditions postulated to occur during transportation and storage. The NUHOMS®-61BT DSC is designed to withstand the maximum possible internal pressure considering 100% fuel rod failure at maximum accident temperature. The NUHOMS®-61BT DSC is pressure tested in accordance with ASME Code Case N-595-1.

D. Electroless Nickel Plated Carbon Steel

The carbon steel top shield plug of the DSC is plated with electroless nickel. This coating is identical to the coating used on the 52B DSC. It has been evaluated for potential galvanic reactions in Transnuclear West's response to NRC Bulletin 96-04 [3.9]. In BWR pools, the reported corrosion rates are insignificant and are expected to result in a negligible rate of reaction for the NUHOMS® BWR systems.

Lubricants and Cleaning Agents

Cleaning agents used for final cleaning on the NUHOMS®-61BT DSC should be selected for compatibility with the spent fuel pool water chemistry and the DSC materials. Never-seez or Neolube (or equivalent) may be used to coat threads. The lubricant should be selected for its ability to maintain lubricity under long term storage conditions.

The DSC is cleaned in accordance with approved procedures to remove cleaning residues prior to shipment to the storage site. The basket is also cleaned prior to installation in the DSC. The cleaning agents and lubricants have no significant affect on the DSC materials and their safety related functions.

Hydrogen Generation

During the initial passivation state, small amounts of hydrogen gas may be generated in the 61BT DSC. The passivation stage may occur prior to submersion of the transfer cask into the spent fuel pool. Any amounts of hydrogen generated in the DSC will be insignificant and will not result in a flammable gas mixture within the DSC.

The small amount of hydrogen which may be generated during DSC operations does not result in a safety hazard. In order for concentrations of hydrogen in the cask to reach flammability levels, most of the DSC would have to be filled with water for the hydrogen generation to occur, and the lid would have to be in place with both the vent and drain ports closed. This does not occur during DSC loading or unloading operations.

After loading fuel into the NUHOMS®-61BT DSC, the shield plug is placed in the DSC and the transfer cask and DSC are raised to the pool surface. At this time the DSC is completely filled with water.

An estimate of the maximum hydrogen concentration can be made, ignoring the effects of radiolysis, recombination, and solution of hydrogen in water. Testing was conducted by Transnuclear [3.10] to determine the rate of hydrogen generation for aluminum metal matrix composite in intermittent contact with 304 stainless steel. The samples represent the neutron poison plates paired with the basket compartment tubes. The test specimens were submerged in deionized water for 12 hours at 70 °F to represent the period of initial submersion and fuel loading, followed by 12 hours at 150 °F to represent the period after the fuel is loaded, until the water is drained. The hydrogen generated during each period was removed from the water and the test vessel and measured.

From the above table, it is seen that the vent block case is the most critical of all cases since temperatures and ΔT between DSC and basket are the highest in this case.

C. Thermal Expansion Calculation

In order to prevent thermal stress, adequate clearance is provided between the poison plates and stainless steel plates, and between the basket outer diameter and DSC cavity inside diameter, for free thermal expansion. To verify that adequate provision exists, the thermal expansion of different components are calculated and tabulated below.

Thermal Expansion of 61BT Components

Fuel Assembly Axial Thermal Expansion						
	F.A. Length at 70°F (in.)*	Max. F.A. Temp (°F)	F.A. Length Hot** (in)	DSC Cavity Length at 70°F (in)***	Min. Cavity Temp (°F)	Cavity Length Hot (in)
Handling/Transfer	176.16	850	177.88	179.31	360	179.78
Operation/Storage	176.16	810	177.86	179.31	425	179.90
Basket Diametral Thermal Expansion						
	Basket O.D. at 70°F (in.)	Basket Temp (°F)	Basket O.D. Hot (in)	DSC Cavity I.D. at 70°F (in)	Min. Cavity Temp (°F)	Cavity I.D. Hot (in)
Handling/Transfer	66.0	710	66.41	66.25	360	66.43
Operation/Storage	66.0	725	66.42	66.25	425	66.47
Basket Axial Thermal Expansion (Including Holddown Ring)						
	Basket Length at 70°F (in.)	Basket Temp (°F)	Basket Length Hot (in)	DSC Cavity Length at 70°F (in)***	Min. Cavity Temp (°F)	Cavity Length Hot (in)
Handling/Transfer	178.50	710	179.61	179.31	360	179.78
Operation/Storage	178.50	725	179.64	179.31	425	179.90

* The GE 7x7 (longest BWR fuel) is chosen for analysis. Total fuel assembly length at room temperature = 176.16 inches. The length of the zircaloy guide tube is 160.47 inches. The remainder of the fuel assembly length 15.69 inches is stainless steel.

** Includes 1.25 in. for irradiation growth.

*** Cavity nominal 179.5, minimum 178.41 inches per dwg NUH-61B-1060-SAR.

As shown in the table above, adequate clearance has been provided for free thermal expansion of the fuel assemblies and the basket.

K.3.4.4.3 Thermal Stress Calculations

The thermal stress calculations for the various system components other than the basket are provided in Sections K.3.6 and K.3.7 for normal, off-normal and accident conditions. The thermal stress calculations for the 61BT basket is presented below.

Table K.3.7-11
NUHOMS®-61BT DSC Enveloping Load Combination Results for Normal and Off-Normal Loads
(ASME Service Levels A and B)

DSC Components	Stress Type	Controlling Load Combination (1)	Stress (ksi)	
			Calculated	Allowable (2)
DSC Shell	Primary Membrane	TR-3, TR-7	7.17	17.5
	Membrane + Bending	N0-1	21.10(7)	40.5
	Primary + Secondary	LD-4	53.69	54.3
Inner Bottom Cover Plate	Primary Membrane	LD-4	4.71	17.5
	Membrane + Bending	N0-1	20.50(7)	40.5
	Primary + Secondary	LD-4	37.71	54.3
Outer Bottom Cover Plate	Primary Membrane	LD-4, LD-5	6.28	17.5
	Membrane + Bending	UL-4,UL-5, UL-6	25.44	29.0
	Primary + Secondary	UL-5	34.68	58.0
Inner Top Cover Plate	Primary Membrane	TR-5	3.75	17.5
	Membrane + Bending	HSM-4	10.69	28.1
	Primary + Secondary	TR-1, TR-5	33.35	52.5
Outer Top Cover Plate	Primary Membrane	HSM-4	4.93	18.7
	Membrane + Bending	HSM-4	16.09	28.1
	Primary + Secondary	HSM-4	29.42	56.1
Basket	Primary Membrane	TR-8	0.8	16.2
	Membrane + Bending	TR-8	3.67	24.3
	Primary + Secondary	HSM-3	17.69	48.6
Rail	Primary Membrane	TR-8	1.18	16.2
	Membrane + Bending	TR-8	5.11	24.3
	Primary + Secondary	HSM-3	11.51	48.6
Rail Stud	Shear	DD-2	0.19	9.72

See Table K.3.7-14 for notes.

Table K.3.7-14
DSC Enveloping Load Combination Table Notes

(1) See Table K.3.2-6 for load combination nomenclature.

(2) See Table K.3.2-9 for allowable stress criteria. Material properties were obtained from Table 8.1-3 at a design temperature of 500°F or as noted.

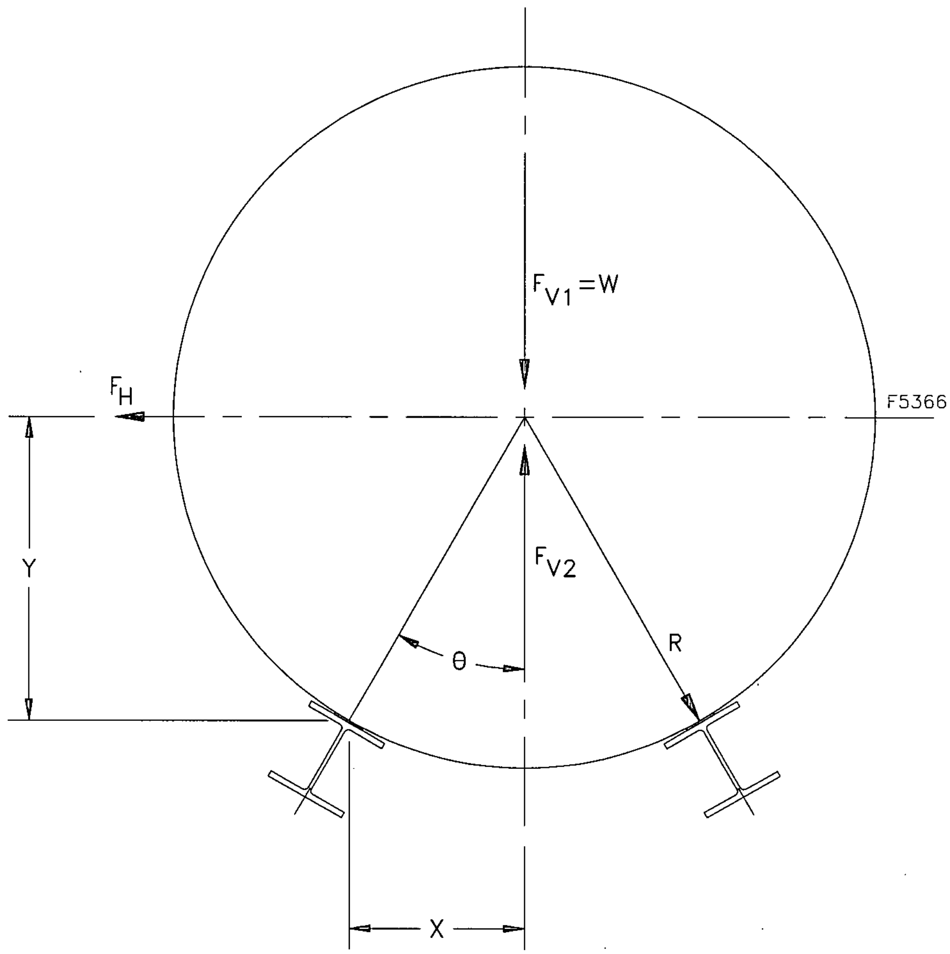
(3) In accordance with the ASME Code, thermal stresses need not be included in Service Level D load combinations.

(4) Evaluated per ASME NB-3228.5 for components with stresses greater than $3.0S_m$.

(5) The maximum side drop membrane + bending stress is highly localized near the cask rail, at the outer bottom cover plate. The maximum temperature in this region is less than 240°F (temperature case 2).

(6) The maximum side drop membrane + bending stress is highly localized over the cask rail. The maximum temperature in this region is less than 300°F (temperature case 2).

(7) Transport condition test pressure is 1.5 times maximum normal operating pressure and for storage condition test pressure is 1.25 times design pressure. This stress covers both conditions at highest pressure test.



WHERE:

R = 33.625 in., DSC outer radius

θ = 30°

X = R Sin θ = 16.8 in.

Y = R Cos θ = 29.1 in.

F_{V1} = W = weight of DSC

F_{V2} = W(0.17g) = upward vertical seismic load

F_H = W(0.37g) = horizontal seismic load

Figure K.3.7-1
DSC Lift-Off Evaluation

K.3.7A Evaluation of 61BT DSC with FANP9 9x9-2 Fuel Assemblies

All of the design parameters for the design basis fuel assembly used in this chapter (e.g., total fuel assembly weight, temperatures, and pressures) bound the Framatome-ANP 9x9 Version 9x9-2 (FANP9 9x9-2) fuel assembly. As a result, all of the structural evaluation results reported in this chapter are bounding for the FANP9 9x9-2 fuel assembly.

K.4 Thermal Evaluation

K.4.1 Discussion

The NUHOMS®-61BT 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:

- Determination of maximum and minimum temperatures with respect to materials limits to ensure components perform their intended safety functions,
- Determination of temperature distributions for the NUHOMS®-61BT DSC components to support the calculation of thermal stresses for the structural components,
- Determination of maximum internal NUHOMS®-61BT DSC pressures for the normal, off-normal and accident conditions,
- Determination of the maximum fuel cladding temperature, and to confirm that this temperature will remain sufficiently low to prevent unacceptable degradation of the fuel during storage.

The NUHOMS®-61BT 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:

- Maximum temperatures of the confinement structural components must not adversely affect the confinement function.
- The maximum initial storage fuel cladding temperature is determined as a function of the initial fuel age using the guidelines provided by the Commercial Spent Fuel Management Program [4.1]. The temperature threshold accounts for the effects of cladding temperature, decay time, burnup and fission gas build-up at 40 GWD/MTU. Waterside corrosion of 0.002 in. (radially) has been assumed. For normal conditions of storage, a fuel temperature limit of 343°C (649°F) has been established. During loading/unloading, transfer and accident conditions, the fuel temperature limit is 570°C (1058°F) [4.9]. The NUHOMS® - 61BT DSC with FANP9 9x9-2 fuel assemblies with a maximum per assembly heat load of 0.21 kdW/FA (13 kW/DSC) meet the NRC Interim Staff Guidance (ISG) -11, Revision 3 [4.15] during all storage and transfer conditions.
- The maximum DSC cavity internal pressures during normal, off-normal and accident conditions must be below the design pressures of 10 psig, 20 psig and 65 psig, respectively.

The thermal analysis methodology used to predict the temperature distribution in the NUHOMS®-61BT DSC basket is benchmarked [4.11] against experimental data obtained for the

TN-24 cask [4.12]. The results of the benchmarking study show with the cask in a horizontal configuration, the TN methodology predicted fuel cladding temperatures which are 77°F higher than the test data. These results were submitted to the NRC staff [4.13].

In the specific case of the TN-24 cask, with the cask backfilled with helium and in a horizontal configuration, the maximum fuel cladding temperature noted in the PNL Report [4.12] was 419°F. These temperature levels are less than the typical peak design temperatures for initial storage conditions of approximately 570°F. Despite this fact, the use of TN-24 test data is appropriate for validating the thermal model intended for use at the higher temperature level based on the following justification:

For a thermal model that captures the basic thermo physical processes (i.e., conduction, convection, and radiation) present, the primary areas of uncertainty will be the modeling of the geometry and the thermal properties used for each component. Once the correct geometry and thermal properties are captured, the effect of higher temperature levels on the fundamental heat transfer processes involved is well understood and documented. Thus, simply changing the temperature level for a simulation will not necessarily increase the uncertainty level for the thermal model.

Changes to the thermal conductivity of the metallic components with temperature are well understood and documented for temperature levels well in excess of 700°F. As such, the effect is easily captured through the use of temperature dependent properties.

Radiation heat transfer is a function of view factor, surface area, and emissivity. View factors and surface area do not change with increased temperature level. As such, a thermal model that incorporates radiation exchange and which has been validated at a lower temperature will typically be conservative (i.e., yield higher temperatures) for application at the higher temperature level.

Therefore, a thermal model that has been properly constructed and validated using the lower temperature data from the TN-24 test can be fully expected to yield accurate results at higher temperature levels similar to the NUHOMS®-61BT DSC design.

The NUHOMS®-61BT DSC is analyzed based on a maximum heat load of 18.3 kW from 61 BWR fuel assemblies. The analyses consider the effect of the decay heat flux varying axially along a fuel assembly. The axial heat flux profile for a BWR fuel assembly shown in Figure K.4-8 and an active length of 144 in. is used for the evaluation. The use of these parameters bounds the peak heat flux for the design basis fuel. A description of the detailed analyses performed for normal storage conditions is provided in Section K.4.4, off-normal conditions in Section K.4.5, accident conditions in Section K.4.6, and loading/unloading conditions in Section K.4.7. The thermal evaluation of 61BT DSC with damaged fuel assemblies is included in Section K.4.1. The thermal evaluation concludes that with a design basis heat load of 18.3 kW, all design criteria are satisfied.

K.4.8A <u>Evaluation of 61BT DSC with FANP9 9x9-2 Fuel Assemblies</u>

The method used for the thermal evaluation of the FANP9 9x9-2 fuel is documented below.

1. Evaluate the effective fuel properties (thermal conductivity (K), heat capacity (Cp) and density (ρ)) of the FANP9 9x9-2 fuel assembly and compare it with the NUHOMS®-61BT DSC design basis fuel. If the FANP9 9x9-2 fuel can be bounded by the design basis fuel, the corresponding thermal analysis results for the NUHOMS®-61BT design basis fuel can be conservatively used for thermal evaluation of the NUHOMS®-61BT DSC with the FANP9 9x9-2 fuel assembly.
2. Based on the thermal analysis results of NUHOMS®-61BT DSC for the maximum design basis heat load of 18.3 kW per DSC, use the ratio of heat loads and the temperature difference (ΔT) to calculate the maximum cladding temperatures in the NUHOMS®-61BT DSC with FANP9 9x9-2 fuel assemblies with a maximum heat load 13 kW per DSC. Use these results to demonstrate that the maximum cladding temperatures with FANP9 9x9-2 fuel meet in NRC Interim Staff Guidance (ISG) -11, Revision 3 [4.15] during all storage and transfer conditions.

A summary of key parameters for the FANP9 9x9-2 Fuel and NUHOMS®-61BT DSC Design Basis Fuel are shown in the table below.

Summary of Key Parameters for FANP9 9x9-2 Fuel and NUHOMS®-61BT DSC Design Basis Fuel

	FANP9 9x9-2 Fuel Assembly Parameters	**NUHOMS®-61BT Design Basis Fuel Parameters**
Maximum Decay Heat Load per Assembly (kW)	0.21	0.3
Maximum Total Decay Heat load per NUHOMS®-61BT DSC (kW)	13.0	18.3

As shown in the table, the maximum decay heat per assembly and maximum total decay heat per DSC for the FANP9 9x9-2 fuel are all bounded by the design basis values used for the NUHOMS®-61BT thermal evaluation.

The fuel assembly effective thermal conductivities for the FANP9 9x9-2 fuel were calculated similar to Chapter K.4 and compared with the design basis fuel assembly values. The comparison is documented in the table below:

Summary of Effective Density, Specific Heat and Axial Thermal Conductivity for NUHOMS®-61BT DSC

Assembly Effective Thermal Properties	NUHOMS®-61BT DSC Fuel Assembly	FANP9 9x9-2 Fuel Assembly
Thermal Properties		
Effective Density, lbm/in^3	0.105	0.106
Heat Capacity Cp, Btu/lbm-°F	0.0574	0.0578
Thermal Conductivity $K_{eff\ axial}$, Btu/hr-in-°F	0.0437	0.0490

Similarly, the computed radial (transverse) fuel thermal effective conductivity values as a function of temperature for helium backfill conditions and vacuum drying conditions are tabulated in the table below for the FANP9 9x9-2 fuel assembly and the bounding NUHOMS®-61BT DSC design basis fuel assembly.

Transverse Fuel Thermal Effective Conductivity for Helium Backfill and Vacuum Drying Condition, FANP9 9x9-2 and NUHOMS®-61BT DSC Bounding Fuel Assembly

	Helium Backfill				Vacuum Drying		
	FANP9 9x9-2	61BT Design Basis Fuel Assembly	Comparison		FANP9 9x9-2	61BT Design Basis Fuel Assembly	Comparison
T	$k_{eff,\ FANP9\ 9x9\text{-}2}$	$k_{eff,\ 61BT}$	Difference (%)	*T*	$k_{eff,\ FANP9\ 9x9\text{-}2}$	$k_{eff,\ 61BT}$	Difference (%)
°*F*	*Btu/(hr-in-°F)*	*Btu/(hr-in-°F)*	$\frac{k_{eff,\ FANP9\ 9x9\text{-}2} - k_{eff,\ 61BT}}{k_{eff,\ 61BT}}$	°*F*	*Btu/(hr-in-°F)*	*Btu/(hr-in-°F)*	$\frac{k_{eff,\ FANP9\ 9x9\text{-}2} - k_{eff,\ 61BT}}{k_{eff,\ 61BT}}$
214.4	0.01590	0.01600	-0.6	240.0	0.005793	0.005800	-0.1
312.4	0.01845	0.01860	-0.8	331.6	0.007367	0.007300	0.9
410.7	0.02145	0.02150	-0.2	425.1	0.009274	0.009200	0.8
509.3	0.02496	0.02490	0.2	520.1	0.011531	0.011400	1.2
608.0	0.02885	0.02880	0.2	616.3	0.013951	0.014100	-1.1

As seen from these tables, the effective density, heat capacity, and axial thermal conductivities for the FANP9 9x9-2 fuel assembly are bounded by the NUHOMS®-61BT DSC design basis fuel assembly used in the thermal evaluation in this section, and the transverse thermal conductivities for the FANP9 9x9-2 fuel assembly are negligibly different from the design basis fuel assembly used in the thermal evaluation in this section.

The maximum decay heat load for the FANP9 9x9-2 fuel assemblies for inclusion in the authorized contents of the NUHOMS®-61BT DSC is 13.0 kW per DSC (0.21 kW per fuel

assembly). This is approximately 29% less than the design basis heat load for NUHOMS®-61BT DSC. The FANP9 9x9-2 fuel thermal properties are similar to the design basis fuel for the NUHOMS®-61BT DSC as described in the two preceding tables. Therefore, the thermal evaluation for the design basis fuel in NUHOMS®-61BT DSC during storage and transfer for normal, off-normal and accident conditions remains bounding for the FANP9 9x9-2 fuel assemblies with decay heat loads less than or equal to 13.0 kW/DSC.

The maximum fuel cladding temperatures during storage and transfer operations are shown in the table below for the NUHOMS®-61BT DSC with design basis heat loads (18.3 kW/DSC) from Tables K.4-1, K.4-2 and K.4-4. When these fuel cladding temperatures are compared with the allowable cladding temperatures in ISG-11, Revision 3, all the fuel cladding temperatures, including the vacuum drying operations at 96 hours, are below the ISG-11 allowable values. The following evaluation calculates the expected maximum fuel cladding temperature with FANP9 9x9-2 fuel assemblies with a maximum heat load of 13.0 kW/DSC.

<u>Maximum Fuel Cladding Temperatures with FANP9 9x9-2 Fuel Assemblies During Vacuum Drying Condition</u>

The maximum fuel cladding temperatures within the NUHOMS®-61BT DSC (decay heat load of 18.3 kW per DSC) after 96 hours of vacuum drying condition (Table K.4-4) is used to evaluate the corresponding maximum fuel cladding temperature for loading the NUHOMS®-61BT DSC with the FANP9 9x9-2 fuel assemblies with 13.0 kW/DSC heat load.

According to this chapter, the maximum fuel cladding temperature after 96 hours of the vacuum drying condition is $T_{FC,\ 18.kW,\ 96hrs}$ = 827°F where the initial temperatures $T_{a,\ 18.3kW}$ for the DSC and basket are assumed to be at 100°F. Therefore, the temperature increase (ΔT) after 96 hours of the vacuum drying condition is:

$$\Delta T_{FC,\ 18.3kW,\ 96hrs} = T_{FC,\ 18.3kW,\ 96hrs} - T_{a,\ 18.3kW,\ 0hr} = 827 - 100 = 727°F$$

For the 13.0 kW per DSC heat load, the corresponding maximum fuel cladding temperature increase after 96 hours of the vacuum drying condition is estimated as:

$$\Delta T_{FC,\ 13kW,\ 96hrs} = 13/18.3 * \Delta T_{FC,\ 18.3kW,\ 96hrs} = 516.4°F$$

Then,

$$T_{FC,\ 13kW,\ 96hr} = 516.4 + 100 = 616.4°F$$

The results show that at the end of 96 hours of the vacuum drying condition for FANP9 9x9-2 fuel assemblies with 13.0 kW/DSC heat load, the maximum fuel cladding temperature during vacuum drying condition also meets the allowable of 752°F from ISG-11.

Maximum Cladding Temperatures during Storage and Transfer

Condition	Operation	Maximum Cladding Temperature with design basis heat load of 18.3 kW/DSC (°F)	Maximum Cladding Temperature with FANP9 9x9-2 Fuel with 13 kW/DSC (°F)	Allowable Temperature Range per ISG-11 Rev. 3 (°F)
Storage	Normal, 100°F Ambient	569	<569	752
	Off-Normal, 125°F Ambient	590	<590	1058
	Accident – Blocked Vent	809	<809	1058
Transfer	Normal/Off-Normal Ambient	638	<638	752
	Vacuum Drying, 96 hrs	827	617	752

This table shows that all maximum fuel cladding temperatures for the FANP9 9x9-2 fuel assembly do not exceed the allowable temperatures from ISG-11 for all storage and transfer operations. Therefore, the inclusion of the FANP9 9x9-2 fuel assembly in the authorized contents of the NUHOMS®-61BT DSC satisfies both the requirements of ISG-11, Revision 3 and this chapter.

All of the design parameters for the design basis fuel assembly used in this chapter (e.g., heat load per assembly, temperatures, and pressures) bound the FANP9 9x9-2 fuel assembly. As a result, all of the thermal evaluation results reported in this chapter are bounding for the FANP9 9x9-2 fuel assembly. In addition, the FANP9 9x9-2 fuel assembly results also meet the guidance provided in ISG-11, Revision 3 [4.15].

K.4.9 References

4.1 Levy et. al., Recommended Temperature Limits for Dry Storage of Spent Light Water Reactor Zircaloy - Clad Fuel Rods in Inert Gas, Pacific Northwest Laboratory, PNL-6189, 1987.

4.2 Rohsenow et. al., Handbook of Heat Transfer Fundamentals, McGraw-Hill Publishing, New York 1985.

4.3 American Society for Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section II, Part D, 1998 Edition Including 1999 Addenda.

4.4 Scoping Design Analyses for Optimized Shipping Casks Containing 1-, 2-, 3-, 5-, 7-, or 10-Year Old PWR Spent Fuel, J. A. Bucholz, ORNL/CSD/TM-149, TTC-9316, January 1983.

4.5 ANSYS, Inc., ANSYS Engineering Analysis System User's Manual for ANSYS Revision 5.6, Houston, PA.

4.6 Standard Review Plan for Dry Cask Storage Systems, NUREG-1536, Nuclear Regulatory Commission.

4.7 Transnuclear, Inc., TN-68 Dry Storage Cask Final Safety Analysis Report, Revision 0, Hawthorne, NY, 2000 (Docket No. 72-1027).

4.8 Transnuclear West, Final Safety Analysis Report for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel, NUH-003 Revision 5, NUH003.0103, Fremont, CA, August 2000.

4.9 Johnson et. al., Technical Basis for Storage of Zircaloy-Clad Spent Fuel in Inert Gases, PNL-4835, Pacific Northwest Laboratory, 1983.

4.10 Consolidated Safety Analysis Report for IF-300 Shipping Cask, CoC 9001.

4.11 Calculation, "TN-24P Benchmarking Analysis Using ANSYS," Transnuclear Calculation No. NUH32PT.0408, Revision 0.

4.12 J. M. Greer, et al, "The TN-24 PWR Spent Fuel Storage Cask: Testing and Analyses," PNL Report No. PNL-6054, Pacific Northwest Laboratory, 1987.

4.13 Application for Amendment No. 5 to the NUHOMS® Certificate of Compliance No. 1004 (TAC No. L23343, Docket No. 72-1004); February 24, 2003.

4.14 NUREG/CR-0497, A Handbook of Material Properties for Use in the Analysis of Light Water Reactor Fuel Rod Behavior, MATPRO-version 11, Revision 2, EG&G Idaho, Inc., TREE-1280, August 1981.

4.15 Interim Staff Guidance (ISG) – 11, Revision 3, "Cladding Considerations for the Transportation and Storage of Spent Fuel," NRC Spent Fuel Project Office, dated November 17, 2003.

K.5.4A Evaluation of 61BT DSC with FANP9 9x9-2 Fuel Assemblies

The initial heavy metal content of the FANP9 9x9x-2 fuel assembly is 0.180 MTU per assembly while the shielding design basis fuel assembly is 0.198 MTU. In addition, the initial Co59 content from the four fuel assembly source regions (i.e., bottom, in-core, plenum and top) for the FANP9 9x9-2 is less than that of the shielding design basis fuel assembly. Therefore, the design basis radiation and thermal source terms for all burnup, initial enrichment and cooling lime combinations allowed to be stored in the NUHOMS®-61BT DSC remain bounding for the FANP9 9x9-2 fuel assembly. As a result, all of the dose rates reported in the tables in this section and dose rate limits reported in the Technical Specifications remain bounding for the FANP9 9x9-2 fuel assembly type.

Table K.5-1
Fuel Assembly Designs Considered

Manufacturer[1]	Array	Version	Active Fuel Length (in)	Number Fuel Rods per Assembly	Number Water Holes per Assembly	Fuel Loading (MTU)[2]
GE	7x7	GE1/GE2	144	49	NA	0.198
GE	7x7	GE3	144	49	NA	0.198
Exxon/ANF	7x7	ENC III-A	144	49	0	0.184
Exxon/ANF	7x7	ENC III[3]	144	48	1[4]	0.184
Exxon/ANF	8x8	ENC Va & Vb	144	60	4[4]	0.177
GE	8x8	GE4	146	63	1	0.188
GE	8x8	GE5	150	62	2	0.186
GE	8x8	GE-Pres	150	62	2	0.186
GE	8x8	GE-Barrier	150	62	2	0.186
GE	8x8	GE8 Type I	150	62	2	0.186
GE	8x8	GE8 Type II	150	60	1	0.183
GE	8x8	GE9	150	60	1	0.184
GE	8x8	GE10	150	60	1	0.184
GE	9x9	GE11	146-Full 90-Partial	66-Full 8-Partial	2	0.177
GE	9x9	GE13	146-Full 90-Partial	66-Full 8-Partial	2	0.177
Framatome	9x9	FANP9 9x9-2	150	79-Full 0-Partial	2	0.180
GE	10x10	GE12	150-Full 93-Partial	78-Full 14-Partial	2	0.187

(1) Or equivalent reload fuel that is enveloped by the fuel assembly design characteristics listed in this table.
(2) Fissile Material is limited to UO2.
(3) Includes ENC III-E and ENC III-F.
(4) Solid Zirc Rod(s)

- only 90% credit for poison plates made of a Boron-Aluminum alloy or Boralyn® and 75% credit for poison plates made with Boral® or Metamic® is taken for the B10 content in the poison plates,
- maximum gaps between poison plates are modeled in their worst case configuration,
- the stainless steel basket rails which hold the basket together are modeled as water,
- Unit 84, and associated arrays and units are added to model the "uncovered" row of fuel above the poison plates.

In all other respects, the model is the same as that described in Sections K.6.3.1 and K.6.3.2. The model is more fully discussed in Section K.6.6.3.

A typical input file is included in Section K.6.6.3. The results of these calculations are listed in Table K.6-8 and Table K.6-9.

D. Evaluation of 61BT with FANP9 9x9-2 Fuel Assemblies

Section K.6.4.2A documents the determination of the most reactive fuel lattice, which is used for the remainder of the criticality evaluation for the NUHOMS®-61BT DSC to demonstrate criticality safety for the system with all of its authorized contents. Additional analysis identical to that documented in Section K.6.4.2A was performed to demonstrate that the criticality design basis fuel assembly bounds the FANP9 9x9-2 fuel assembly. Using the same models (except the fuel assembly is replaced with the FANP9 9x9-2 assembly) the calculated reactivity for the FANP9 9x9-2 assembly without a fuel channel and with a 0.065, 0.080 and 0.120 inch-thick fuel channels were evaluated. The results of the calculations are provided in the table below. The evaluation was performed using the same CSAS25 control module of the SCALE4.4 computer code, with 44 Group ENDF-V cross section library.

As demonstrated in the table, the design basis fuel assembly for criticality remains bounding. Therefore, all of the results of the criticality evaluation presented in this chapter remain bounding for the FANP9 9x9-2 fuel assembly. The CSAS25 input file for the FANP9 9x9-2 criticality evaluation is listed in Section K.6.6.5.

K.6.4.3 Criticality Results

Table K.6-10 lists the results that bound all loading, transfer, and storage normal and off-normal conditions. These criticality calculations were performed with CSAS25 of SCALE-4.4. For each case, the result includes (1) the KENO-calculated k_{KENO}; (2) the one sigma uncertainty σ_{KENO}; and (3) the final k_{eff}, which is equal to $k_{KENO} + 2\sigma_{KENO}$. As stated before, the NUHOMS®-61BT system can transfer and store up to 16 damaged and 45 (or more) undamaged BWR fuel assemblies listed in Table K.6-3. Table K.6-10 lists the minimum poison plate B10 loading required as a function of fuel lattice average initial enrichment for intact assemblies and maximum pellet enrichment in the case of damaged fuel.

The criterion for subcriticality is that

$$k_{KENO} + 2\sigma_{KENO} < USL,$$

where USL is the upper subcritical limit established by an analysis of benchmark criticality experiments. From Section 6.5, the minimum USL over the parameter range (in this case, pitch) is 0.9414. From Table K.6-10 for the most reactive case,

$$k_{KENO} + 2\sigma_{KENO} = 0.9340 + 2\ (0.0012) = 0.9364 < 0.9414.$$

K.6.6.5 Input File for Criticality Analysis of FANP9 9x9-2

```
=csas25
61B Most Reactive Fuel Analysis with FANP 9x9, Prakash 02/2005
44groupndf5 latticecell
uo2    1 0.95 293 92235 4.4 92238 95.6 end
zirc2  2 1.0  293 end
h2o    3 1.0  293 end
carbonsteel 4 1.0 293 end
ss304  5 1.0  293 end
h2o    6 1.0  293 end
h2o    7 1.0  293 end
b-10   8 den=0.046 1.0 293 end
al     8 0.9  293 end
end comp
squarepitch 1.45288 0.90551 1 3 1.07696 2 0.92456 6 end
NUH61BTH Most Reactive - FANP 9x9 No channel
read param
gen=500 npg=1000 nsk=5 nub=yes run=yes plt=yes
end param
read geom
unit 1     com='Fuel Rod'
cylinder  1   1  0.452755     381.0         0.0
cylinder  6   1  0.46228      381.0         0.0
cylinder  2   1  0.53848      381.0         0.0
cuboid    3   1  4p0.72644    381.0         0.0
unit 2     com='FANP 9x9 Center Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  4p8.3566     381.0         0.0
unit 3     com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  7.9629 -8.3566 2p8.3566      381.0          0.0
unit 4     com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  8.3566 -7.9629 2p8.3566      381.0          0.0
unit 5     com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  4p8.3566     381.0         0.0
unit 6     com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  8.3566 -7.9629 2p8.3566      381.0          0.0
unit 7     com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  7.9629 -8.3566 2p8.3566      381.0          0.0
```

```
unit 8     com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62      381.0        0.0
cuboid    5   1  4p7.9629    381.0        0.0
cuboid    8   1  4p8.3566    381.0        0.0
unit 9     com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62      381.0        0.0
cuboid    5   1  4p7.9629    381.0        0.0
cuboid    8   1  2p8.3566      7.9629 -8.3566 381.0          0.0
unit 10    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62      381.0        0.0
cuboid    5   1  4p7.9629    381.0        0.0
cuboid    8   1  7.9629 -8.3566 7.9629 -8.3566 381.0          0.0
unit 11    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62      381.0        0.0
cuboid    5   1  4p7.9629    381.0        0.0
cuboid    8   1  8.3566 -7.9629 7.9629 -8.3566 381.0          0.0
unit 12    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62      381.0        0.0
cuboid    5   1  4p7.9629    381.0        0.0
cuboid    8   1  4p8.3566    381.0        0.0
unit 13    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62      381.0        0.0
cuboid    5   1  4p7.9629    381.0        0.0
cuboid    8   1  2p8.3566 8.3566 -7.9629      381.0          0.0
unit 14    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62      381.0        0.0
cuboid    5   1  4p7.9629    381.0        0.0
cuboid    8   1  7.9629 -8.3566 8.3566 -7.9629 381.0          0.0
unit 15    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62      381.0        0.0
cuboid    5   1  4p7.9629    381.0        0.0
cuboid    8   1  7.9629 -8.3566 2p8.3566      381.0          0.0
unit 16    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62      381.0        0.0
cuboid    5   1  4p7.9629    381.0        0.0
cuboid    8   1  8.3566 -7.9629 8.3566 -7.9629 381.0          0.0
unit 17    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62      381.0        0.0
cuboid    5   1  4p7.9629    381.0        0.0
cuboid    8   1  8.3566 -7.9629 2p8.3566      381.0          0.0
unit 18    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62      381.0        0.0
cuboid    5   1  4p7.9629    381.0        0.0
cuboid    8   1  8.3566 -7.9629 8.3566 -7.9629 381.0          0.0
unit 19    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
```

```
cuboid    3   1  4p7.62        381.0         0.0
cuboid    5   1  4p7.9629      381.0         0.0
cuboid    8   1  2p8.3566 8.3566 -7.9629        381.0           0.0
unit 20    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0         0.0
cuboid    5   1  4p7.9629      381.0         0.0
cuboid    8   1  7.9629 -8.3566 8.3566 -7.9629 381.0           0.0
unit 21    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0         0.0
cuboid    5   1  4p7.9629      381.0         0.0
cuboid    8   1  8.3566 -7.9629 2p8.3566        381.0           0.0
unit 22    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0         0.0
cuboid    5   1  4p7.9629      381.0         0.0
cuboid    8   1  4p8.3566      381.0         0.0
unit 23    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0         0.0
cuboid    5   1  4p7.9629      381.0         0.0
cuboid    8   1  7.9629 -8.3566 2p8.3566        381.0           0.0
unit 24    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0         0.0
cuboid    5   1  4p7.9629      381.0         0.0
cuboid    8   1  8.3566 -7.9629 7.9629 -8.3566 381.0           0.0
unit 25    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0         0.0
cuboid    5   1  4p7.9629      381.0         0.0
cuboid    8   1  2p8.3566        7.9629 -8.3566 381.0           0.0
unit 26    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0         0.0
cuboid    5   1  4p7.9629      381.0         0.0
cuboid    8   1  7.9629 -8.3566 7.9629 -8.3566 381.0           0.0
unit 27    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0         0.0
cuboid    5   1  4p7.9629      381.0         0.0
cuboid    8   1  8.3566 -7.9629 8.3566 -7.9629 381.0           0.0
unit 28    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0         0.0
cuboid    5   1  4p7.9629      381.0         0.0
cuboid    8   1  2p8.3566 8.3566 -7.9629        381.0           0.0
unit 29    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0         0.0
cuboid    5   1  4p7.9629      381.0         0.0
cuboid    8   1  7.9629 -8.3566 8.3566 -7.9629 381.0           0.0
unit 30    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0         0.0
cuboid    5   1  4p7.9629      381.0         0.0
```

```
cuboid    8   1  8.3566 -7.9629 7.9629 -8.3566 381.0          0.0
unit 31    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  2p8.3566       7.9629 -8.3566 381.0          0.0
unit 32    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  7.9629 -8.3566 7.9629 -8.3566 381.0          0.0
unit 33    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  8.3566 -7.9629 8.3566 -7.9629 381.0          0.0
unit 34    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  2p8.3566 8.3566 -7.9629       381.0          0.0
unit 35    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  7.9629 -8.3566 8.3566 -7.9629 381.0          0.0
unit 36    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  8.3566 -7.9629 7.9629 -8.3566 381.0          0.0
unit 37    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  2p8.3566       7.9629 -8.3566 381.0          0.0
unit 38    com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9629     381.0         0.0
cuboid    8   1  7.9629 -8.3566 7.9629 -8.3566 381.0          0.0
unit 39   com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9248     381.0         0.0
cuboid    8   1  8.3185 -7.9248 8.3185 -7.9248 381.0          0.0
unit 40  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9248     381.0         0.0
cuboid    8   1  7.9248 -8.3185 8.3185 -7.9248 381.0          0.0
unit 41  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0         0.0
cuboid    5   1  4p7.9248     381.0         0.0
cuboid    8   1  8.3185 -7.9248 7.9248 -8.3185 381.0          0.0
unit 42  com='FANP 9x9 Assembly'
```

```
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
cuboid    8   1  7.9248 -8.3185 7.9248 -8.3185 381.0         0.0
unit 43   com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
cuboid    8   1  8.3185 -7.9248 8.3185 -7.9248 381.0         0.0
unit 44  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
cuboid    8   1  7.9248 -8.3185 8.3185 -7.9248 381.0         0.0
unit 45  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
cuboid    8   1  8.3185 -7.9248 7.9248 -8.3185 381.0         0.0
unit 46  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
cuboid    8   1  7.9248 -8.3185 7.9248 -8.3185 381.0         0.0
unit 47   com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
cuboid    8   1  8.3185 -7.9248 8.3185 -7.9248 381.0         0.0
unit 48  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
cuboid    8   1  7.9248 -8.3185 8.3185 -7.9248 381.0         0.0
unit 49  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
cuboid    8   1  8.3185 -7.9248 7.9248 -8.3185 381.0         0.0
unit 50  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
cuboid    8   1  7.9248 -8.3185 7.9248 -8.3185 381.0         0.0
unit 51   com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
cuboid    8   1  8.3185 -7.9248 8.3185 -7.9248 381.0         0.0
unit 52  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
cuboid    5   1  4p7.9248      381.0          0.0
cuboid    8   1  7.9248 -8.3185 8.3185 -7.9248 381.0         0.0
unit 53  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62        381.0          0.0
```

```
cuboid    5   1  4p7.9248     381.0          0.0
cuboid    8   1  8.3185 -7.9248 7.9248 -8.3185 381.0          0.0
unit 54  com='FANP 9x9 Assembly'
array 1 -6.53796 -6.53796 0.0
cuboid    3   1  4p7.62       381.0          0.0
cuboid    5   1  4p7.9248     381.0          0.0
cuboid    8   1  7.9248 -8.3185 7.9248 -8.3185 381.0          0.0
unit 55  com='center 9x9 array'
array 2 -24.6761 -24.6761 0.0
cuboid    5   1  4p24.9428    381.0          0.0
cuboid    8   1  4p25.7302    381.0          0.0
unit 56  com='right 9x9 array'
array 3 -24.6761 -24.6761 0.0
cuboid    5   1  4p24.9428    381.0          0.0
unit 57  com='top 9x9 array'
array 4 -24.6761 -24.6761 0.0
cuboid    5   1  4p24.9428    381.0          0.0
unit 58  com='left 9x9 array'
array 5 -24.6761 -24.6761 0.0
cuboid    5   1  4p24.9428    381.0          0.0
unit 59  com='bottom 9x9 array'
array 6 -24.6761 -24.6761 0.0
cuboid    5   1  4p24.9428    381.0          0.0
unit 60  com='upper right 2x2 array'
array 7 -16.2433 -16.2433 0.0
cuboid    5   1  4p16.51      381.0          0.0
unit 61  com='upper left 2x2 array'
array 8 -16.2433 -16.2433 0.0
cuboid    5   1  4p16.51      381.0          0.0
unit 62  com='lower right 2x2 array'
array 9 -16.2433 -16.2433 0.0
cuboid    5   1  4p16.51      381.0          0.0
unit 63  com='lower right 2x2 array'
array 10 -16.2433 -16.2433 0.0
cuboid    5   1  4p16.51      381.0          0.0
unit 64  com='0.31" poison plate'
cuboid    8   1  2p16.51 2p0.3937 381.0     0.0
unit 65  com='0.31" poison plate'
cuboid    8   1  2p0.3937 2p16.51 381.0     0.0
unit 66  com='water rod'
cylinder  3  1  0.46228   381.0     0.0
cylinder  2  1  0.53975   381.0     0.0
cuboid    3  1  4P0.72644 381.0     0.0
global unit 67
cylinder  3   1  84.757       381.0          0.0
    hole 55   0.0       0.0      0.0
    hole 56   50.673    0.0      0.0
    hole 57   0.0       50.673   0.0
    hole 58  -50.673    0.0      0.0
    hole 59   0.0      -50.673   0.0
    hole 60   42.2404  42.2404 0.0
    hole 61  -42.2404  42.2404 0.0
    hole 62  -42.2404 -42.2404 0.0
    hole 63   42.2404 -42.2404 0.0
    hole 64   42.2404  25.3366 0.0
    hole 64  -42.2404  25.3366 0.0
    hole 64  -42.2404 -25.3366 0.0
```

```
    hole 64   42.2404 -25.3366 0.0
    hole 65   25.3366  42.2404 0.0
    hole 65  -25.3366  42.2404 0.0
    hole 65  -25.3366 -42.2404 0.0
    hole 65   25.3366 -42.2404 0.0
cylinder  5   1  86.027       381.0          0.0
cuboid    7   1  4p86.03      381.0          0.0
end FANPom
read array
   com='FANP 9x9 fuel assembly slice, sd, fuel regions'
   ara=1       nux=9       nuy=9       nuz=1
   fill
        1  1  1  1  1  1  1  1  1
        1  1  1  1  1  1  1  1  1
        1  1  1  1  1  1  1  1  1
        1  1  1  1  1  1  1  1  1
        1  1  1  1 66  1  1  1  1
        1  1  1 66  1  1  1  1  1
        1  1  1  1  1  1  1  1  1
        1  1  1  1  1  1  1  1  1
        1  1  1  1  1  1  1  1  1
   end fill
   com='Center 9x9 Array of Fuel'
   ara=2       nux=3       nuy=3       nuz=1
   fill
        18 19 20
         6  2  3
        11  9 10
   end fill
   com='Right 9x9 Array of Fuel'
   ara=3       nux=3       nuy=3       nuz=1
   fill
        27 28 29
         4  5  3
        30 31 32
   end fill
   com='Top 9x9 Array of Fuel'
   ara=4       nux=3       nuy=3       nuz=1
   fill
        16 13 14
        17 12 15
        11  9 10
   end fill
   com='Left 9x9 Array of Fuel'
   ara=5       nux=3       nuy=3       nuz=1
   fill
        33 34 35
         6  8  7
        36 37 38
   end fill
   com='Bottom 9x9 Array of Fuel'
   ara=6       nux=3       nuy=3       nuz=1
   fill
        18 19 20
        21 22 23
        24 25 26
   end fill
```

```
   com='Upper Right 2x2 Array of Fuel'
   ara=7      nux=2      nuy=2      nuz=1
   fill
        39 40
        41 42
   end fill
   com='Upper Left 2x2 Array of Fuel'
   ara=8      nux=2      nuy=2      nuz=1
   fill
        43 44
        45 46
   end fill
   com='Lower Left 2x2 Array of Fuel'
   ara=9      nux=2      nuy=2      nuz=1
   fill
        47 48
        49 50
   end fill
   com='Lower Right 2x2 Array of Fuel'
   ara=10     nux=2      nuy=2      nuz=1
   fill
        51 52
        53 54
   end fill
end array
read bounds
   xyf=specular
   zfc=water
end bounds
read plot
   ttl='cask material plot  - plan view'
   pic=mat
   nch=' fzmcsblxg'
   xul=-87   yul=87    zul=200
   xlr=87    ylr=-87   zlr=200
   uax=1.0    vdn=-1.0
   nax=650
end plot
end data
end
```

Table K.6-2
Authorized Contents for NUHOMS®-61BT System

Assembly Type (1)	Array
Intact Fuel	
General Electric 7x7 /GE1	7x7
General Electric 7x7 /GE2	7x7
General Electric 7x7 /GE3	7x7
Exxon/ANF 7x7 /ENC III-A	7x7
Exxon/ANF 7x7 /ENC III(2)	7x7
General Electric 8x8 /GE4	8x8
General Electric 8x8 /GE5	8x8
General Electric 8x8 /GE-Pres	8x8
General Electric 8x8 /GE-Barrier	8x8
General Electric 8x8 /GE8 Type I	8x8
General Electric 8x8 /GE8 Type II	8x8
General Electric 8x8 /GE9	8x8
General Electric 8x8 /GE10	8x8
Exxon/ANF 8x8 /ENC Va and Vb	8x8
General Electric 9x9 /GE11	9x9
General Electric 9x9 /GE13	9x9
Framatome ANP 9x9/FANP9 9x9-2	9x9
General Electric 10x10 /GE12	10x10
Damaged Fuel with up to 7 damaged rods per assembly	
General Electric 7x7 /GE1	7x7
General Electric 7x7 /GE2	7x7
General Electric 7x7 /GE3	7x7
Exxon/ANF 7x7 /ENC III-A	7x7
Exxon/ANF 7x7 /ENC III(2)	7x7
General Electric 8x8 /GE4	8x8
General Electric 8x8 /GE5	8x8
General Electric 8x8 /GE-Pres	8x8
General Electric 8x8 /GE-Barrier	8x8
General Electric 8x8 /GE8 Type I	8x8
General Electric 8x8 /GE8 Type II	8x8
General Electric 8x8 /GE9	8x8
General Electric 8x8 /GE10	8x8
Exxon/ANF 8x8 /ENC Va and Vb	8x8

(1) Reload fuel from other manufacturers with the same parameters as those listed in Table K.6-3 are also considered as authorized contents.

(2) Includes ENC III-E and ENC III-F.

Table K.6-3
Parameters for BWR Assemblies

Manufacturer(1)	Array	Version	Active Fuel Length (in)	Number Fuel Rods per Assembly	Pitch (in)	Fuel Pellet OD (in)	Clad Thickness (in)	Clad OD (in)	Water Rod OD (in)	Water Rod ID (in)
GE	7x7	GE1	144	49	0.738	0.488	0.0355	0.570	NA	NA
GE	7x7	GE2	144	49	0.738	0.487	0.032	0.563	NA	NA
GE	7x7	GE3	144	49	0.738	0.487	0.032	0.563	NA	NA
Exxon/ANF	7x7	ENC III-A	144	49	0.738	(2)	0.0355(4)	0.570	NA	NA
Exxon/ANF	7x7	ENC III	144	48	0.738	(3)	0.0355(4)	0.570	0.572(5)	NA
GE	8x8	GE4	146	63	0.640	0.416	0.034	0.493	0.591	0.531
GE	8x8	GE5	150	62	0.640	0.410	0.032	0.483	0.591	0.531
GE	8x8	GE-Pres	150	62	0.640	0.410	0.032	0.483	0.591	0.531
GE	8x8	GE-Barrier	150	62	0.640	0.410	0.032	0.483	0.591	0.531
GE	8x8	GE8 Type I	150	62	0.640	0.410	0.032	0.483	0.591	0.531
GE	8x8	GE8 Type II	150	60	0.640	0.411	0.032	0.483	2@0.0591 2@0.0483	2@0.531 2@0.4312
GE	8x8	GE9	150	60	0.640	0.411	0.032	0.483	1.34	1.26
GE	8x8	GE10	150	60	0.640	0.411	0.032	0.483	1.34	1.26
Exxon/ANF	8x8	ENC Va and Vb	144	60	0.642	0.4195	0.036	0.5015	0.5015(5)	NA
GE	9x9	GE11	146-Full 90-Partial	66-Full 8-Partial	0.566	0.376	0.028	0.440	0.98	0.92
GE	9x9	GE13	146-Full 90-Partial	66-Full 8-Partial	0.566	0.376	0.028	0.440	0.98	0.92
Framatome	9x9	FANP9 9x9-2	150	79	0.572	0.3565	0.030	0.424	0.425	0.364
GE	10x10	GE12	150-Full 93-Partial	78-Full 14-Partial	0.510	0.345	0.026	0.404	0.98	0.92

(1) Reload fuel from other manufacturers with these parameters are also acceptable.
(2) Variable Fuel Pellet OD – evaluated from 0.468 to 0.488 in same assembly
(3) Variable Fuel Pellet OD – evaluated from 0.468 to 0.491 in same assembly.
(4) Variable Fuel Clad Thickness from 0.0355 to 0.0455 in – Thinnest clad thickness listed and conservatively used in the analysis.
(5) Solid Zirc rod(s)

Table K.6-6
Most Reactive Fuel Type

(Continued)

Manufacturer	Array	Version	k_{KENO}	1σ	k_{eff}
FANP	9x9	FANP 9	0.9072	0.0015	0.9102
FANP	9x9 0.120 channel	FANP 9	0.9066	0.0013	0.9092
FANP	9x9 0.080 channel	FANP 9	0.9074	0.0013	0.9100
FANP	9x9 0.065 channel	FANP 9	0.9065	0.0011	0.9087
GE	10x10	GE12	0.9095	0.0013	0.9121
GE	10x10 0.120 channel	GE12	0.9094	0.0010	0.9114
GE	10x10 0.080 channel	GE12	0.9092	0.0013	0.9118
GE	10x10 0.065 channel	GE12	0.9076	0.0011	0.9098
GE	7x7 w/variable enrichment	GE2, GE3	0.8947	0.0012	0.8971
GE	8x8 w/variable enrichment	GE5	0.8951	0.0011	0.8973
GE	8x8 w/variable enrichment	GE9	0.9008	0.0013	0.9034

(1) Small Fuel Pellet (0.468") OD (Note Large Pellet (0.488") OD identical to GE1 analysis)
(2) Small Fuel Pellet (0.468") OD
(3) Large Fuel Pellet (0.491") OD

9. Inspect the trunnions to insure that they are properly seated onto the skid and install the trunnion tower closure plates.

10. Fill the neutron shield.

11. Remove the bottom ram access cover plate from the cask. Install the two-piece temporary neutron/gamma shield plug to cover the bottom ram access. Install the ram trunnion support frame on the bottom of the transfer cask. (The temporary shield plug and ram trunnion support frame are not required with integral ram/trailer.)

K.8.1.6 <u>DSC Transfer to the HSM</u>

1. Prior to transporting the cask to the ISFSI or prior to positioning the transfer cask at the HSM designated for storage, remove the HSM door, inspect the cavity of the HSM, removing any debris and ready the HSM to receive a DSC. The doors on adjacent HSMs should remain in place.

   Caution: The insides of empty modules have the potential for high dose rates due to adjacent loaded modules. Proper ALARA practices should be followed for operations inside these modules and in the areas outside these modules whenever the door from the empty HSM has been removed.

2. Inspect the HSM air inlet and outlets to ensure that they are clear of debris. Inspect the screens on the air inlet and outlets for damage.

   CAUTION: Verify that the requirements of Technical Specification 1.2.14, "TC/DSC Transfer Operations at High Ambient Temperatures" are met prior to next step.

3. Using a suitable heavy haul tractor, transport the cask from the plant's fuel/reactor building to the ISFSI along the designated transfer route.

4. Once at the ISFSI, position the transport trailer to within a few feet of the HSM.

5. Check the position of the trailer to ensure the centerline of the HSM and cask approximately coincide. If the trailer is not properly oriented, reposition the trailer, as necessary.

6. Unbolt and remove the cask top cover plate.

7. Back the cask to within a few inches of the HSM, set the trailer brakes and disengage the tractor. Drive the tractor clear of the trailer. Extend the transfer trailer vertical jacks.

8. Connect the skid positioning system hydraulic power unit to the positioning system via the hose connector panel on the trailer, and power it up. Remove the skid tie-down bolts and use the skid positioning system to bring the cask into approximate vertical and horizontal alignment with the HSM. Using optical survey equipment and the alignment marks on the cask and the HSM, adjust the position of the cask until it is properly aligned with the HSM.

9. Using the skid positioning system, fully insert the cask into the HSM access opening docking collar.

10. Secure the cask trunnions to the front wall embedments of the HSM using the cask restraints.

11. After the cask is docked with the HSM, verify the alignment of the transfer cask using the optical survey equipment.

12. Position the hydraulic ram behind the cask in approximate horizontal alignment with the cask and level the ram. Remove either the bottom ram access cover plate or the outer plug of the two-piece temporary shield plug. Power up the ram hydraulic power supply and extend the ram through the bottom cask opening into the DSC grapple ring.

13. Activate the hydraulic cylinder on the ram grapple and engage the grapple arms with the DSC grapple ring.

14. Recheck all alignment marks in accordance with the Technical Specification 1.2.9 limits and ready all systems for DSC transfer.

15. Activate the hydraulic ram to initiate insertion of the DSC into the HSM. Stop the ram when the DSC reaches the support rail stops at the back of the module.

16. Disengage the ram grapple mechanism so that the grapple is retracted away from the DSC grapple ring.

17. Retract and disengage the hydraulic ram system from the cask and move it clear of the cask. Remove the cask restraints from the HSM.

18. Using the skid positioning system, disengage the cask from the HSM access opening. Insert the inner tube of the DSC axial retainer.

19. The trailer may be moved as necessary to install the HSM door. Install the HSM door and secure it in place.

20. Replace the transfer cask top cover plate. Secure the skid to the trailer, retract the vertical jacks and disconnect the skid positioning system.

21. Tow the trailer and cask to the designated equipment storage area. Return the remaining transfer equipment to the storage area.

22. Close and lock the ISFSI access gate and activate the ISFSI security measures.

K.8.1.7 Monitoring Operations

1. Perform routine security surveillance in accordance with the licensee's ISFSI security plan.

2. Perform a daily visual surveillance of the HSM air inlets and outlets to insure that no debris is obstructing the HSM vents in accordance with Technical Specification 1.3.1 requirements.
   OR
   Perform a temperature measurement of the thermal performance, for each HSM, on a daily basis in accordance with Technical Specification 1.3.2 requirements.

K.8.2 Procedures for Unloading the Cask

K.8.2.1 DSC Retrieval from the HSM

1. Ready the transfer cask, transport trailer, and support skid for service and tow the trailer to the HSM.

2. Back the trailer as close to the HSM as compatible with HSM door removal, and remove the cask top cover plate.

3. Remove the HSM door. Remove the inner tube of the DSC axial retainer.

4. Using the skid positioning system, align the cask with the HSM and position the skid until the cask is docked with the HSM access opening.

5. Using optical survey equipment, verify alignment of the cask with respect to the HSM. Install the cask restraints.

6. Install and align the hydraulic ram with the cask.

7. Extend the ram through the cask into the HSM until it is inserted in the DSC grapple ring.

8. Activate the arms on the ram grapple mechanism with the DSC grapple ring.

9. Retract ram and pull the DSC into the cask.

10. Retract the ram grapple arms.

11. Disengage the ram from the cask.

12. Remove the cask restraints.

13. Using the skid positioning system, disengage the cask from the HSM.

14. Install the cask top cover plate and ready the trailer for transport.

15. Replace the door on the HSM.

Point detectors are placed at the following locations as measured from each face of the "box": 6.095 m (20ft), 10 m, 20 m, 30 m, 40 m, 50 m, 60 m, 70 m, 80 m, 90 m, 100 m, 200 m, 300 m, 400 m, 500 m, and 600 m. Each point detector is placed 91.4 cm (3 feet) above the ground.

The MCNP results for each detector from the front of 2x10 back-to-back array are summarized in Table K.10-6. The MCNP results as a function of distance from the back of the two 1x10 front-to-front array are summarized in Table K.10-7. The MCNP results as a function of distance from the side of the 2x10 back-to-back array and the two 1x10 front-to-front arrays are summarized in Table K.10-8. The results from Table K.10-6, Table K.10-7 and Table K.10-8 are plotted in Figure K.10-1.

K. 10.2A Evaluation of 61BT DSC with FANP9 9x9-2 Fuel Assemblies

As addressed in the Shielding Evaluation discussion in Section K5.4A, the design basis source terms and calculated dose rates with the design basis fuel bound those for the FANP9 9x9-2 fuel. Therefore, the Occupational Exposure and Off-site dose evaluations presented in this chapter remain bounding.

highly unlikely. Any fire within the ISFSI boundary while the DSC is in the HSM would be bounded by the fire during transfer cask movement. The HSM concrete acts as a significant insulating fire wall to protect the 61BT-DSC from the high temperatures of the fire.

K.11.2.10.2 Accident Analysis

The evaluation of the hypothetical fire event is presented in Section K.4.6.5. The fire thermal evaluation is performed primarily to demonstrate the confinement integrity and fuel retrievability of the 61BT-DSC. This is assured by demonstrating that the DSC temperatures and internal pressures will not exceed those of the blocked vent condition (see Section K.11.2.7) during the fire scenario. Peak temperatures for the NUHOMS®-61BT system components are summarized in Table K.4-6.

K.11.2.10.3 Accident Dose Calculations

The 61BT-DSC confinement boundary will not be breached as a result of the postulated fire/explosion scenario. Accordingly, no 61BT-DSC damage or release of radioactivity is postulated. Because no radioactivity is released, no resultant dose increase is associated with this event.

The fire scenario may result in the loss of cask neutron shielding should the fire occur while the 61BT-DSC is in the cask. The effect of loss of the neutron shielding due to a fire is bounded by that resulting from a cask drop scenario. See Section K.11.2.5.3 for evaluation of the dose consequences of a cask drop.

K.11.2.10.4 Corrective Actions

Evaluation of HSM or cask neutron shield damage as a result of a fire is to be performed to assess the need for temporary shielding (for HSM or cask, if fire occurs during transfer operations) and repairs to restore the transfer cask and HSM to pre-fire design conditions.

K.11.2.11 Evaluation of 61BT DSC with FANP9 9x9-2 Fuel Assemblies

As addressed in the discussion for the Structural Evaluation (Section K.3.7A), Thermal Evaluation (Section K.4.8A), and Shielding Evaluation (Section K.5.4A) above, the critical parameters for these analyses with design basis fuel bound those for the FANP9 fuel. Therefore, the off-normal and accident analyses results presented in this chapter remain bounding.

LIST OF FIGURES

Page

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

ALL DIMENSIONS ARE NOMINAL UNLESS A SPECIFIC TOLERANCE IS INDICATED WITH THE DRAWING DIMENSION

DIMENSIONS ARE IN INCHES AND DEGREES UNLESS OTHERWISE SPECIFIED. DIMENSIONING IN ACCORDANCE WITH ASME Y14.5M

INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4

TRANSNUCLEAR
AN AREVA COMPANY

SAFETY ANALYSIS REPORT
NUHOMS® 32PT TRANSPORTABLE STORAGE CANISTER FOR PWR FUEL MAIN ASSEMBLY

DRAWING NO.	SCALE	SHEET	REVISION
NUH-32PT-1001-SAR	NONE	1 OF 3	4

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO. NUH-32PT-1001-SAR SHEET 2 OF 3

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO.	SHEET	REVISION
NUH-32PT-1001-SAR	3 OF 3	4

Table M.3.1-1
Alternatives to the ASME Code for the NUHOMS®-32PT DSC Confinement Boundary

Reference ASME Code Section/Article	Code Requirement	Alternatives, Justification & Compensatory Measures
NCA	All	Not compliant with NCA. TN Quality Assurance requirements, which are based on 10CFR72 Subpart G, are used in lieu of NCA-4000. Fabrication oversight is performed by TN and utility personnel in lieu of an Authorized Nuclear Inspector.
NB-1100	Requirements for Code Stamping of Components	The NUHOMS®-32PT DSC shell is designed & fabricated in accordance with the requirements of ASME Code, Section III, Subsection NB and the alternative provisions described in this table. However, Code Stamping is not required. As Code Stamping is not required, the fabricator is not required to hold an ASME "N" or "NPT" stamp, or to be ASME Certified.
NB-2130	Material must be supplied by ASME approved material suppliers.	Material is certified to meet all ASME Code criteria but is not eligible for certification or Code Stamping if a non-ASME fabricator is used. As the fabricator is not required to be ASME certified, material certification to NB-2130 is not possible. Material traceability & certification are maintained in accordance with TN's NRC approved QA program.
NB-4121	Material Certification by Certificate Holder	
NB-4243 and NB-5230	Category C weld joints in vessels and similar weld joints in other components shall be full penetration joints. These welds shall be examined by UT or RT and either PT or MT	The joints between the top outer and inner cover plates and containment shell are designed and fabricated per ASME Code Case N-595-2, which provides alternative requirements for the design and examination of spent fuel canister closures. This includes the inner top cover plate weld around the vent & siphon block and the vent and siphon block welds to the shell. The closure welds are partial penetration welds and the root and final layer are subject to PT examination (in lieu of volumetric examination) in accordance with the provisions of ASME Code Case N-595-2. The 32PT closure system employs austenitic stainless steel shell, lid materials, and welds. Because austenitic stainless steels are not subject to brittle failure at the operating temperatures of the DSC, crack propagation is not a concern. Thus, multi-level PT examination provides reasonable assurance that flaws of interest will be identified. The PT examination is done by qualified personnel, in accordance with Section V and the acceptance standards of Section III, Subsection NB-5000. This alternative does not apply to other shell confinement welds, i.e., the longitudinal and circumferential welds applied to the DSC shell, and the inner bottom cover plate-to-shell weld which comply with NB-4243 and NB-5230.

Table M.3.1-2
Alternatives to the ASME Code Exceptions for the NUHOMS®-32PT DSC Basket Assembly

Reference ASME Code Section/Article	Code Requirement	Alternatives, Exception, Justification & Compensatory Measures
NG-1100	Requirements for Code Stamping of Components	The NUHOMS®-32PT DSC baskets are designed & fabricated in accordance with the ASME Code, Section III, Subsection NG as described in the SAR, but Code Stamping is not required. As Code Stamping is not required, the fabricator is not required to hold an ASME N or NPT stamp or be ASME Certified.
NG-2000	Use of ASME Material	The poison material and aluminum plates are not used for structural analysis, but to provide criticality control and heat transfer. They are not ASME Code Class 1 material. Material properties in the ASME Code for Type 6061 aluminum are limited to 400°F to preclude the potential for annealing out the hardening properties. Annealed properties (as published by the Aluminum Association and the American Society of Metals) are conservatively assumed for the solid aluminum rails for use above the Code temperature limits.
NG-2130	Material must be supplied by ASME approved material suppliers.	Material is certified to meet all ASME Code criteria, but is not eligible for certification or Code Stamping if a non-ASME fabricator is used. As the fabricator is not required to be ASME certified, material certification to NG-2130 is not possible. Material traceability & certification are maintained in accordance with TN's NRC approved QA program.
NG-4121	Material Certification by Certificate Holder	
NG-8000	Requirements for nameplates, stamping & reports per NCA-8000	The NUHOMS®-32PT DSC nameplate provides the information required by 10CFR71, 49CFR173 and 10CFR72 as appropriate. Code stamping is not required for the NUHOMS®-32PT DSC. In lieu of Code stamping, QA Data packages are prepared in accordance with the requirements of 10CFR71, 10CFR72 and TN's approved QA program.
NCA	All	Not compliant with NCA as no Code stamp is used. TN Quality Assurance requirements, which are based on 10CFR72 Subpart G, are used in lieu of NCA-4000. Fabrication oversight is performed by TN and utility personnel in lieu of an Authorized Nuclear Inspector.
NG-3000/ Section II, Part D, Table 2A	Maximum temperature limit for XM-19 plate material is 800°F	Not compliant with ASME Section II Part D Table 2A material temperature limit for XM-19 steel for the postulated transfer accident case (117°F, loss of sunshade, loss of neutron shield). This is a post-drop accident scenario, where the calculated maximum steady state temperature is 852°F, the expected reduction in material strength is small (less than 1 ksi by extrapolation), and the only primary stresses in the basket grid are deadweight stresses. The recovery actions following the postulated drop accident are as described in Section 8.2.5 of the FSAR.

2000 ppm borated water. The behavior is only slightly different than 1100 series aluminum, hence, satisfactory long-term usage in these environments is expected. Neutron irradiation up to 10^{17} n/cm^2 level did not cause any measurable dimensional changes or any other damage to the material.

At high temperature, the borated aluminum still exhibits high corrosion resistance in the pure water environment. However, at temperatures of 80°C, in 2000 ppm borated water, local pitting corrosion has been observed. At 100°C and room temperature, the pitting attack was less than at 80°C. In all cases, passivation occurs limiting the pit depth.

From tests on pure aluminum, it was found that borated aluminum was more resistant to uniform corrosion attack than pure aluminum. Local pitting corrosion, can occur over time, causing localized damage to the borated aluminum.

There are no chemical, galvanic or other reactions that could reduce the areal density of boron in the 32PT-DSC neutron poison plates.

D. Electroless Nickel Plated Carbon Steel

The carbon steel top shield plug of the DSC is plated with electroless nickel. This coating is identical to the coating used on the NUHOMS®-52B DSC. It has been evaluated for potential galvanic reactions in Transnuclear West's response to NRC Bulletin 96-04 [3.7]. In PWR pools, the reported corrosion rates are insignificant and are expected to result in a negligible rate of reaction for the NUHOMS® PWR systems.

Lubricants and Cleaning Agents

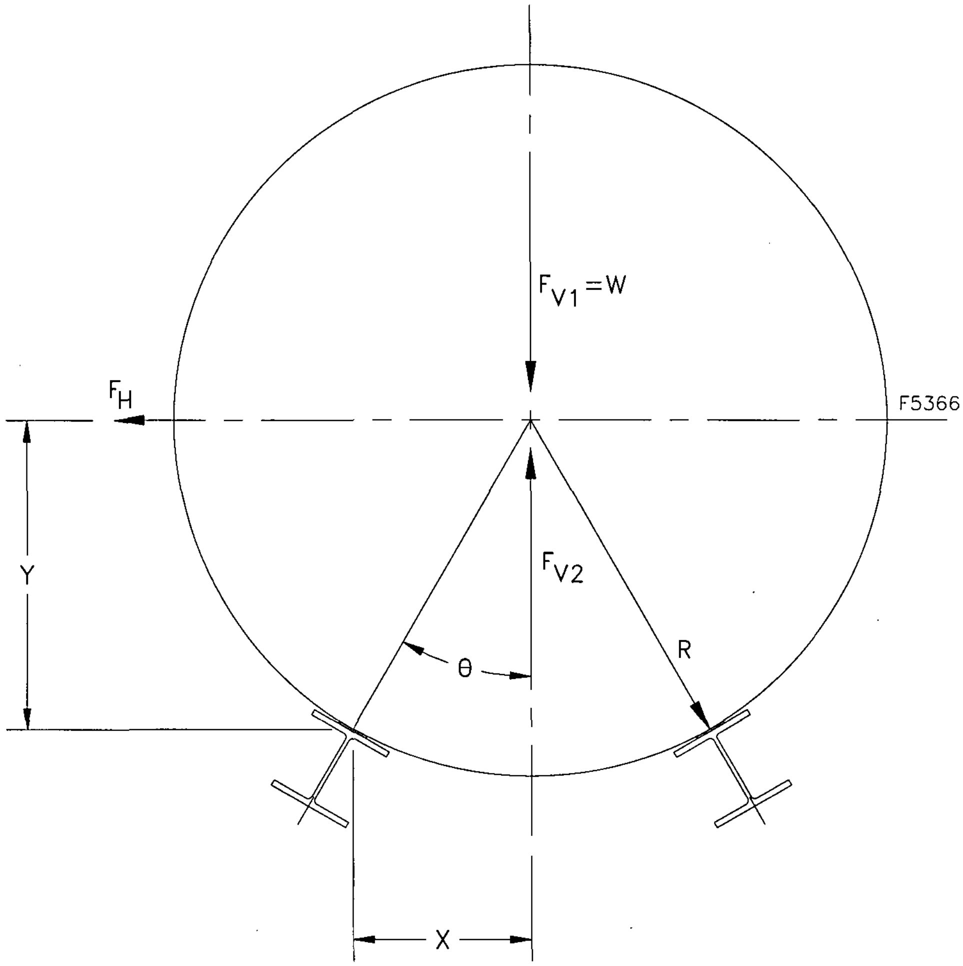
Lubricants and cleaning agents used on the NUHOMS®-32PT DSC should be selected for compatibility with the spent fuel pool water chemistry and the DSC materials. Never-seez or Neolube (or equivalent) may be used to coat threads. The lubricant should be selected for its ability to maintain lubricity under long term storage conditions.

The DSC is cleaned in accordance with approved procedures to remove cleaning residues prior to shipment to the storage site. The basket is also cleaned prior to installation in the DSC. The cleaning agents and lubricants have no significant affect on the DSC materials and their safety related functions.

Hydrogen Generation

During the initial passivation state, small amounts of hydrogen gas may be generated in the 32PT DSC. The passivation stage may occur prior to submersion of the TC into the spent fuel pool. Any amounts of hydrogen generated in the DSC will be insignificant and will not result in a flammable gas mixture within the DSC.

The small amount of hydrogen which may be generated during DSC operations does not result in a safety hazard. In order for concentrations of hydrogen in the cask to reach flammability



WHERE:

R = 33.595 in., DSC outer radius
θ = 30°
X = R Sin θ = 16.8 in.
Y = R Cos θ = 29.1 in.
F_{V1} = W = weight of DSC
F_{V2} = W(0.17g) = upward vertical seismic load
F_H = W(0.40g) = horizontal seismic load

Figure M.3.7-1
DSC Lift-Off Evaluation

Table M.6-3
Parameters For PWR Assemblies[3]

Manufacturer[1]	Array	Version	Active Fuel Length (in)	Number Fuel Rods per Assembly	Pitch (in)	Fuel Pellet OD (in)
WE	17x17	LOPAR	144	264	0.496	0.3225
WE	17x17	OFA/Van 5	144	264	0.496	0.3088
B&W	15x15	Mark B	141.8	208	0.568	0.3686
CE[4]	15x15	Palisades	132	216[4]	0.550	0.3580
Exxon/ANF	15x15	CE	131.8	216	0.550	0.3565
Exxon/ANF	15x15	WE	144	204	0.563	0.3565
WE	15x15	Std/ZC	144	204	0.563	0.3559
CE	14x14	Std/Gen	137	176	0.580	0.3765
CE	14x14	Ft. Calhoun	128	176	0.580	0.3815
Exxon/ANF	14x14	WE	142	179	0.556	0.3505
WE	14x14	ZCA/ZCB	144	179	0.556	0.3659
WE	14x14	OFA	144	179	0.556	0.3444

Manufacturer [1]	Array	Version	Clad Thickness (in)	Clad OD (in)	Guide Tube/ Instrument Tube	
					OD (in)	ID (in)
WE	17x17	LOPAR	0.0225	0.374	24@0.474 1@0.480	24@0.422 1@0.450
WE	17x17	OFA/Van 5	0.0225	0.360	24@0.482 1@0.476	24@0.450 1@0.460
B&W[5]	15x15	Mark B	0.0265	0.430	16@0.530 1@0.493	16@0.498 1@441
CE	15x15	Palisades	0.0260	0.418	8@0.4135	8@0.3655
Exxon/ANF	15x15	CE	0.0300	0.417	8 Guide Bars[2] 1@0.417	1@0.363
Exxon/ANF	15x15	WE	0.0300	0.424	20@0.544 1@0.544	20@0.510 1@0.510
WE	15x15	Std/ZC	0.0242	0.422	20@0.546 1@0.546	20@0.512 1@0.512
CE	14x14	Std/Gen	0.0280	0.440	5@1.115	5@1.035
CE	14x14	Ft. Calhoun	0.0280	0.440	5@1.115	5@1.035
Exxon/ANF	14x14	WE	0.0300	0.424	16@0.541 1@0.480	16@0.507 1@0.448
WE	14x14	ZCA/ZCB	0.0225	0.422	16@0.539 1@0.422	16@0.505 1@0.392
WE	14x14	OFA	0.0243	0.400	16@0.526 1@0.400	16@0.492 1@0.353

NOTES:
(1) Reload fuel from other manufacturers with these parameters are also acceptable.
(2) Guide Bars are solid Zircaloy-4 approximately 0.40 inches x 0.45 inches
(3) All dimensions shown are nominal
(4) CE 15x15 assemblies with 208 fuel rods and a stainless steel plugging cluster installed in each of the 8 guide tubes are also acceptable.
(5) Design details of sub-components like guide tube and instrument tube oversleeves are not important for criticality and are not provided.

M.8.1 Procedures for Loading the Cask

Process flow diagrams for the NUHOMS® System operation are presented Figure M.8-1 and Figure M.8-2. The location of the various operations may vary with individual plant requirements. The following steps describe the recommended generic operating procedures for the standardized NUHOMS® System.

M.8.1.1 Preparation of the TC and DSC

1. Prior to placement in dry storage, the candidate intact fuel assemblies shall be evaluated (by plant records or other means) to verify that they meet the physical, thermal and radiological criteria specified in Technical Specification. Depending on the length of the fuel assemblies to be loaded, fuel spacers may be placed within the DSC to reduce the fuel assembly/DSC cavity gap in consideration of Part 71requirements. There are no requirements for fuel spacers under Part 72. Fuel spacers, if used, may be placed below the assembly, above the assembly, or both, and shall be evaluated for any adverse impact.

2. Prior to being placed in service, the TC is to be cleaned or decontaminated as necessary to insure a surface contamination level of less than those specified in Technical Specification 1.2.12.

3. Place the TC in the vertical position in the cask decon area using the cask handling crane and the TC lifting yoke.

4. Place scaffolding around the cask so that the top cover plate and surface of the cask are easily accessible to personnel.

5. Remove the TC top cover plate and examine the cask cavity for any physical damage and ready the cask for service. If loading 32PT-S100 or 32PT-L100 DSC (qualified for 100-ton crane capacity), drain neutron shield water from the TC.

6. Examine the DSC for any physical damage which might have occurred since the receipt inspection was performed. The DSC is to be cleaned and any loose debris removed.

7. Using a crane, lower the DSC into the cask cavity by the internal lifting lugs and rotate the DSC to match the cask and DSC alignment marks.

8. Fill the cask-DSC annulus with clean, demineralized water. Place the inflatable seal into the upper cask liner recess and seal the cask-DSC annulus by pressurizing the seal with compressed air.

9. Fill the DSC cavity with water from the fuel pool or an equivalent source which meets the requirements of Technical Specification 1.2.15a.

   NOTE: A TC/DSC annulus pressurization tank filled with demineralized water as described above is connected to the top vent port of the TC via a hose to provide a positive head above the level of water in the TC/DSC annulus. This is an optional arrangement,

8. Lower the cask onto the skid until the weight of the cask is distributed to the trunnion pillow blocks.

9. Inspect the trunnions to insure that they are properly seated onto the skid and install the trunnion tower closure plates.

10. Fill the neutron shield, if it was drained in step M.8.1.5.1.

11. Remove the bottom ram access cover plate from the cask. Install the two-piece temporary neutron/gamma shield plug to cover the bottom ram access. Install the ram trunnion support frame on the bottom of the TC. (The temporary shield plug and ram trunnion support frame are not required with integral ram/trailer.)

M.8.1.6 DSC Transfer to the HSM

1. Prior to transporting the cask to the ISFSI, remove the HSM door, inspect the cavity of the HSM, removing any debris and ready the HSM to receive a DSC. The doors on adjacent HSMs should remain in place.

   Caution: The insides of empty modules have the potential for high dose rates due to adjacent loaded modules. Proper ALARA practices should be follower for operations inside these modules and in the areas outside these modules whenever the door from the empty HSM has been removed.

2. Inspect the HSM air inlet and outlets to ensure that they are clear of debris. Inspect the screens on the air inlet and outlets for damage.

   CAUTION: Verify that the requirements of Technical Specification 1.2.14, "TC/DSC Transfer Operations at High Ambient Temperatures" are met prior to next step.

3. Using a suitable heavy haul tractor, transport the cask from the plant's fuel/reactor building to the ISFSI along the designated transfer route.

4. Once at the ISFSI, position the transport trailer to within a few feet of the HSM.

5. Check the position of the trailer to ensure the centerline of the HSM and cask approximately coincide. If the trailer is not properly oriented, reposition the trailer, as necessary.

6. Unbolt and remove the cask top cover plate.

7. Back the cask to within a few inches of the HSM, set the trailer brakes and disengage the tractor. Drive the tractor clear of the trailer. Extend the transfer trailer vertical jacks.

8. Connect the skid positioning system hydraulic power unit to the positioning system via the hose connector panel on the trailer, and power it up. Remove the skid tie-down bracket fasteners and use the skid positioning system to bring the cask into approximate vertical and horizontal alignment with the HSM. Using optical survey equipment and the alignment marks on the cask and the HSM, adjust the position of the cask until it is properly aligned with the HSM.

9. Using the skid positioning system, fully insert the cask into the HSM access opening docking collar.

10. Secure the cask trunnions to the front wall embedments of the HSM using the cask restraints.

11. After the cask is docked with the HSM, verify the alignment of the TC using the optical survey equipment.

12. Position the hydraulic ram behind the cask in approximate horizontal alignment with the cask and level the ram. Remove either the bottom ram access cover plate or the outer plug of the two-piece temporary shield plug. Power up the ram hydraulic power supply and extend the ram through the bottom cask opening into the DSC grapple ring.

13. Activate the hydraulic cylinder on the ram grapple and engage the grapple arms with the DSC grapple ring.

14. Recheck all alignment marks in accordance with the Technical Specification 1.2.9 limits and ready all systems for DSC transfer.

15. Activate the hydraulic ram to initiate insertion of the DSC into the HSM. Stop the ram when the DSC reaches the support rail stops at the back of the module.

16. Disengage the ram grapple mechanism so that the grapple is retracted away from the DSC grapple ring.

17. Retract and disengage the hydraulic ram system from the cask and move it clear of the cask. Remove the cask restraints from the HSM.

18. Using the skid positioning system, disengage the cask from the HSM access opening.

19. Install the DSC axial retainer through the HSM door opening.

20. The trailer may be moved as necessary to install the HSM door. Install the HSM door and secure it in place. Door may be welded for security. Verify that the HSM dose rates are compliant with the limits specified in Technical Specification 1.2.7.

21. Replace the TC top cover plate. Secure the skid to the trailer, retract the vertical jacks and disconnect the skid positioning system.

22. Tow the trailer and cask to the designated equipment storage area. Return the remaining transfer equipment to the storage area.

23. Close and lock the ISFSI access gate and activate the ISFSI security measures.

M.8.1.7 Monitoring Operations

1. Perform routine security surveillance in accordance with the licensee's ISFSI security plan.

2. Perform a daily visual surveillance of the HSM air inlets and outlets to insure that no debris is obstructing the HSM vents in accordance with Technical Specification 1.3.1 requirements

OR

Perform a temperature measurement of the thermal performance, for each HSM, on a daily basis in accordance with Technical Specification 1.3.2 requirements.

M.8.2 Procedures for Unloading the Cask

M.8.2.1 DSC Retrieval from the HSM

1. Ready the TC, transport trailer, and support skid for service and tow the trailer to the HSM.
2. Back the trailer as close to the HSM as compatible with HSM door removal, and remove the cask top cover plate.
3. Cut any welds from the door and remove the HSM door. Remove the DSC drop-in retainer.
4. Using the skid positioning system align the cask with the HSM and position the skid until the cask is docked with the HSM access opening.
5. Using optical survey equipment, verify alignment of the cask with respect to the HSM. Install the cask restraints.
6. Install and align the hydraulic ram with the cask.
7. Extend the ram through the cask into the HSM until it is inserted in the DSC grapple ring.
8. Activate the arms on the ram grapple mechanism with the DSC grapple ring.
9. Retract ram and pull the DSC into the cask.
10. Retract the ram grapple arms.
11. Disengage the ram from the cask.
12. Remove the cask restraints.
13. Using the skid positioning system, disengage the cask from the HSM.
14. Install the cask top cover plate and ready the trailer for transport.
15. Replace the door on the HSM.

M.8.2.2 Removal of Fuel from the DSC

When the DSC has been removed from the HSM, there are several potential options for off-site shipment of the fuel. It is preferred to ship the DSC intact to a reprocessing facility, monitored retrievable storage facility or permanent geologic repository in a compatible shipping cask licensed under 10CFR71.

If it becomes necessary to remove fuel from the DSC prior to off-site shipment, there are two basic options available at the ISFSI or reactor site. The fuel assemblies could be removed and reloaded into a shipping cask using dry transfer techniques, or if the applicant so desires, the initial fuel loading sequence could be reversed and the plant's spent fuel pool utilized. Procedures for

N.2.1 Spent Fuel to be Stored

There are two design configurations for the NUHOMS®-24PHB DSC: the 24PHBS and 24PHBL, which are nearly identical to the standard and long cavity 24P DSCs, respectively. Each of the DSC configurations is designed to store 24 intact PWR fuel assemblies, including reconstituted assemblies with characteristics described in Table N.2-1. The 24PHBL DSC is designed to store 24 intact B&W 15x15, WE 17x17, WE 15x15, CE 14x14, and WE 14x14 Class PWR fuel assemblies. BPRAs are allowed only in the B&W 15x15 fuel assembly. Replacement assemblies by other manufacturers are also allowed provided they meet limiting features listed in Table N.2-1.

The NUHOMS®-24PHB DSC may store PWR fuel assemblies arranged in one of two alternate Heat Load Zoning Configurations with a maximum decay heat of 1.3 kW per assembly and a maximum heat load of 24 kW per DSC. The Heat Load Zoning Configurations are shown in Figure N.2-1 and Figure N.2-2. The NUHOMS®-24PHB DSC is vacuum dried and backfilled with helium at the time of loading. The maximum (bounding) fuel assembly weight of 1682 lbs with a BPRA is identical to the NUHOMS®-24P DSC design.

The maximum fuel cladding temperature limit of 400°C (752°F) is applicable to normal conditions of storage and all short term operations from spent fuel pool to ISFSI pad including vacuum drying and helium backfilling of the 24PHB DSC per Interim Staff Guidance (ISG) No. 11, Revision 2 [2.6]. In addition, ISG-11 does not permit thermal cycling of the fuel cladding with temperature differences greater than 65°C (117°F) during DSC drying, backfilling and transfer operations.

The maximum fuel cladding temperature limit of 570°C (1058°F) is applicable to accidents or off-normal thermal transients [2.6].

The information provided in Table N.2-1 is based on the design basis B&W 15x15 fuel which is the bounding fuel assembly. The types of spent fuel considered in Appendix N include the following:

- B&W 15x15 Mark B2, B3, B4, B4Z, B5, B5Z, B6, B7, B8, B9 and B10 fuel assemblies.
- B&W 15x15 reconstituted fuel assemblies with a maximum of 10 stainless steel rods per assembly or unlimited number of lower enrichment UO_2 rods instead of zircaloy clad enriched UO_2 rods. The stainless steel rods are assumed to have two thirds the irradiation time as the zircaloy rods of the assembly. The reconstituted UO_2 rods are assumed to have the same irradiation history as the entire fuel assembly. The reconstituted rods can be at any location in the fuel assemblies. The maximum number of reconstituted fuel assemblies per DSC is four.
- The standard BPRA design for the B&W 15x15 class assemblies is described in Appendix J and B&W 15x15 BPRAs with a different material composition (bounding values of 24.46 lbs. of poison, plus 28.17 Kgs of other materials, containing 9.15 grams of Co59) designated Mark-B BPRAs, for the NUHOMS®-24PHB system, are evaluated in this appendix.
- WE 17x17, WE 15x15, CE 14x14 and WE 14x14 fuel assemblies, all with no BPRAs.

Calculations are performed to determine the fuel assembly type which is most limiting for each of the analyses including shielding, criticality, heat load and confinement. Analyses performed

Therefore, the moles of fission gas released for normal, off-normal and accident conditions are tabulated below:

Case	Percentage of Rods Ruptured	Moles of Fission Gas Released
Normal	1	2.63
Off-Normal	10	26.3
Accident	100	263

N.4.4.4.2 Quantity of Gas in BPRAs

The NUHOMS®-24PHBL DSC may include Burnable Poison Rod Assemblies (BPRAs). The evaluation for the design basis B&W 15x15 BPRAs as authorized contents of the NUHOMS®-24P Long Cavity DSC is provided in Appendix J. Those results are reflected in the discussion which follows, along with results for B&W 15x15 BPRAs with a different material composition (bounding values of 24.46 lbs. of poison, plus 28.17 Kgs of other materials, containing 9.15 grams of Co59) designated Mark-B Bpras, for the NUHOMS®-24PHB system. 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 g-moles of gas could be released to the DSC assuming 100% cladding rupture as given in Appendix J.4.4 (59.1 g-moles for Mark-B BPRAs, when the ration of poison content (24.46/22.3 (from Appendix J)) is applied).

The higher (Mark-B BPRA) values are used in equations and results through the remainder of Section N.4.

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 24PHB DSC cavity from the BPRAs for normal, off-normal and accident conditions is tabulated below.

Case	Percentage of BPRA Rods Ruptured	Moles of Control Component Gas Released per DSC, 30% Pellet Release
Normal	1	0.591
Off-Normal	10	5.91
Accident	100	59.1

N.4.4.4.3 Helium Fill Gas within Fuel Rods

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 465.3 psig (480 psia) and the fill temperature is assumed to be room temperature (70°F or 530°R). The quantity of fuel rod fill gas in 24 assemblies is:

$$n_{plenum} = \frac{(480\,psia)(6894.8\,Pa/psi)(24 \cdot 208 \cdot 1.6\,in^3)(1.6387x10^{-5}\,m^3/in^3)}{(8.314\,J/mol \cdot K)(530\,°R)(5/9\,K/°R)}$$

$$n_{plenum} = 176.9\,g - moles$$

The maximum fraction of the fuel pins that are assumed to rupture and release their charge gas for normal, off-normal and accident events is 1, 10 and 100%, respectively [4.8]. The amount of helium fill gas released for each of these conditions is summarized below.

Case	Percentage of Rods Ruptured	Moles of Helium Charge Gas Released
Normal	1	1.77
Off-Normal	10	17.7
Accident	100	176.9

N.4.4.4.4 Initial Helium Fill Gas in the DSC

The amount of helium present within the DSC is calculated using the ideal gas law and a maximum initial helium fill pressure of 3.5 psig. The long term average helium fill temperature of 449°F (909°R) is used as the basis for the initial fill. Using the ideal gas law, the quantity of helium in the 24PHB DSC is then equal to:

$$n_{he} = \frac{(18.2\,psia)(6894.8\,Pa/psi)(384{,}463\,in^3)(1.6387x10^{-5}\,m^3/in^3)}{(8.314\,J/mol \cdot K)(909\,°R)(5/9\,K/°R)}$$

$$n_{he} = 188.3\,g - moles$$

N.4.4.4.5 Maximum Internal Pressures During Storage and Transfer

The maximum average cavity gas temperature during normal conditions of storage and transfer is bounded by the normal transfer condition. The maximum average helium temperature for that case is 563°F (1,023°R). With rupture of one percent of the fuel rods, the pressures within the 24PHB DSC are calculated via the ideal gas law:

$$n_{DSC-NOC} = n_{DSC-He} + 0.01 \cdot n_{pin-He} + 0.01 \cdot n_{fg} + 0.01 \cdot n_{BPRA}$$

$$n_{DSC-NOC} = 188 + 1.77 + 2.63 + 0.591 = 193\,g - moles$$

The maximum normal operating pressure is then,

$$P_{DSC-NOC} = nRT/V$$

$$P_{DSC-NOC} = \frac{\left(1.4504x10^{-4}\,\frac{psia}{Pa}\right)(193\,g - moles)(8.314\,J/mol \cdot K)(1{,}023\,°R)(5/9\,K/°R)}{(384{,}463\,in^3)(1.6387x10^{-5}\,m^3/in^3)}$$

$$P_{DSC-NOC} = 21\,psia\,(6.3\,psig)$$

This pressure is presented with the controlling pressures for the off-normal and accident cases in Table N.4-7.

N.4.4.5 Maximum Thermal Stresses

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

The average cavity gas temperature during off-normal conditions of storage and transfer is bounded by the normal condition transfer case, where the average helium temperature is 563°F (1,023°R). With rupture of 10% of the fuel rods, the pressures within the 24PHB DSC are calculated via the ideal gas law:

$$n_{DSC-ON} = n_{DSC-He} + 0.1 \cdot n_{pin-He} + 0.1 \cdot n_{fg} + 0.1 \cdot n_{BPRA}$$

$$n_{DSC-ON} = 188 + 17.7 + 26.3 + 5.91 = 237.9\, g-moles$$

$$P_{DSC-ON} = \frac{\left(1.4504x10^{-4}\,\frac{psia}{Pa}\right)(237.9\,g-moles)(8.314\,J/mol\cdot K)(1{,}023°R)(5/9\,K/°R)}{(384{,}463\,in^3)(1.6387x10^{-5}\,m^3/in^3)}$$

$$P_{DSC-ON} = 25.9\, psia(11.2\, psig)$$

This pressure is reported in Table N.4-7.

N.4.5.4 Maximum Thermal Stresses

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

N.4.5.5 Evaluation of Cask Performance for Off-Normal Conditions

The temperatures in the NUHOMS® HSM and TC with the NUHOMS®-24PHB DSC are identical to or bounded by the analyses in Section 8.1.3 with NUHOMS®-24P DSC. The NUHOMS®-24PHB DSC shell and basket are evaluated for calculated temperatures and pressures in Section N.3. The maximum fuel cladding temperatures are below the allowable fuel temperature limit of 1058°F (570°C) for of-normal storage and 752°F (400°C) for off-normal transfer conditions [4.14]. The 24PHB DSC internal cavity pressures remain below 20.0 psig during off-normal conditions of storage and transfer. Therefore, the NUHOMS®-24PHB DSC design meets all applicable off-normal conditions thermal requirements.

Fuel Cladding and Basket Materials

The blocked vent results are reported at 40 hours for bounding Heat Load Zoning Configuration 1 in Table N.4-1. The calculated fuel cladding temperature of 762°F is below the short-term limit of 1058°F [4.14]. The temperatures reported in Table N.4-2 are for the transfer cask accident steady state case. These temperatures are bounded by the blocked vent accident case temperature results reported in Table N.4-1. The temperature distribution from the bottom to the top of DSC for the blocked vent accident at the end of 40 hours is listed in Figure N.4-17.

N.4.6.3 Hypothetical Fire Accident Evaluation

For the postulated worst case fire accident, a 300-gallon diesel fire is simulated for a NUHOMS®-24PHB 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 calculated temperature responses of selected components in the TC and 24PHB DSC during the first 2,000 minutes of the fire accident are shown in Figure N.4-14. The calculated maximum fire transient DSC surface temperature is 499°F, which is less than the blocked vent case maximum DSC temperature of 762°F. Therefore, the NUHOMS®-2PHB DSC temperatures and pressures calculated for the blocked vent case bound the hypothetical fire accident case.

N.4.6.4 Maximum Internal Pressures

The average cavity gas temperature during the blocked vent accident condition is 613°F (1,073°R). With rupture of one hundred percent of the fuel rods, the pressures within the DSC are calculated via the ideal gas law:

$$n_{DSC-ACC} = n_{DSC-He} + n_{pin-He} + n_{fg} + n_{BPRA}$$

$$n_{DSC-ACC} = 188 + 177 + 263 + 59.1 = 687\, g-moles$$

$$P_{DSC-ACC} = \frac{\left(1.4504x10^{-4}\frac{psia}{Pa}\right)(687\, g-moles)(8.314\, J/mol\cdot K)(1{,}073\,°R)(5/9\, K/°R)}{(384{,}463\, in^3)(1.6387x10^{-5}\, m^3/in^3)}$$

$$P_{DSC-ACC} = 78.4\, psia\,(63.7\, psig)$$

This pressure is presented with the controlling pressures for the normal and off-normal cases in Table N.4-7.

Table N.4-7
NUHOMS®-24PHB DSC Normal, Off-Normal and Accident Pressures

Operation Condition	Limiting Case Description	Average Cavity Gas Temp. (°F)	Maximum DSC Pressure (psig)	Design Basis Pressure (psig)
Normal	DSC in Cask, 100°F, Full Solar	563	6.3	15.0
Off-Normal	DSC in Cask 100°F, Full Solar	563	11.2	20.0
Accident	Blocked Vent Case	613	63.7	68.0

N.5 Shielding Evaluation

The shielding evaluation for the Standardized NUHOMS® System (during loading, transfer and storage) for the 24P and 52B canisters is discussed in Sections 3.3.5, 7.0 and 8.0. The following evaluation specifically addresses the bounding dose rates due to design basis B&W 15x15 PWR fuel and Burnable Poison Rod Assemblies (BPRAs) loaded in a NUHOMS®-24PHB DSC. The fuel assemblies and BPRA characteristics are described in Section N.2-1.

The shielding analysis is performed for the two DSC configurations (24PHBS and 24PHBL) of the NUHOMS®-24PHB System described in Section N.2.1. The basket layout for these two DSC configurations is identical except for the shield plug design and length of the DSC components. For shielding purposes, the 24PHBL DSC bounds the 24PHBS DSC because of the additional gamma source due to the BPRAs. Therefore, the dose rates calculated for the 24PHBL DSC with fuel plus BPRAs bound the dose rates for the 24PHBS DSC with fuel. The 24PHBL optional configuration, which consists of the integral cover plate/shield plug forging assemblies in lieu of separate cover plates/lead shield plugs, is also evaluated. Where dose rates are higher for this option the higher dose rates are provided. The dose rates for this optional configuration are calculated using the same methods and codes as those calculated for the other configurations.

The 24PHB DSC also allows storage of WE 17x17, WE 15x15, WE 14x14 and CE 14x14 fuel assemblies without BPRAs. The B&W 15x5 fuel assembly is the bounding assembly for shielding analysis because it has the highest initial heavy metal loading.

The design basis PWR fuel source terms are derived from the bounding fuel, B&W 15x15 Mark B 10 assembly design as described in Section N.5.2. The information provided in the Table N.5-1 is based on B&W 15x15 fuel. The types of spent fuel considered in this Appendix include the following:

- B&W 15x15 Mark B2, B3, B4, B4Z, B5, B5Z, B6, B7, B8, B9 and B10 fuel assemblies.
- B&W 15x15 reconstituted fuel assemblies with a maximum of 10 stainless steel rods or unlimited number of zircaloy clad lower enriched UO_2 rods instead of zircaloy clad UO_2 rods. (Note that lower enriched UO_2 rods are of similar design and behavior as the standard fuel rod aside from the uranium enrichment.) The reconstituted rods can be at any location in the fuel assemblies. The maximum number of reconstituted fuel assemblies per DSC is four. The reconstituted assemblies can be placed anywhere in the basket.
- Standard BPRA design for the B&W 15x15 class assemblies are as listed in Appendix J and B&W 15x15 BPRAs with a different material composition (bounding values of 24.46 lbs. of poison, plus 28.17 Kgs of other materials, containing 9.15 grams of Co59) designated Mark-B BPRAs, for the NUHOMS®-24PHB system, are evaluated in this appendix.
- WE 17x17, WE 15x5, CE 14x14 and WE 14x14 class PWR fuel assemblies, all with no BPRAs.

Load Zoning Configuration 2, all twenty fuel assemblies in the DSC are modeled with neutron and gamma source terms consistent with 1.3 kW heat load. Therefore, these source terms result in conservative dose rates because the shielding analysis is based on a 26 kW heat load per DSC compared to the 24 kW per DSC design basis limit. (Note that when loading for Configuration 2, the actual decay heat for each assembly must be determined to assure that the maximum decay heat load of 24 kW for the canister is not exceeded.)

The design basis source terms for the B&W 15x15 BPRAs with up to 2 cycles burnup and 5-year cooling are taken from Appendix J. These source terms are appropriately scaled to evaluate the change in the Co59 content (Mark-B BPRAs). The properties used to calculate the design basis source terms for the authorized BPRAs are reproduced in Table N.5-2.

The cooling times for the reconstituted fuel assemblies are determined such that the source terms of reconstituted fuel assemblies are bounded by the standard fuel assemblies.

The methodology, assumptions, and criteria used in this evaluation are summarized in the following subsections.

gamma source for the in-core region and only the light element source for the plenum, top and bottom nozzle regions.

The design basis source terms for the authorized BPRA designs, taken from Appendix J, are listed in Table N.5-11, including a discussion of the effects on the source terms due to changes in Co60 content in Mark-B BPRAs. The SAS2H/ORIGEN-S gamma source is output in the CASK-81 energy group structure shown in Table N.5-8 [5.3]. Gamma source terms for the in-core region include contributions from actinides, fission products, and activation products. The bottom, plenum and top nozzle regions include the contribution from the activation products in the specified region only. These results for the bounding neutron and gamma source terms for various zones are given in Table N.5-9 and Table N.5-10.

Gamma source terms used in the shielding models are calculated by multiplying the assembly sources by the number of assemblies in the zone of interest and dividing by the appropriate heat load configuration zone volume. The appropriate assembly region volumes for the Heat Load Zoning Configuration zones are listed in Table N.5-12.

The volumes of the Zones for Configuration 1 are calculated as follows. Zone 1 encompasses the center four assemblies as shown in Figure N.2-1. The equivalent cross sectional area of this four assembly region is calculated such that the cross sectional area of the four fuel assembly compartments is conserved. The cross section of a fuel assembly compartment is 8.9 inches square. The cross sectional area is therefore $4*(8.9 \text{ inches})^2 = 316.84 \text{ in}^2$ or $2{,}044 \text{ cm}^2$. This forms an equivalent radius of 25.52 cm. The lengths of the various assembly regions are given in Table N.5-5.

The volumes of the assembly regions in Zone 1 are therefore the product of the cross sectional area of Zone 1 and the length of the assembly region.

Zone 2 encompasses the middle ring of twelve assemblies as shown in Figure N.2-1. The equivalent cross sectional area of this twelve assembly ring is calculated such that the cross sectional area of the twelve fuel assembly compartments is conserved. The cross sectional area of Zone 2 is therefore $12*(8.9 \text{ inches})^2 = 950.52 \text{ in}^2$ or $6{,}132 \text{ cm}^2$. This forms an equivalent annular region with an inner radius of 25.52 cm and an outer radius of 51.02 cm. The volumes of the assembly regions in Zone 2 are therefore the product of the cross sectional area of Zone 2 and the length of the assembly region.

The radius of Zone 3 is calculated by conserving the total area occupied and enclosed by the 24 fuel assemblies, including the guide sleeves, and guide sleeve wrappers, in the loaded DSC. The distance to the outer edge of each outer cutout in the spacer disc is used to calculate the area of this region. The resultant cross sectional area is $2{,}523.64 \text{ in}^2$ or $16{,}281 \text{ cm}^2$. The radius of the equivalent cylinder is 71.99 cm. Therefore the cross sectional area attributed to Zone 3 is $\pi(71.99^2\text{-}51.02^2) = 8{,}104 \text{ cm}^2$. The volumes of the assembly regions in Zone 3 are therefore the product of the cross sectional area of Zone 3 and the length of the assembly region.

The volumes of the Zone 3 for Configuration 2 are simply the sum of the volumes of Zone 2 and 3 from Configuration 1.

N.5.4.8.4 HSM End Shield Wall Surface Dose Rates

The HSM end shield wall dose rates are calculated using the DORT X-Z model. The average dose calculation is performed in the same manner as was used on the HSM roof. The results are summarized in Table N.5-4.

N.5.4.8.5 HSM Front and Roof Bird Screen Surface Dose Rates

Dose rate values calculated with MCNP code models are provided in Table N.5-3. Gamma dose rate distribution at the HSM roof bird screen and front bird screen are shown in Figure N.5-7 and Figure N.5-8.

N.5.4.8.6 HSM Dose Rates for Fuel with BPRAs

The resulting dose rates on the HSM surfaces are given in Table N.5-3 and Table N.5-4 for fuel with BPRAs. Similarly, the dose rates including BPRAs adjacent to the HSM's birdscreens are shown in Table N.5-3.

N.5.4.9 TC Dose Rates

The NUHOMS® TC containing a NUHOMS®-24PHB DSC is modeled in cylindrical coordinates using material zones as shown in Figure N.5-5. The dose rates for a OS197 TC with a liquid neutron shield (shown in Figure N.5-5) bound the dose rates for the Standard TC with a solid neutron shield. The materials used in these zones are varied to model the various welding and decontamination cases during fuel loading, canister sealing and transfer operations.

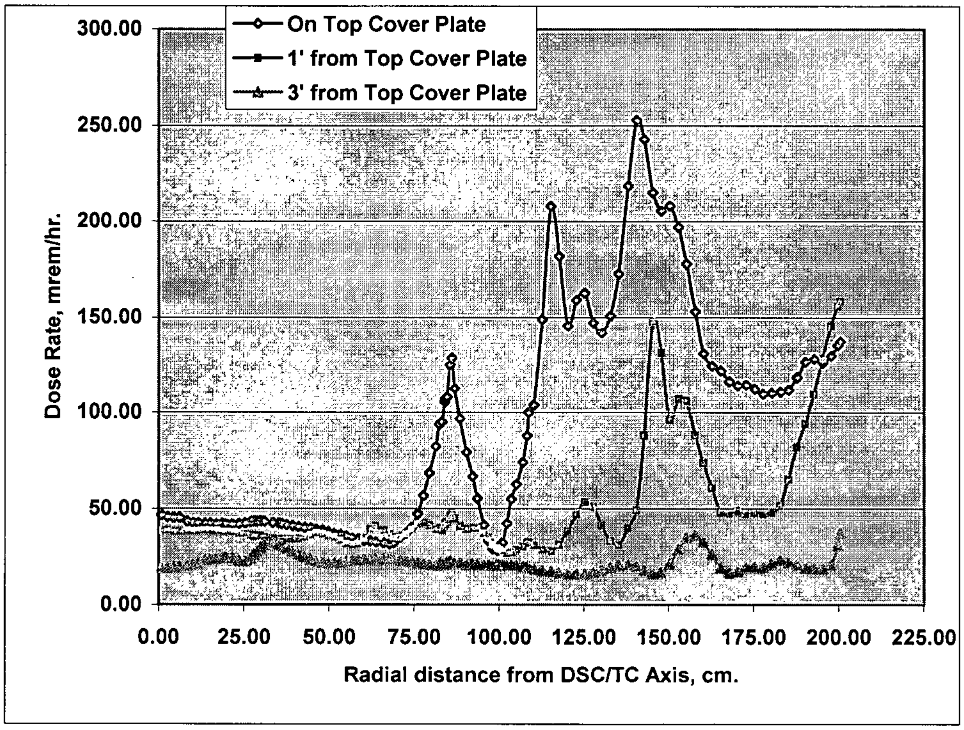
The onsite transfer case includes all cask and DSC covers, air in the DSC cavity (air versus helium has no effect on the results), air in the cask/DSC annulus, and water in the neutron shield cavity. The decontamination model is similar except it includes water in the DSC and in the cask/DSC annulus; the cask cover and both top DSC covers are removed. The DSC inner top cover plate welding (Wet Welding) model is similar to the decontamination model except that the water inside the DSC is assumed to be lowered four inches below the top shield plug, the inner top cover plate is added and supplemental shielding consisting of three inches of NS-3 and one inch of steel is added. The DSC outer top cover plate welding case (Dry Welding) model is similar to the wet welding case except the water is removed from the DSC cavity and the outer top cover plate is added to the inner top cover plate and the supplemental shielding described above. The accident condition model (Configuration 2) is identical to the onsite transfer model except that the neutron shield is removed.

The results of the evaluation, with and without BPRAs, are provided in Table N.5-3 and shown graphically in Figure N.5-10 to Figure N.5-18 for the various cases and at various distances from the TC. For Mark-B BPRAs, Figures N.5-13 and N.5-18 shift upward 5% and 7%, respectively.

Table N.5-11
Design Basis BPRA Source Terms[1]

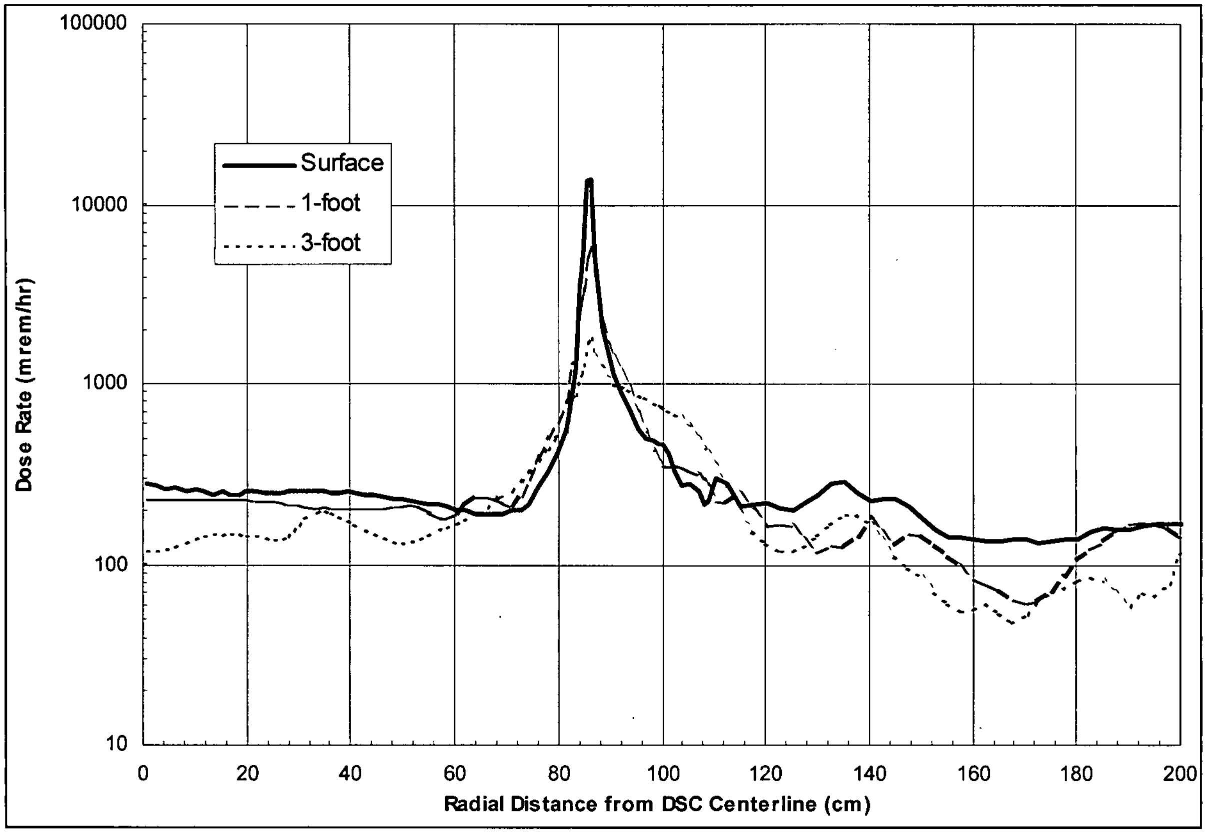
CASK-81 Energy Group	E_{upper} (MeV)	E_{mean} (MeV)	Top Region γ/s/BPRA	Plenum Region γ/s/BPRA	In-Core Region γ/s/BPRA
23	10	9	0.000E+00	0.000E+00	0.000E+00
24	8	7.25	0.000E+00	0.000E+00	0.000E+00
25	6.5	5.75	0.000E+00	0.000E+00	0.000E+00
26	5	4.5	0.000E+00	0.000E+00	0.000E+00
27	4	3.5	3.947E-15	6.520E-14	7.266E-18
28	3	2.75	3.942E+04	2.179E+04	5.495E+05
29	2.5	2.25	1.274E+07	7.040E+06	1.775E+08
30	2	1.83	9.577E+01	8.812E+01	9.153E-05
31	1.66	1.495	7.138E+11	3.946E+11	9.953E+12
32	1.33	1.165	1.690E+12	9.340E+11	2.356E+13
33	1	0.9	6.951E+09	4.180E+09	4.699E+09
34	0.8	0.7	4.155E+09	1.783E+10	2.835E+09
35	0.6	0.5	3.235E+07	3.854E+10	4.508E+08
36	0.4	0.35	7.014E+07	2.431E+10	9.776E+08
37	0.3	0.25	2.060E+08	3.482E+09	2.872E+09
38	0.2	0.15	1.217E+09	3.534E+09	1.697E+10
39	0.1	0.075	8.191E+09	5.176E+09	1.142E+11
40	0.05	0.025	8.484E+10	1.382E+11	1.170E+12

(1) For Mark-B BPRAs, the Top and Plenum Region values shown would increase by a factor of 2, while the In-Core Region values shown would reduce by a factor of 4.



Note: For Mark-B BPRAs, the results in this figure shift upward 5%.

Figure N.5-13
Gamma Dose Rates at Top End of TC, Transfer Mode



Note: For Mark-B BPRAs, the results in this figure shift upward 7%.

Figure N.5-18
Gamma Dose Rates Including BPRAs Along Top of DSC During Dry Welding

N.6.2 Package Fuel Loading

The package fuel loading for the 24PHB DSC remains unchanged from previous analysis presented in Section 3.3.4.1 and Appendix J.

The B&W 15x15 fuel assembly design parameters and layout used in this evaluation are given in Table N.6-1, Table N.6-2, Table N.6-3, Table N.6-4 and Figure N.6-1. A sensitivity analysis was performed with the guide tube and instrument tubes modeled with twice their design thicknesses. The results of this analysis demonstrates that the design details of the guide tube and instrument tube thicknesses and sub-components like "oversleeves" are not important for criticality and do not affect the conclusions of this evaluation. These results, therefore, cover for sub-components like "oversleeves" with thicknesses up to the design thickness of the guide tube or instrument tube.

The WE 17x17 fuel assembly parameters and layout used in this evaluation are given in Table N.6-17, Table N.6-18 and Figure N.6-7.

The WE 15x15 fuel assembly parameters and layout used in this evaluation are given in Table N.6-19, Table N.6-20 and Figure N.6-8.

The CE 14x14 fuel assembly parameters and layout used in this evaluation are given in Table N.6-21, Table N.6-22 and Figure N.6-9.

The WE 14x14 fuel assembly parameters and layout used in this evaluation are given in Table N.6-23, Table N.6-24, Table N.6-25 and Figure N.6-10.

Table N.6-2
B&W 15x15 Mark B8 Fuel Assembly

Parameter	Value
Maximum number of fuel rods	208
Fuel density, % theoretical	95.0%
Quantity of guide tubes	16
Quantity of instrument tubes	1

Parameter	Inches	cm
Pellet diameter	0.3686	0.9362
Active fuel length	141.8	360.2
Plenum Length	8.73	22.17
Cladding thickness	0.0265	0.0673
Fuel rod OD	0.43	1.0922
Fuel rod pitch	0.568	1.44272
Guide tube OD	0.53	1.3462
Guide tube thickness(1)	0.016	0.0406
Instrument tube OD	0.493	1.2522
Instrument tube thickness(1)	0.026	0.0660

(1) Note that the guide tubes and instrument tubes have been modeled with twice their design thicknesses. This modeling does not affect the conclusions of the evaluation.

Table N.6-3
B&W 15x15 Mark B9 Fuel Assembly

Parameter	Value
Maximum number of fuel rods	208
Fuel density, % theoretical	95.0%
Quantity of guide tubes	16
Quantity of instrument tubes	1

Parameter	Inches	cm
Pellet diameter	0.37	0.9398
Active fuel length	140.6	357.1
Plenum Length	8.73	22.17
Cladding thickness	0.0265	0.0673
Fuel rod OD	0.43	1.0922
Fuel rod pitch	0.568	1.44272
Guide tube OD	0.53	1.3462
Guide tube thickness(1)	0.016	0.0406
Instrument tube OD	0.493	1.2522
Instrument tube thickness(1)	0.026	0.0660

(1) Note that the guide tubes and instrument tubes have been modeled with twice their design thicknesses. This modeling does not affect the conclusions of the evaluation.

Table N.6-4
B&W 15x15 Mark B10 Fuel Assembly

Parameter	Value
Maximum number of fuel rods	208
Fuel density, % theoretical	96.0%
Quantity of guide tubes	16
Quantity of instrument tubes	1

Parameter	Inches	cm
Pellet diameter	0.3735	0.9487
Active fuel length	142.3	361.4
Plenum Length	8.73	22.17
Cladding thickness	0.025	0.0635
Fuel rod OD	0.43	1.0922
Fuel rod pitch	0.568	1.44272
Guide tube OD	0.53	1.3462
Guide tube thickness(1)	0.016	0.0406
Instrument tube OD	0.493	1.2522
Instrument tube thickness(1)	0.026	0.0660

(1) Note that the guide tubes and instrument tubes have been modeled with twice their design thicknesses. This modeling does not affect the conclusions of the evaluation.

Table N.10-1
Occupational Exposure Summary, 24PHB System

Locations	Task Description	# of workers	Duration (hr)	Area Dose Rate (mrem/hr)	Total Exposure 24 PHBS (person-mrem)	Area Dose Rate w/BPRA (mrem/hr) *	Exposure 24PHBL (person-mrem)
Auxilary Building and Fuel Pool	Ready the DSC and TC for Service	2	4.00	0.00	0.00	0.00	0.00
	Place the DSC into the Transfer Cask	3	1.00	2.00	6.00	2.00	6.00
	Fill the Cask/DSC Annulus with Clean Water and Install the Inflatable Seal	2	2.00	2.00	8.00	2.00	8.00
	Fill the DSC Cavity with Water (borated for PWRs)	1	6.00	2.00	12.00	2.00	12.00
	Place the Cask Containing the DSC in the Fuel Pool	5	0.50	2.00	5.00	2.00	5.00
	Verify and Load the Candidate Fuel Assemblies into the DSC	3	5.00	2.00	30.00	2.00	30.00
	Place the Top Shield Plug on the DSC	2	1.00	2.00	4.00	2.00	4.00
	Remove the Cask/DSC from the Fuel Pool and Place them in the Decon Area	5	0.50	2.00	5.00	2.00	5.00
		1	0.03	100.00	3.33	107.28	3.58
		1	1.00	67.13	67.13	72.02	72.02
Cask Decontamination Area	Decontaminate the Outer Surface of the Cask	1	1.75	67.13	117.48	72.02	126.03
		1	1.00	2.00	2.00	2.00	2.00
	Decontaminate the Top Region of the Cask and DSC	2	0.50	121.37	121.37	201.92	201.92
		1	1.00	2.00	2.00	2.00	2.00
	Drain Water Above DSC Shield Plug	1	0.08	100.00	8.33	107.28	8.94
	Remove Cask/DSC Annulus Seal and Set-Up Welding Machine	1	0.25	121.36	30.34	201.90	50.48
		1	1.25	98.89	123.61	164.52	205.65
		1	1.50	2.00	3.00	2.00	3.00
	Weld the Top Inner Top Cover to the DSC Shell and Perform NDE (PT)	2	6.00	2.00	24.00	2.00	24.00
		1	0.50	98.89	49.45	164.52	82.26
	Drain the Cask/DSC Annulus and the DSC Cavity	1	0.25	225.31	56.33	374.84	93.71
		1	0.02	423.99	7.07	705.38	11.76
		1	0.50	2.00	1.00	2.00	1.00
	Vacuum Dry and Backfill the DSC with Helium	Same as Draining			64.39		106.47
	Helium Leak Test the Shield Plug Weld	2	1.00	2.00	4.00	2.00	4.00
	Seal Weld the Prefabricated Plugs to the Vent	1	0.50	240.09	120.05	257.78	128.89
	Fit-Up the DSC Top Cover Plate	1	0.50	2.00	1.00	2.00	1.00
		1	0.50	240.09	120.05	257.78	128.89
	Weld the Outer Top Cover Plate and Perform NDE	1	1.25	240.09	300.11	257.78	322.23
		1	1.50	2.00	3.00	2.00	3.00
		2	14.00	2.00	56.00	2.00	56.00
		1	0.50	240.09	120.05	257.78	128.89
	Install the Cask Lid	2	1.00	56.27	112.54	59.16	118.31
Reactor/Fuel Building Bay	Ready the Cask Support Skid and Transport Trailer for Service	2	2.00	2.00	8.00	2.00	8.00
	Place the Cask onto the Skid and Trailer	2	0.50	200.00	200.00	214.56	214.56
	Secure the Cask to the Skid	1	0.25	200.00	50.00	214.56	53.64

Table N.10-1
Occupational Exposure Summary, 24PHB System
(concluded)

Locations	Task Description	# of workers	Duration (hr)	Area Dose Rate (mrem/hr)	Total Exposure 24 PHBS (person-mrem)	Area Dose Rate w/BPRA (mrem) *	Exposure 24 PHBL (person-mrem)
ISFSI Site	Ready the Cask Support Skid and Transport Trailer for Service	2	2.00	0.00	0.00	0.00	0.00
	Transport the Cask to ISFSI	6	1.00	0.00	0.00	0.00	0.00
	Position the Cask in Close Proximity with the HSM	3	1.00	0.00	0.00	0.00	0.00
	Remove the Cask Lid	2	1.00	162.79	325.58	171.14	342.29
	Align and Dock the Cask with the HSM	2	0.25	200.00	100.00	214.56	107.28
	Position and Align Ram with Cask	2	0.50	200.00	200.00	214.56	214.56
	Remove Ram Access Cover Plate	1	0.25	140.55	35.14	140.69	35.17
	Transfer the DSC from the Cask to the HSM	3	0.50	0.00	0.00	0.00	0.00
	Lift the Ram Back onto the Trailer and Un-Dock the Cask from the HSM	2	0.08	200.00	33.33	214.56	35.76
	Install HSM Access Door	2	0.50	106.52	106.52	107.39	107.39
Totals			66.22		2646		3085

* As discussed in Section N.5.4.9, for the Mark-B BPRAs, these dose rate estimates are slightly higher at the DSC top during dry welding and the TC top end during transfer.
Total estimated dose is 2.7 person-rem per 24PHBS canister load.
Total estimated dose is 3.1 person-rem per 24PHBL canister load.
Total estimated completion time is approximately 68 hrs.

Figure P.1-4 shows these features in a cross sectional view of the HSM-H. The key design parameters and estimated weights of the HSM-H module are shown in Table P.1-1. The geometry and materials used to fabricate the HSM-H module are shown in the Parts List on Drawings NUH-03-7001-SAR included in Section P.1.5.

P.1.2.1.3 NUHOMS®-OS197FC Transfer Cask

The OS197FC TC is a modified version of the OS 197/OS197H TC described in the FSAR and in the drawings included in Appendix E of the FSAR.

The top lid of the OS197/OS197H TC is scalloped out at sixteen locations on the lid underside (See Figure P.1-5) to provide slots that provide an exit path for air circulation through the TC/DSC annulus. This external air circulation feature is needed during the transfer mode if decay heat is greater than 31.2 kW and basket type used in the DSC is 1A, 1B, or 1C and specific time limits for transfer are not met, or if the decay heat is greater than 24.0 kW (but not greater than 31.2 kW) and basket type used is 2A, 2B, 2C, and specific time limits for transfer are not met.

To achieve this air circulation, the NUHOMS® TC support skid is modified by the addition of two motor-driven redundant industrial grade blowers and associated hoses (See Figure P.1-6) which are connected via a cone adapter to the ram access opening. The TC spacer inside the TC cavity also requires minor modifications to ensure distribution of the airflow to the perimeter region of the TC. The air circulation system is sized to provide a minimum capacity of 450 cfm.

The modifications necessary to convert OS197/OS197H TC into a OS197FC TC are shown on Drawings NUH-03-8000-SAR, included in Section E.3, and NUH-03-8006-SAR, included in Section P.1.5.

P.1.2.2 Operational Features

P.1.2.2.1 General Features

The NUHOMS®-24PTH DSC is designed to safely store 24 intact standard PWR fuel assemblies or up to 12 damaged and remaining intact fuel assemblies with or without CCs. The NUHOMS®-24PTH DSC is designed to maintain the fuel cladding temperature below allowable limits during normal storage, short-term accident conditions, short-term off-normal conditions and fuel loading/transfer operations.

The criticality control features of the NUHOMS®-24PTH 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.

P.1.2.2.2 Sequence of Operations

The sequence of operations to be performed in loading fuel into the NUHOMS®-24PTH DSCs is presented in Chapter P.8.

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

ALL DIMENSIONS ARE NOMINAL UNLESS A SPECIFIC TOLERANCE IS INDICATED WITH THE DRAWING DIMENSION

DIMENSIONS ARE IN INCHES AND DEGREES UNLESS OTHERWISE SPECIFIED. DIMENSIONING IN ACCORDANCE WITH ASME Y14.5M

INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4

TRANSNUCLEAR
AN AREVA COMPANY

SAFETY ANALYSIS REPORT
STANDARDIZED NUHOMS® ISFSI
HSM-H
MAIN ASSEMBLY

DRAWING NO.	SCALE	SHEET	REVISION
NUH-03-7001-SAR	NONE	1 OF 11	3

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

NUH-03-7001-SAR 3 OF 11

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

8 | 7 | 6 | 5 | 4 | 3 | 2 | 1

NUH-03-7001-SAR 4 OF 11

H
G
F
E
D
C
B
A

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO.	SHEET	REVISION
NUH-03-7001-SAR	4 OF 11	3

8 | 7 | 6 | 5 | 4 | 3 | 2 | 1

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO.	SHEET	REVISION
NUH-03-7001-SAR	5 OF 11	3

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO.	SHEET	REVISION
NUH-03-7001-SAR	7 OF 11	3

PROPRIETARY AND
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DRAWING NO.	SHEET	REVISION
NUH-03-7001-SAR	8 OF 11	3

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO. NUH-03-7001-SAR | SHEET 9 OF 11 | REVISION 3

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

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DRAWING NO.	SHEET	REVISION
NUH-03-7001-SAR	11 OF 11	3

The 24PTH-DSC is supported inside the base unit on two carbon steel rails. The rail assembly spans between the front and the rear wall of the base unit and acts as a sliding surface during 24PTH-DSC insertion and retrieval.

The air inlet vents are located at the bottom of the side walls of the base unit. The air outlet vents are formed along the sides of the roof. A roof vent shield cap above the outlet vent provides additional shielding. Steel liner plates are used at the inlet and outlet vents to provide additional shielding and reduce dose rates.

For thermal protection of the HSM-H concrete, stainless steel heat shields with anodized aluminum backing plates and fins are installed on the sidewalls of the base unit. Heat shields with stainless steel mounting bars and aluminum louvers are also installed under the roof. The heat shields guide cooling airflow through the HSM-H. Flat stainless steel heat shields on the side walls of the base unit and under the roof are also allowed.

The HSM-H front standard door is a composite door, which consists of a rectangular steel face plate at the front attached to a circular thick steel plate and a circular reinforced concrete block at the rear. The rectangular steel face plate of the door is attached to the front wall concrete using four bolts anchored through four embedments. The alternate circular door is similar to the standard door except that the front face plate is a circular steel plate. The circular steel plate of the door is attached to the front wall concrete by four clamps which are located at the 45° line in each quadrant of the door. The clamps consist of four "L" shaped clips which are bolted to the front wall concrete through four embedments. The door provides missile protection and shielding for the 24PTH-DSC.

During 24PTH-DSC insertion/retrieval operations, the TC is docked with the HSM-H docking surface and mechanically secured to the HSM-H cask restraint embedments provided in the front of the HSM-H base unit. These embedments are equally spaced on either side of the HSM-H access opening and serve to restrain the transfer cask during insertion/retrieval of the 24PTH-DSC.

P.3.1.1.3 General Description of the HSM Model 102

The 24PTH-S-LC DSC, which has a maximum heat load of 24 kW, is stored in either HSM-H or HSM Model 102. The description of HSM Model 102 is included in Appendix E drawings for the standardized HSM. There is no change to the design of HSM Model 102 to accommodate the 24PTH-S-LC DSC.

P.3.1.1.4 General Description of the OS197FC TC

The OS197FC TC is identical to the OS197/OS197H TCs described in the FSAR and in the drawings included in Appendix E of the FSAR, with the exception of the TC top lid, which is modified to improve the TC thermal performance. The modification consists of adding vent passages around the periphery of the TC, in between the bolt holes. The vents are added to permit airflow through the TC. Ambient air is circulated at the bottom of the TC through the ram access opening and distributed to the annular space between the DSC and the TC. The cooling air travels through the TC length and exists through the vent passages in the TC top lid. Figure P.1.1-5 shows an isometric view of the modified TC top lid. Drawing NUH-03-8000-SAR describes the OS197FC TC and Drawing NUH-03-8006-SAR shows the TC top lid modification as implemented in the OS197FC TC. These drawings are provided in Section P.1.5.

Table P.3.1-1
Alternatives to the ASME Code for the NUHOMS®-24PTH DSC Confinement Boundary

Reference ASME Code Section/Article	Code Requirement	Alternatives, Justification & Compensatory Measures
NCA	All	Not compliant with NCA. TN Quality Assurance requirements, which are based on 10CFR72 Subpart G, are used in lieu of NCA-4000. Fabrication oversight is performed by TN and utility personnel in lieu of an Authorized Nuclear Inspector.
NB-1100	Requirements for Code Stamping of Components	The NUHOMS®-24PTH DSC shell is designed & fabricated in accordance with the requirements of ASME Code, Section III, Subsection NB and the alternative provisions described in this table. However, Code Stamping is not required. As Code Stamping is not required, the fabricator is not required to hold an ASME "N" or "NPT" stamp, or to be ASME Certified.
NB-2130	Material must be supplied by ASME approved material suppliers.	Material is certified to meet all ASME Code criteria but is not eligible for certification or Code Stamping if a non-ASME fabricator is used. As the fabricator is not required to be ASME certified, material certification to NB-2130 is not possible. Material traceability & certification are maintained in accordance with TN's NRC approved QA program.
NB-4121	Material Certification by Certificate Holder	
NB-4243 and NB-5230	Category C weld joints in vessels and similar weld joints in other components shall be full penetration joints. These welds shall be examined by UT or RT and either PT or MT	The joints between the top outer and inner cover plates (or top forging assembly for the 24PTH-S-LC) and containment shell are designed and fabricated per ASME Code Case N-595-2, which provides alternative requirements for the design and examination of spent fuel canister closures. This includes the inner top cover plate weld around the vent & siphon block and the vent and siphon block welds to the shell. The closure welds are partial penetration welds and the root and final layer are subject to PT examination (in lieu of volumetric examination) in accordance with the provisions of ASME Code Case N-595-2. The 24PTH closure system employs austenitic stainless steel shell, lid materials, and welds. Because austenitic stainless steels are not subject to brittle failure at the operating temperatures of the DSC, crack propagation is not a concern. Thus, multi-level PT examination provides reasonable assurance that flaws of interest will be identified. The PT examination is done by qualified personnel, in accordance with Section V and the acceptance standards of Section III, Subsection NB-5000. This alternative does not apply to other shell confinement welds, i.e., the longitudinal and circumferential welds of the DSC shell, and the inner bottom cover plate-to-shell weld (or bottom forging to shell weld, as applicable) which comply with NB-4243 and NB-5230.

Table P.3.1-2
Alternatives to the ASME Code for the NUHOMS®-24PTH DSC Basket Assembly

Reference ASME Code Section/Article	Code Requirement	Alternatives, Exception, Justification & Compensatory Measures
NG-1100	Requirements for Code Stamping of Components	The NUHOMS®-24PTH DSC baskets are designed & fabricated in accordance with the ASME Code, Section III, Subsection NG as described in the SAR, but Code Stamping is not required. As Code Stamping is not required, the fabricator is not required to hold an ASME N or NPT stamp or be ASME Certified.
NG-2000	Use of ASME Material	The poison material and aluminum plates are not used for structural analysis, but to provide criticality control and heat transfer. They are not ASME Code Class 1 material. Material properties in the ASME Code for Type 6061 aluminum are limited to 400°F to preclude the potential for annealing out the hardening properties. Annealed properties (as published by the Aluminum Association and the American Society of Metals) are conservatively assumed for the aluminum transition rails for use above the Code temperature limits.
NG-2130	Material must be supplied by ASME approved material suppliers.	Material is certified to meet all ASME Code criteria, but is not eligible for certification or Code Stamping if a non-ASME fabricator is used. As the fabricator is not required to be ASME certified, material certification to NG-2130 is not possible. Material traceability & certification are maintained in accordance with TN's NRC approved QA program.
NG-4121	Material Certification by Certificate Holder	
NG-8000	Requirements for nameplates, stamping & reports per NCA-8000	The NUHOMS®-24PTH DSC nameplate provides the information required by 10CFR71, 49CFR173 and 10CFR72 as appropriate. Code stamping is not required for the NUHOMS®-24PTH DSC. In lieu of Code stamping, QA Data packages are prepared in accordance with the requirements of 10CFR71, 10CFR72 and TN's approved QA program.
NCA	All	Not compliant with NCA as no Code stamp is used. TN Quality Assurance requirements, which are based on 10CFR72 Subpart G, are used in lieu of NCA-4000. Fabrication oversight is performed by TN and utility personnel in lieu of an Authorized Nuclear Inspector.
NG-3000/ Section II, Part D, Table 2A	Maximum temperature limit for Type 304 plate material is 800°F	Not compliant with ASME Section II Part D Table 2A material temperature limit for Type 304 steel for the postulated transfer accident case (117°F, loss of sunshade, loss of neutron shield). This is a post-drop accident scenario, where the calculated maximum steady state temperature is 862°F, the expected reduction in material strength is small (less than 1 ksi by extrapolation), and the only primary stresses in the basket grid are deadweight stresses. The recovery actions following the postulated drop accident are as described in Section 8.2.5 of the FSAR.

film develops, the corrosion process is arrested at the surface of the metal. The film remains stable over a pH range of 4.5 to 8.5.

Tests were performed by Eagle Picher which concluded that borated aluminum exhibits a strong corrosion resistance at room temperature in either reactor grade deionized water or in 2000 ppm borated water. The behavior is only slightly different than 1100 series aluminum; hence, satisfactory long-term usage in these environments is expected. Neutron irradiation up to 10^{17} n/cm^2 level did not cause any measurable dimensional changes or any other damage to the material.

At high temperature, the borated aluminum still exhibits high corrosion resistance in the pure water environment. However, at temperatures of 80°C, in 2000 ppm borated water, local pitting corrosion has been observed. At 100°C and room temperature, the pitting attack was less than at 80°C. In all cases, passivation occurs limiting the pit depth.

From tests on pure aluminum, it was found that borated aluminum was more resistant to uniform corrosion attack than pure aluminum. Local pitting corrosion can occur over time, causing localized damage to the borated aluminum.

There are no chemical, galvanic or other reactions that could reduce the areal density of boron in the 24PTH-DSC neutron poison plates.

Electroless Nickel Plated Carbon Steel

The carbon steel top shield plug of the DSC (option in 24PTH-S and –L) is plated with electroless nickel. This coating is identical to the coating used on the NUHOMS®-52B DSC. It has been evaluated for potential galvanic reactions in Transnuclear West's response to NRC Bulletin 96-04 [3.7]. In PWR pools, the reported corrosion rates are insignificant and are expected to result in a negligible rate of reaction for the NUHOMS® PWR systems.

Lubricants and Cleaning Agents

Lubricants and cleaning agents used on the NUHOMS®-24PTH DSC should be selected for compatibility with the spent fuel pool water chemistry and the DSC materials. Never-seez or Neolube (or equivalent) may be used to coat threads. The lubricant should be selected for its ability to maintain lubricity under long-term storage conditions.

The DSC is cleaned in accordance with approved procedures to remove cleaning residues prior to shipment to the storage site. The basket is also cleaned prior to installation in the DSC. The cleaning agents and lubricants have no significant affect on the DSC materials and their safety related functions.

Hydrogen Generation

During the initial passivation state, small amounts of hydrogen gas may be generated in the 24PTH DSC. The passivation stage may occur prior to submersion of the TC into the spent fuel

Table P.3.6-14
OS197/OS197H/OS197FC TC Structural Shell Stresses at TC Trunnions

Location	Load	Load	Stress Category	SI (ksi)	Allowable[3] (ksi)	Ratio
2	Shell @ Trunnion Sleeve	Critical Lift	P_L	4.77	28.1	0.17
			$P_L + P_b + Q_{MECH}$	12.4	56.1	0.22
			$Q_{THERMAL}$[1]	10.0	--	--
			$P_L + P_b + Q_{TOTAL}$	23.5	56.1	0.42
		Handling	P_L	14.2	28.1	0.51
			$P_L + P_b + Q_{MECH}$	35.5	56.1	0.63
			$Q_{THERMAL}$[1]	10.0	--	--
			$P_L + P_b + Q_{TOTAL}$	46.8	56.1	0.83
	Shell Away from Trunnion Sleeve	Critical Lift	P_m	4.16	18.7	0.22
			$P_L + P_b$	9.61	28.1	0.34
			$Q_{THERMAL}$[1]	10.0	--	--
			$P_L + P_b + Q_{TOTAL}$	21.0	56.1	0.37
		Handling	P_m	9.08	18.7	0.49
			$P_L + P_b$	22.8	28.1	0.81
			$Q_{THERMAL}$[1]	10.0	--	--
			$P_L + P_b + Q_{TOTAL}$	34.7	56.1	0.62
Lower Trunnion	Shell @ Trunnion Sleeve	Critical Lift	P_L	5.78	28.1	0.21
			$P_L + P_b + Q_{MECH}$	12.2	56.1	0.22
			$Q_{THERMAL}$[2]	20.8	--	--
			$P_L + P_b + Q_{TOTAL}$	33.0	56.1	0.59
		Handling	P_L	9.45	28.1	0.34
			$P_L + P_b + Q_{MECH}$	21.4	56.1	0.38
			$Q_{THERMAL}$[2]	20.8	--	--
			$P_L + P_b + Q_{TOTAL}$	42.2	56.1	0.75
	Shell Away from Trunnion Sleeve	Critical Lift	P_m	5.59	18.7	0.30
			$P_L + P_b$	10.6	28.1	0.38
			$Q_{THERMAL}$[2]	20.8	--	--
			$P_L + P_b + Q_{TOTAL}$	31.4	56.1	0.56
		Handling	P_m	8.83	18.7	0.47
			$P_L + P_b$	18.0	28.1	0.64
			$Q_{THERMAL}$[2]	20.8	--	--
			$P_L + P_b + Q_{TOTAL}$	38.8	56.1	0.69

Notes:
1. Maximum thermal stress in the upper trunnion area of the structural shell is 10.0 ksi.
2. Maximum thermal stress in the lower trunnion area of the structural shell is 20.8 ksi.
3. Allowables for SA-240 Type 304 at 400°F.
4. Primary stress are based on the OS197H stresses are summarized in Chapter 8.
5. Thermal stresses are applicable to the OS197/OS197H/OS197FC TCs for heat loads above 24 kW. For heat loads of up to 24 kW, the thermal stresses as reported in Chapter 8 are applicable.
6. Envelop of results with multiple and single solid piece trunnion analyses.

resulting amplified accelerations are 0.37g and 0.33g in the transverse and longitudinal directions, respectively and 0.20g in the vertical direction. For conservatism, a value of 0.37g is used for both horizontal directions in the seismic analysis of the HSM-H.

P.3.7.2.3.2 Seismic Stress Analysis

An equivalent static analysis of the HSM-H is performed using the ANSYS model described in Section P.3.7.11.6 and the seismic accelerations of 0.37g horizontally (longitudinal and transverse directions) and 0.2g vertically. These amplified accelerations are determined based on the frequency analysis of the HSM-H.

The responses for each orthogonal direction are combined using the SRSS method. The seismic analysis results are incorporated in the loading combination C4C (Table P.3.7-16) and C4S (Table P.3.7-17) for the concrete and support structure components respectively.

P.3.7.2.3.3 HSM-H Seismic Overturning Analysis

The following conservative analysis is performed to show that a single freestanding HSM-H without an end shield wall (in an array of two or more loaded modules) will not overturn due to seismic loads. Overturning about the long axis (i.e., in the short direction of the module) is considered.

Stabilizing moment = $M_{st} = (W_{hsm} + W_{dsc})\ b/2$

Overturning moment = $M_{ot} = (W_{hsm}\ 0.4a_{v1} + W_{dsc} 0.4a_{v2})b/2 + W_{hsm}\ d_1 a_{h1} + W_{dsc} d_2 a_{h2}$

(100% of horizontal acceleration is combined with 40% of vertical acceleration, Ref. [3.19].)

Where:

W_{hsm} = 310 K, Weight of the HSM-H (conservatively assumed)
W_{DSC} = 110 K, Weight of DSC (conservatively assumed)
$b/2$ = 52 in, Horizontal distance from CG to corner(half width of the HSM-H)
d_1 = 123.45 in, Height of CG of HSM-H without the DSC
d_2 = 106 in, Height of the DSC center line
a_{v1} = 0.20g, HSM-H peak vertical seismic acceleration
a_{v2} = 0.20g, DSC peak vertical seismic acceleration
a_{h1} = 0.37g, HSM-H peak horizontal seismic acceleration
a_{h2} = 0.43g, DSC peak horizontal seismic acceleration (conservatively assumed)
M_{st} = 21,840 K-in
M_{ot} = 20,921 K-in

Because stabilizing moment is greater than the overturning moment the HSM-H will not overturn during the seismic event.

P.3.7.2.3.4 HSM-H Seismic Sliding Analysis

The friction force resisting sliding = $F_{st} = W_{hsm}(1-0.4*a_{v1}) + W_{dsc}(1-0.4*a_{v2})]\mu$

The applied horizontal seismic force = $F_{hs} = [W_{hsm}a_{h1} + W_{dsc}a_{h2}]$

load. The computed maximum ductility ratio for the door is less than 1 (compared to the allowable ductility of 20).

For the door anchorage, the controlling load is tornado generated differential pressure drop load. The maximum tensile force per bolt (there are four bolts that attach the door assembly to the front concrete wall of the HSM-H) is 9.0 kips. This is less than the allowable load per bolt of 10.8 kips. The concrete pull-out strength is conservatively estimated as 24 kips which is greater than the ultimate capacity of the four bolts, thus satisfying the ductility requirements of the ACI Code.

P.3.7.11.6.6 Evaluation of the HSM-H Heat Shields

The top heat shield (louvers) consists of six panels. Each panel has two aluminum mounting bars. The aluminum louvers are mounted on the mounting bars. Each mounting bar is suspended from the roof by two threaded rods. The natural lateral frequency of a typical rod is conservatively estimated to be 9.0 Hz. The combined axial and bending stress in the hanger rods is 24.0 ksi. The allowable axial and bending stress is 84.3 ksi.

The side heat shields consists of three panels. Each panel is suspended from the roof by two threaded rods, and supported laterally and longitudinally by four rods. The maximum axial plus bending stress in the lateral and longitudinal support rods is 83.7 ksi. The allowable axial and bending stress is 84.3 ksi. The maximum temperature used in the stress analysis of the heat shields bounds the maximum temperature reported in Chapter P.4.

The alternate top heat shield consists of two panels made of stainless steel plate. The panels are suspended from the roof by fifteen ½" diameter rods threaded into concrete embedments. The combined axial and bending stress in the rods is 59.5 ksi. The allowable stress is 70.2 ksi.

The alternate side heat shield configuration may consist of four panels made from aluminum or stainless steel. The panels are supported off the base unit side wall by thirty four rod stand-offs threaded into concrete embedments. For the aluminum heat shield configuration, the maximum axial and bending stress in the rods is about 1 ksi and 53.7 ksi, respectively. For the stainless steel heat shield configuration, the maximum axial and bending stress in the rods is about 1.4 ksi and 79.3 ksi, respectively. The axial and bending stress allowable for the rods is 67.9 ksi and 112.3 ksi, respectively.

P.3.7.11.6.7 Evaluation of the HSM-H Seismic Retainers

The seismic retainer consists of a capped tube steel embedment located within the bottom center of the round access opening of the HSM-H, and a tube steel retainer assembly that drops into the embedment cavity after 24PTH-DSC transfer is complete. The drop-in retainer extends approximately 4" above the rail to provide axial restraint of the 24PTH-DSC. The maximum seismically induced shear load in the retainer is 61 kips. The maximum shear stress in the retainer is 15.25 ksi. The allowable shear stress is 17.8 ksi.

P.3.7.11.6.8 Thermal Cycling of the HSM-H

No change.

Table P.3.7-21
Maximum/Minimum Forces/Moments in the Rail Components in the Local System

Load Combination		F_x Kips	F_y Kips	F_z Kips	M_x kip-in	M_y kip-in	M_z Kip-in
C1S	MAX	0.0	33.0	65.2	63.5	231.1	213.7
	MIN	0.0	-41.0	-61.3	-52.4	-1146.7	-236.2
C2S	MAX	38.5	39.8	77.0	0.22	428.2	247.8
	MIN	-28.9	-39.8	-60.9	-0.32	-1137.6	-247.8
C3S	MAX	86.5	30.7	89.6	63.6	592.7	199.4
	MIN	-86.5	-38.1	-63.0	-52.4	-1422.4	-230.4
C4S	MAX	22.3	38.2	102.1	63.6	562.5	-267.6
	MIN	-22.3	-46.3	-98.3	-52.4	-1869.0	-290.2
C5S	MAX	0.	49.6	82.1	183.7	264.8	267.3
	MIN	0.	-54.1	-80.9	-159.3	-1434	-267.1

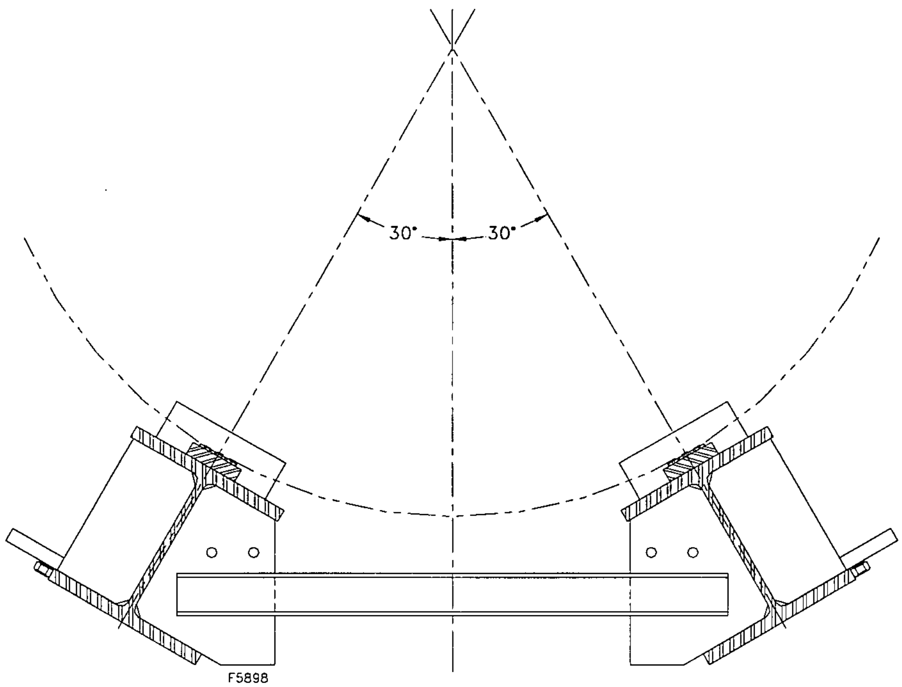


Figure P.3.7-14
Components of HSM-H Support Structure

P.4.4 Thermal Analysis of HSM Model 102 and HSM-H with 24PTH DSC

The maximum decay heat loads that are considered for the NUHOMS®-24PTH-S and 24PTH-L DSCs as described in Section P.4.1 are 40.8 kW and 31.2 kW.

The maximum heat load allowed in the 24PTH-S-LC DSC is 24 kW. The HSM Model 102 is designed for a maximum heat load of 24 kW from a NUHOMS®-24P DSC as described in Section 8.1.3. There is no change in this thermal analysis due to the storage of 24PTH-S-LC inside HSM Model 102. The 24PTH-S-LC and 24P DSCs have same heat loads and analytically equivalent outer shell geometry (outside diameter and length), therefore the shell temperatures calculated in Section 8.1.3.1 for 24P DSC in HSM Model 102 are also applicable to 24PTH-S-LC DSC. The DSC shell temperatures are summarized in Table P.4-34. These shell temperatures are used in the 24PTH-S-LC DSC model in Section P.4.8 to calculate the basket and fuel temperatures.

P.4.4.1 Ambient Temperature Specification

Ambient temperatures in the range of 0-100°F are considered as normal storage conditions. A maximum day temperature of 117°F is considered as off-normal, hot storage condition. A 24-hour average ambient temperature of 105°F is conservatively used for the off-normal steady state analysis, based on the 102°F calculated in Section M.4.5 [4.38]. The lowest off-normal ambient temperature is considered to be -40°F.

P.4.4.2 Thermal Analysis of HSM-H with 24PTH DSC

The HSM-H is an improved version of the HSM Model 102, described in the FSAR, with the following unique design features to enhance its heat rejection and shielding capabilities:

- Module internals optimized for heat transfer by enhanced DSC support structure design,
- Use of slotted plates (optional) and holes in the DSC support rails to increase airflow at the bottom portion of canister,
- Increased height of the module to increase module cavity height resulting in an increased stack height and minimum flow resistance in the module cavity,
- Use of finned side heat shields option at high heat loads to improve convection heat transfer by increasing surface area of heat shield, and
- Use of louvered top heat shield (optional) to minimize flow resistance.

The design of 24PTH DSC shell, top and bottom cover plates and shield plugs is similar to the other NUHOMS® canisters like 24P. The design of the basket is similar to the licensed TN-68 [4.43] with additional design features to greatly improve the heat rejection capability of the canister as follows:

- Use of thick aluminum plates results in uninterrupted radial conduction path,
- Use of slotted aluminum and poison plates with interlocking feature to form "eggcrate" type basket that minimizes gaps between components,

The total equivalent loss coefficients calculated for the steady state cases for the HSM-H regions are:

Decay Heat Load (kW)	Ambient Temperature (°F)	Total equivalent loss coefficient K (ft^{-4})[(1)]	Total equivalent loss coefficient K (ft^{-4})[(2)]
40.8	-40	0.0864	0.0980
	0	0.0872	0.0990
	100	0.0889	0.1011
	117	0.0890	0.1012
31.2	-40	0.0865	0.0984
	117	0.0892	0.1017
24	-40	0.0868	0.0988
	117	0.0896	0.1021

(1) Based on louvered top heat shields, finned side heat shields and with slots on plate on top of support rail.

(2) Based on flat top heat shields, flat side heat shields and without slots on plate on top of support rail.

Using these loss coefficients in equation for ΔT_{HSM-H}, the exit and stack air temperature for the normal and off-normal cases are calculated.

The DSC outer surface is divided into three regions along the DSC circumference as shown in Figure P.4-2. The bulk air temperatures at each of these specified regions on the DSC are shown in Table P.4-1 for the range of ambient conditions. These bulk air temperatures are used in the subsequent HSM-H analyses to calculate the temperatures throughout HSM-H and 24PTH DSC shell.

P.4.4.4 Description of the Thermal Model of HSM-H with 24PTH DSC

A half symmetric, three dimensional, ANSYS [4.31] finite element model of the HSM-H loaded with 24PTH DSC is shown in Figure P.4-3.

The thermal model consists of SOLID70 conduction elements that simulate concrete and steel support structures of the HSM-H, and SHELL57 elements superimposed on SOLID70 elements, as required, to model radiating surfaces using MATRIX50 super elements. As such, radiation between the DSC shell, heat shields, and HSM-H walls is modeled using the ANSYS /AUX12 methodology. For elements wherein radiation is not applicable, the SHELL57 elements are unselected prior to solving the model. Additionally, to reduce the number of the nodes associated with the model's super-elements, the web of the supporting beam is modeled using only SHELL57 elements. As such, conservatively, radiation is not applied on the web of the supporting beam. This methodology is valid since the supporting beam's web greatly shields the support steel from the DSC radiation via its own flanges. The properties and dimensions of the support beam, such as the thickness of the web are given as real constants to the appropriate SHELL57 elements.

The base plate of the side heat shields are modeled as flat plates. Convection from the fins attached to the side shields is modeled using an equivalent convection coefficient. The purpose of adding fins on the side heat shield is to provide more surface area for the convection. Flat stainless steel heat shields are also evaluated.

This analysis assumes that the finned side heat shield is fabricated completely out of Al-1100. Since the main purpose of the side heat shield is to protect the concrete walls against direct thermal radiation from the DSC, reducing the side heat shield conductivity from Al-1100 to stainless steel does not have any significant effect on the temperature distribution within the HSM-H, provided that the emissivity values of the front and back side of the heat shield remain unchanged. As such, the conductivity values used for the side heat shield are the same as those used for stainless steel.

The top heat shield is a louvered design that is supported from the ceiling of the HSM-H. It is modeled to reflect the actual geometry of the louvers. Flat stainless steel heat shields are also evaluated.

The lower part of the HSM-H sidewall is offset by 6" toward the HSM-H cavity. The thickness of the offset wall is 18". To simplify the analysis, the HSM-H sidewall is modeled as a straight, 12" thick wall without the 6-inch offset. The modeling simplification has an insignificant effect on resultant temperature distribution output. This modeling simplification is justified since majority of the heat removal is via convection, and only a small portion of the heat removal is via conduction through the walls. Modeling of this short segment of the HSM-H wall thinner than it is in actuality does not impact the overall results.

Boundary Conditions

The maximum off-normal ambient temperature of 117°F is considered. In the thermal analysis, a 24-hour average ambient temperature of 105°F, calculated in Section M.4.5 [4.38] is used as the ambient air temperature for the off-normal steady- state analyses.

Convection Coefficients

The correlation for heat transfer convection coefficients over the HSM-H surfaces, including the HSM-H vertical flat surfaces, horizontal surfaces, the side finned heat shield, the top heat shield and the horizontal DSC cylinder surface are determined in Section P.4.9.

The semi-empirical natural convection correlations from [4.17] are based on the ambient temperature being both the initial temperature for the boundary layer at the bottom of the horizontal cylinder, as well as the temperature of any air entrained in the boundary layer as it grows around the circumference of the cylinder. However, it is also true that the temperature of any additional air entrained in the boundary layer will not be equal to the inlet air temperature, but to local bulk air temperature adjacent to the boundary layer. As such, the true value of the 'reference' air temperature within the HSM-H cavity to be used in determining the mean film properties and for computing the heat transfer rate from the surface lies somewhere in between the entering and exit air temperatures. Figure 4-16 in Rohsenow et al., [4.3] suggests the use of mean air temperature when the surface is placed in a stratified medium. Therefore, the average of the entering and exit air temperatures is considered as the bulk temperature around the DSC. This assumption more accurately captures the nature of the flow regime within the module when using free convection correlations for a horizontal cylinder to predict surface temperature of the DSC in the storage module.

The convection correlation used in the ANSYS thermal model provides an average heat transfer rate over the entire circumference of the DSC for the implied geometry and thermal conditions.

However, as the work of Misumi et al., [4.49] and others have shown, the heat transfer rate will be substantially higher for the portion of the DSC's surface downstream of the onset point for turbulence. By not accounting for the variation in heat transfer rate over the surface of the DSC, the methodology will predict higher temperatures for the upper portions of the DSC than will be experienced in reality. At lower decay heat loads, the level of turbulence and the temperature rise in the airflow through the module will be relatively low. As such, although the methodology would still predict conservative temperatures, the deviation from actual values will be smaller everywhere except near the top of the DSC shell.

At higher heat loads for the HSM-H design, the turbulent air regime will be the dominant heat transfer mechanism for the air flow over a greater portion of the DSC surface (see Misumi et al., [4.49]). In this case, the transition to turbulent flow occurs lower down on the DSC's circumference, thus elevating the local convective heat transfer rate. Therefore, applying a constant heat transfer rate with an assumed linear temperature rise for the air flow around the DSC as described in Section 8.1.3.1 will not accurately predict the heat transfer phenomenon at the higher decay heat loads. The under-prediction of the convection heat transfer from the DSC shell would result in the over-prediction of the DSC shell temperatures. The increased convective heat transfer coefficients near the top 22.5° segment of the DSC due to the onset of turbulent flow are estimated by using a "flat-plate-facing-up" correlation for the convective heat transfer coefficient vs. applying the average convection heat transfer coefficient for a cylinder everywhere.

For the space between the HSM-H sidewall and the HSM-H side shield, free convection correlation for a narrow channel is also presented in Section P.4.9.

Convection and radiation from the HSM-H roof and the front wall to the ambient are combined as a total effective coefficient as discussed in Section P.4.9.3.

P.4.4.7 HSM-H Thermal Model Results

P.4.4.7.1 Normal and Off-normal Operating Condition Results

Temperature distributions for the normal and off-normal cases are shown in Figure P.4-6 through Figure P.4-13. The maximum component temperatures for the normal and off-normal cases are listed in Table P.4-2, Table P.4-3, and Table P.4-4. Temperature distributions for the single HSM-H which provides maximum temperature gradients in concrete walls, are shown in Figure P.4-16. Note that Figure P.4-16 shows the analysis temperature distribution before any adjustments made based on the results for bounding Case 1 documented in Table P.4-2. As seen from Table P.4-2 and Table P.4-3, the HSM-H concrete and DSC shell temperatures without the fins on the side heat shield for 31.2 kW are bounded by the case with the fins for 40.8 kW decay heat load. Therefore, fins are not required on the side heat shields in the HSM-H, if the total heat load is 31.2 kW or less. This is summarized in Table P.4-43.

P.4.4.7.2 Accident Condition Results

Temperature distributions for the blocked vent accident case with 40.8 kW decay heat load at 38.5 hours after blockage of the vents are shown in Figure P.4-14. The maximum component temperatures for the blocked vent accident case are listed in Table P.4-5.

Figure P.4-15 shows the time-temperature history of HSM-H components for this transient.

The maximum component temperatures for these cases are listed in Table P.4-6. Figure P.4-17 provides maximum temperature gradients in concrete walls during accident conditions. Table P.4-5 and Table P.4-6 incorporate the adjustments made to the analytical results as described in P.4.4.8 based on the thermal tests of the HSM-H [4.48]. Note that Figure P.4-14, Figure P.4-15 and Figure P.4-17 show the analysis temperature distributions, before any adjustments made based on the results for bounding Case 1 documented in Table P.4-2.

P.4.4.8 Evaluation of HSM-H Performance

The thermal performance of the HSM-H is evaluated under normal, off-normal, and accident conditions of operation as described above and is shown to satisfy all the temperature limits and criteria. The DSC shell temperatures calculated here, are used in the DSC basket and fuel cladding models as a boundary condition in Section P.4.6. The results show that all the basket and fuel cladding material temperature limits are satisfied. The results of the HSM-H temperatures are used in Section P.3 to show that thermal stresses in the HSM-H are also within these allowables.

The results of the 117°F ambient blocked vent condition show that the maximum concrete temperature at the end of 38.5 hours (with finned side heat shields, louvered top heat shield, and with slots on plate on top of support rail) and 30.0 hours (with flat stainless steel heat shields and without slots on plate on top of support rail) in the blocked vent accident are 431 °F and 415 °F, respectively. These are above the 350°F limit given in NUREG 1536 [4.42] for accident conditions. To account for the effect of higher concrete temperature on the concrete compressive strengths, the structural analysis of HSM-H concrete components in Section P.3 is based on 10% reduction in concrete material properties. Testing will be performed to document that concrete compressive strength will be greater than that used in the structural analysis documented in Section P.3.

P.4.6.5.5 Maximum Thermal Stresses

The maximum thermal stresses for the normal conditions of storage and transfer for the NUHOMS®-24PTH DSC are calculated in Section P.3.

P.4.6.5.6 Evaluation of 24PTH DSC Performance for Normal Conditions

The NUHOMS®-24PTH DSC shell and basket are evaluated for the calculated temperatures and pressures as presented in Section P.3. The maximum fuel cladding temperatures are well below the allowable fuel temperature limit of 752°F (400°C) [4.19] as documented in Table P.4-14. The maximum DSC internal pressure remains below 15.0 psig used in Section P.3 during normal conditions of storage and transfer operations. Hence, it is concluded that the NUHOMS®-24PTH DSC design meets all applicable normal condition thermal requirements.

P.4.6.6 DSC Thermal Evaluation for Off-Normal Conditions

The NUHOMS®-24PTH 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®-24PTH system components.

P.4.6.6.1 Off-Normal Ambient Temperatures during Storage

The thermal performance of the NUHOMS®-24PTH DSC within the HSM-H and within HSM Model 102 under the extreme minimum ambient temperatures of -40°F with no insolation and extreme maximum ambient temperature of 117°F with maximum insolation are evaluated for HLZCs 1, 2, 3, 4 and 5.

P.4.6.6.2 Boundary Conditions, Off-Normal Storage

Off-normal conditions of storage analyses of the NUHOMS®-24PTH DSC within the HSM-H and within HSM Model 102 includes (refer to Table P.4-34 for HSM Model 102 cases):

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

The HSM-H thermal model described in Section P.4.4.4 above provides the surface temperatures that are applied to the DSC shell, basket and payload model.

P.4.6.6.3 Off-Normal Ambient Temperatures during Transfer

The thermal performance of the NUHOMS®-24PTH DSC during transfer under the minimum ambient temperature of 0°F with no insolation and 117°F with maximum insolation, and HLZCs 1 (bounds configurations 2 and 3), 4 and 5 are examined. Note: A solar shield is used for transfer operations when ambient temperatures exceed 100°F up to 117°F.

The value of h_{fin} used in the model is 0.031 Btu/hr-in^2-°F which bounds all ambient conditions and decay heat loads. Alternatively, flat stainless side heat shields are also evaluated.

The distance between the base plate of the HSM-H side heat shield and the HSM-H side wall is 2". The intersections of the HSM-H base plate and the HSM-H side walls create a narrow channels behind the side heat shield. The convection coefficient for these narrow channels are calculated using the same methodology described above.

The value of $h_{channel}$ used in the model is 0.003 Btu/hr-in^2-°F which bounds all ambient conditions and decay heat loads.

<u>Convection Coefficients for a Horizontal Cylinders (DSC):</u>

The following equations from Reference [4.17] are used to calculate the free convection coefficients.

$$Nu = \left[(Nu_l)^m + (Nu_t)^m\right]^{1/m} \qquad with \quad m = 3.3 \quad for \;\; 10^{-10} < Ra < 10^{10}$$

$$h_c = \frac{Nu\, k}{D}$$

with:

D = diameter of the horizontal cylinder,
k = air conductivity.

$$Ra = Gr\, \Pr \quad , \quad Gr = \frac{g\,\beta\,(T_w - T_\infty)\, D^3}{\nu^2}$$

$$Nu_l = \frac{2f}{\ln(1 + 2f / Nu^T)} \quad \text{(Nusselt number for fully laminar heat transfer)}$$

$$Nu_t = \overline{C}_t \; Ra^{1/3} \quad \text{(Nusselt number for fully turbulent heat transfer)}$$

$\overline{C}_t = 0.103$ -for horizontal cylinders [4.14].

<u>Convection Coefficients for the HSM-H Vertical Flat Surfaces (End Wall, Side Wall, Vertical Surface of the DSC Plugs, and Side Heat Shield without Fins):</u>

$$Nu = \left[(Nu_l)^m + (Nu_t)^m\right]^{1/m} \qquad with \quad m = 6 \quad for \;\; 1 < Ra < 10^{12}$$

$$h_c = \frac{Nu\, k}{L}$$

with:

L = height of the vertical surface

The above correlations are incorporated in ANSYS model described in Section P.4.4.4.

P.4.9.2 Convection Coefficient for the HSM-H Top Heat Shield

The top shield is a louver design that consists of several inclined plates. Because of the relative large opening between these inclined plates and their collective short length, the interference of the thermal boundary layers is assumed to be minimal such that the convection coefficient can be calculated separately for each plate as follows.

h_{up} = convection coefficient on upper surface of louver plates (positive angled)
h_{down} = convection coefficient on lower surface of louver plates (negative angled)

h_{up} and h_{down} are calculated using the correlations described above in Section P.4.9.1 for inclined plates. Alternatively, flat stainless top heat shields are also evaluated.

P.4.9.3 Combination of Heat Transfer Coefficients for the HSM-H Roof and Front Wall

The HSM-H roof and the front wall dissipate heat to the ambient via free convection and radiation. The total heat transfer coefficient, H_t, is used to combine the convection and radiation heat transfer together, as follows:

$$H_t = h_r + h_c$$

where:

h_r = radiation heat transfer coefficient
h_c = free convection heat transfer coefficient,
horizontal surface facing upwards for roof and
vertical flat surface for front wall described above in Section P.4.9.1

The radiation heat transfer coefficient, h_r, is given by the equation:

$$h_r = \varepsilon\, F_{12}\left[\frac{\sigma(T_1^4 - T_2^4)}{T_1 - T_2}\right] Btu/hr\text{-}ft^2\text{-}^oF$$

where,

ε = surface emissivity,
F_{12} = view factor from surface 1 to ambient,
σ = 0.1714×10^{-8} Btu/hr-ft^2-R^4,
T_1 = surface temperature, (R),
T_2 = ambient temperature, (R).

The above correlations for heat transfer coefficients are incorporated in ANSYS model of Section P.4.4.4.

Table P.4-1
Bulk Air Temperatures at Specified HSM-H Regions for the Various Cases[(1)]

Louvered Top Heat Shield/Finned Side Heat Shield								
Bulk Air Temperature	**Case 8**	**Case 7**	**Case 6**	**Case 5**	**Case 4**	**Case 3**	**Case 2**	**Case 1**
$T_{ambient}$ (°F)	-40	117	-40	117	-40	0	100	117
T_{exit} (°F)	5	168	14	180	26	73	190	196
$T_{average}$ (°F)	-17.5	136.5[(2)]	-13.0	142.5[(2)]	-7.0	36.5	145	150.5[(2)]

Flat Stainless Heat Shields (Top and Sides)								
Bulk Air Temperature	**Case 8B**	**Case 7B**	**Case 6B**	**Case 5B**	**Case 4B**	**Case 3B**	**Case 2B**	**Case 1B**
$T_{ambient}$ (°F)	-40	117	-40	117	-40	0	100	117
T_{exit} (°F)	8	172	18	185	30	78	196	202
$T_{average}$ (°F)	-16	139[(2)]	-11	145[(2)]	-5	39	148	154[(2)]

[(1)] Cases are as listed in Section P.4.4.3.

[(1)] A 24-hour average ambient temperature of 105°F is used as the ambient air temperature for the off-normal steady-state analyses.

Table P.4-2
HSM-H Components Normal and Off-Normal Maximum Temperatures, 40.8 kW Heat Load

Louvered Top Heat Shield/Finned Side Heat Shield				
	Maximum Temperature (°F)			
Component	Ambient 117°F Case 1	Ambient 100°F Case 2[(1)]	Ambient 0°F Case 3[(1)]	Ambient -40°F Case 4[(1)]
DSC Shell	442	439	361	327
Concrete	225	220	99	48
Top Heat Shield	208	202	85	38
Side Shield	199	193	78	32
DSC Support Rail	327	323	224	182

Flat Stainless Heat Shields (Top and Sides)				
	Maximum Temperature (°F)			
Component	Ambient 117°F Case 1B	Ambient 100°F Case 2B	Ambient 0°F Case 3B	Ambient -40°F Case 4B
DSC Shell	459	455	366	327
Concrete	239	232	107	53
Top Heat Shield	258	252	126	67
Side Shield	256	250	125	69
DSC Support Rail	329	324	221	179

(1) The results for these cases are estimated based on the results for Case 1.

Table P.4-3
HSM-H Components Normal and Off-Normal Maximum Temperatures, 31.2 kW Heat Load

Louvered Top Heat Shield/Finned Side Heat Shield or Flat Aluminum Plate			
	Maximum Temperature (°F)(3)		
Component	Ambient 117°F Case 5(1),(4)	Ambient 117°F Case 5A(2)	Ambient -40°F Case 6(4)
DSC Shell	378	388	257
Concrete	198	216	24
Top Heat Shield	189	192	24
Side Heat Shield	180	237	17
DSC Support Rail	285	291	136

Flat Stainless Heat Shields (Top and Side)	
	Maximum Temperature (°F)(3)
Component	Ambient 117°F Case 5B
DSC Shell	398
Concrete	210
Top Heat Shield	226
Side Heat Shield	223
DSC Support Rail	287

Notes:
(1) The results are with fins on side heat shields.
(2) The results are without fins on side heat shields.
(3) The maximum temperatures shown are for the off-normal condition which bounds the normal condition maximum temperatures.
(4) The results for these cases are estimated based on the results for Case 5A.

Table P.4-4
HSM-H Components Normal and Off-Normal Maximum Temperatures, 24 kW Heat Load

Louvered Top Heat Shield/Finned Side Heat Shield		
	Maximum Temperature (°F)(1)	
Component	**Ambient 117°F Case 7**	**Ambient -40°F Case 8(2)**
DSC Shell	335	207
Concrete	186	16
Top Heat Shield	175	13
Side Heat Shield	167	6
DSC Support Rail	253	103

Flat Stainless Heat Shields (Top and Side)	
	Maximum Temperature (°F)
Component	**Ambient 117°F Case 5B**
DSC Shell	348
Concrete	189
Top Heat Shield	203
Side Heat Shield	199
DSC Support Rail	254

Note:

(1) The maximum temperatures shown are for the off-normal condition which bounds the normal condition maximum temperatures.

(2) The results for this case are estimated based on the results for Case 7.

Table P.4-5
HSM-H Components Maximum Temperatures (°F), 40.8 kW Decay Heat Load, 117°F Ambient, Blocked Vent Accident

Component	Louvered/Finned Aluminum Heat Shield 38.5 hr Blockage (Case 9) (2)	Flat Stainless Heat Shields 30.0 hr Blockage (3)
DSC Shell	631	637
Concrete(1)	431	415
Top Heat Shield	375	400
Side Heat Shield	517	553
DSC Support Rail	603	548

(1) The calculated temperature is above the 350°F limit given in [4.7]. Testing will be performed to document that concrete compressive strength will be greater than that assumed in the structural analyses.

(2) The results for this case are estimated based on the results for Case 1 from Table P.4-2.

(3) The results for this case are estimated based on the results for Case 1B from Table P.4-2.

Table P.4-14
Fuel Cladding Normal Condition Maximum Temperatures

Operating Condition	HLZC 1[4] (°F)	HLZC 4 (°F)	HLZC 5 (°F)	Limit (°F)
DSC in HSM-H, 0°F ambient	656	<656[1]	<561[2] / 561[3]	752[6]
DSC in HSM-H, 100°F ambient	718	<718[1]	<634[2] / 634[3]	
DSC in HSM-H, 100°F ambient [8]	734	<704[7]	<628[7]	
DSC in TC, 0°F ambient	<711 @ 12.8 hrs	<732 @ 30 hrs	630	
DSC in TC, 100°F ambient	711 @ 11.5 hrs	732 @ 27.3 hrs	714	
DSC in TC, 100°F ambient [5]	N/A	733	N/A	

1) Temperature is bounded by temperature for HLZC 1.
2) Temperature for storage in HSM-H is bounded by temperature for storage in HSM model 102.
3) Temperature for storage in HSM model 102.
4) Temperatures for HLZC 1 bounds the temperatures for HLZC 2 and 3.
5) Temperatures with aluminum inserts in R45 transition rails.
6) ISG-11, Revision 2 [4.20]
7) Temperatures are bounded by DSC in HSM-H, 117 °F ambient cases (Table P.4-20).
8) HSM-H with flat stainless steel heat shields.

Table P.4-15
DSC Basket Assembly Maximum Normal Operating Component Temperatures; HLZC 1 (40.8 kW)

Operating Condition	T_{alum} (°F)	T_{poison} (°F)	T_{tube} (°F)	$T_{DSC\ shell}$ (°F)
DSC in HSM-H, 0°F ambient (Case 3)	577	578	580	367(3)
DSC in HSM-H, 100°F ambient (Case 2)	649	650	652	445(3)
DSC in HSM-H, 0°F ambient (Case 3B)(5)	<665(1)	<666(1)	<668(1)	<461(1)
DSC in HSM-H, 100°F ambient (Case 2B)(4)(5)	665	666	668	461
DSC transfer in OS197FC, 0°F ambient	<641(1)	<642(1)	<643(1)	444
DSC transfer in OS197FC, 100°F ambient	641(2)	642(2)	643(2)	445

1) Temperatures are bounded by temperatures for 100°F ambient case.
2) Temperatures are provided using bounding storage in HSM-H case with 117°F ambient. See Table P.4-21.
3) Temperatures are conservative. Calculated temperatures are given in Table P.4-2 for Cases 2 and 3.
4) The results for this case are estimated based on Case 2.
5) HSM-H with flat stainless steel heat shields.

Table P.4-16
DSC Basket Assembly Maximum Normal Operating Component Temperatures; HLZC 4 (31.2 kW)

Operating Condition	T_{alum} (°F)	T_{poison} (°F)	T_{tube} (°F)	$T_{DSC\ shell}$ (°F)
DSC in HSM-H, 0°F ambient[(1)]	649	650	651	413
DSC in HSM-H, 100°F ambient[(1)]	<649	<650	<651	<413
DSC in OS197FC cask, 0°F ambient[(3)]	<680[(2)]	<681[(2)]	<682[(2)]	454
DSC in OS197FC cask, 100°F ambient[(3)]	680	681	682	475
DSC in OS197FC cask, 100°F ambient[(4)] (with inserts)	678	679	680	548

1) Temperatures are bounded by Case 5B (Table P.4-22).
2) Temperatures are bounded by temperatures for 100°F ambient case.
3) Assumes 24PTH-S DSC without aluminum inserts in R45 transition rails.
4) Assumes 24PTH-S DSC with aluminum inserts in R45 transition rails.

Table P.4-20
Fuel Cladding Off-Normal Condition Maximum Temperatures

Operating Condition	HLZC 1(5) (°F)	HLZC 4 (°F)	HLZC 5 (°F)	Limit (°F)
DSC in HSM-H, -40°F ambient[12]	630	590	<531[1] / 531[2]	1058
DSC in HSM-H, 117°F ambient[12]	721	684	<653[1] / 653[2]	
DSC in TC, 117°F ambient [3] [4]	<711 @ 11.5 hrs	<732 @ 27.3 hrs	718	752
DSC in OS197FC, 117°F ambient [3] [6] (31.2 kW HLZC 4 with inserts)	N/A	733	N/A	752
DSC in OS197FC, 117°F ambient [3] [7]	681	638	N/A	752

1) Temperature for storage in HSM-H is bounded by temperature for storage in HSM model 102.
2) Temperature for storage in HSM model 102.
3) Sunshade is used for ambient temperatures >100°F and ≤117°F.
4) Temperatures are bounded by transfer in OS197FC without sunshade, 100°F ambient.
5) Temperatures for HLZC 1 bound the temperatures for HLZC 2 and 3.
6) Assumes 24PTH-S DSC with aluminum inserts in R45 transition rails.
7) Assumes 24PTH-S DSC without aluminum inserts in R45 transition rails and use of 475 cfm air circulation with external fan per Table P.4-41 for HLZC 1 and Table P.4-42 for HLZC 4.
8) The results are estimated based on Cases 1, 5, and 7.
9) Temperatures for storage in HSM-H are bounded by Case 1B.
10) Temperatures for storage in HSM-H are bounded by Case 5B.
11) Temperatures for storage in HSM-H are bounded by Case 7B.
12) Temperatures for storage in HSM-H based on louvered top heat shields and finned side heat shields.

Table P.4-21
DSC Basket Assembly Maximum Off-Normal Operating Component Temperatures, HLZC 1[4] (40.8 kW)

Operating Condition	T_{alum} (°F)	T_{poison} (°F)	T_{tube} (°F)	$T_{DSC\ shell}$ (°F)
DSC in HSM-H, -40°F Ambient	546	547	549	333[5]
DSC in HSM-H, 117° F Ambient	653	654	655	448[5]
DSC in OS197FC with sunshade, 117°F ambient[2]	<653[1]	<654[1]	<655[1]	444
DSC in OS197FC with sunshade, 117°F ambient[3]	604	605	607	480
DSC in HSM-H, 117° F Ambient (Case 1B)	670	671	672	465

1) Temperature is provided using bounding storage in HSM-H case with 117°F ambient.
2) Assumes 24PTH-S DSC with aluminum inserts in R45 transition rails.
3) Assumes 24PTH-S DSC with aluminum inserts in R45 transition rails and use of 475 cfm air circulation with external fan per Table P.4-41.
4) HLZC 1 bounds the temperatures for HLZC 2 and 3.
5) Temperatures are conservative. Calculated temperatures are given in Table P.4-2 for Cases 1 and 4.

Table P.4-22
DSC Basket Assembly Maximum Off-Normal Operating Component Temperatures, HLZC 4 (31.2 kW)

Operating Condition	T_{alum} (°F)	T_{poison} (°F)	T_{tube} (°F)	$T_{DSC\ shell}$ (°F)
DSC in HSM-H, -40°F Ambient	522	522	524	270[5]
DSC in HSM-H, 117°F Ambient	649	650	651	413
DSC in OS197FC with sunshade, 117°F Ambient[2]	<680[1]	<681[1]	<682[1]	474
DSC in OS197FC with sunshade, 117°F Ambient[3]	682	683	684	548
DSC in OS197FC with sunshade, 117°F Ambient[4]	575	576	577	415

1) Temperatures are bounded by temperatures for transfer 100°F ambient without sunshade case reported in Table P.4-16.
2) Assumes 24PTH-S DSC without aluminum inserts in R45 transition rails.
3) Assumes 24PTH-S DSC with aluminum inserts in R45 transition rails.
4) Assumes 24PTH-S DSC without aluminum inserts in R45 transition rails and use of 475 cfm air circulation with external fan per Table P.4-42.
5) Temperatures are conservative. Calculated temperatures are given in Table P.4-3 for Cases 5, 5B, and 6.
6) Temperatures are bounded by Case 5B.

Table P.4-25
Fuel Cladding Accident Condition Maximum Temperatures

Heat Load Zoning	HLZC 1(2) (°F)	HLZC 4 (°F)	HLZC 5 (°F)	Limit (°F)
DSC in HSM, Blocked Vent, 117°F	891[1]	<891[2]	<821[3] / 821[4]	1058[5]
DSC in TC, loss of sun shade, neutron shield water and air circulation with fan, if used, 117°F	914	843	747	

1) Temperature at 38.5 hour and 30.0 hour of blocked vents for louvered top heat shield/finned side heat shield and stainless steel heat shields (top and side) respectively.
2) Temperatures for HLZC 1 bound the temperatures for HLZC 2, 3, and 4.
3) Temperature for storage in HSM-H is bounded by temperature for storage in HSM Model 102.
4) Temperature for storage in HSM Model 102 at 40 hours of blocked vent.
5) ISG-11, Revision 2 [4.20]

Table P.4-26
DSC Basket Assembly Accident Maximum Component Temperatures; HLZC 1 (40.8 kW)

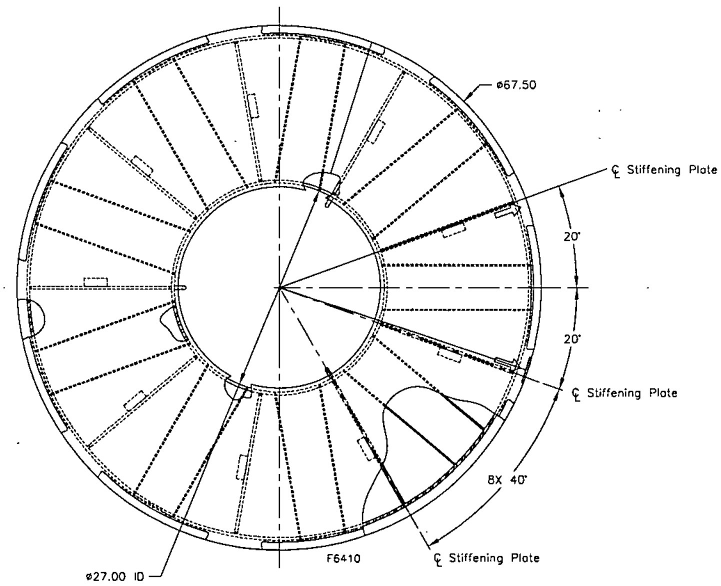
Operating Condition	T_{alum} (°F)	T_{poison} (°F)	T_{tube} (°F)	$T_{DSC\ shell}$ (°F)
DSC in HSM-H, Blocked Vent[(1)], 117°F	840	841	842	637
DSC horizontal in OS197FC loss of sun shade, neutron shield water and air circulation with fan, if used, 117°F Ambient	860	861	862	685

1) Temperature at 38.5 hour and 30.0 hour of blocked vents for louvered top heat shield/finned side heat shield and stainless steel heat shields (top and side) respectively.

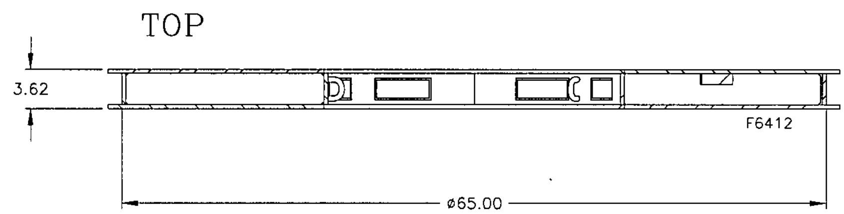
Table P.4-43
HSM-H Concrete and DSC Shell temperatures with and without Side Heat Shield Fins

Case	Heat Load (kW)	Maximum DSC Shell Temperature (°F)	Maximum Concrete Temperature (°F)	Reference
With fins	31.2	391	183	Figure P.4-8
Without fins	31.2	401	201	Figure P.4-10
With fins	40.8	448	202	Figure P.4-11
Without fins(1)	40.8	459	239	--

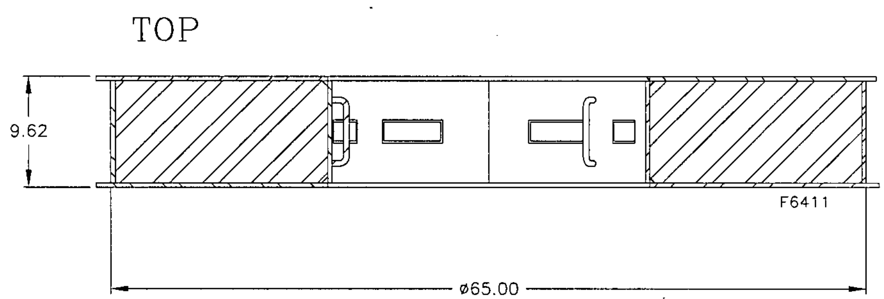
(1) Flat stainless heat shields.



PLAN VIEW OF SHORT SPACER
(LONG SPACER SIMILAR)



ELEVATION VIEW OF SHORT SPACER



ELEVATION VIEW OF LONG SPACER

Figure P.4-18 Plan & Elevation Views of Short and Long Canister Spacers

Table P.6-5
Parameters For PWR Assemblies

(Concluded)

Manufacturer [1]	Array	Version	Clad Thickness (in)	Clad OD (in)	Guide Tube OD (in)	Instrument Tube ID (in)
WE	17x17	LOPAR	0.0225	0.374	24@0.474 1@0.480	24@0.422 1@0.450
WE	17x17	OFA/Van 5	0.0225	0.360	24@0.482 1@0.476	24@0.450 1@0.460
CE	16x16	System 80	0.0250	0.382	5@0.768	5@0.687
B&W[7]	15x15	Mark B2 – B7	0.0265	0.430	16@0.530 1@0.493	16@0.498 1@441
B&W	15x15	Mark B8	0.0265	0.430	16@0.530 1@0.493	16@0.498 1@441
B&W	15x15	Mark B9	0.0265	0.430	16@0.530 1@0.493	16@0.498 1@441
B&W	15x15	Mark B10	0.0250	0.430	16@0.530 1@0.493	16@0.498 1@441
B&W	15x15	Mark B11[2]	0.0240	0.416	16@0.530 1@0.493	16@0.498 1@441
CE	15x15	Palisades	0.0260[3]	0.418[4]	8@0.4135	8@0.3655
Exxon/ANF	15x15	CE	0.0300	0.417	8Guide Bars[5] 1@0.417	1@0.363
Exxon/ANF	15x15	WE	0.0300	0.424	20@0.544 1@0.544	20@0.510 1@0.510
WE	15x15	Std/ZC	0.0242	0.422	20@0.546 1@0.546	20@0.512 1@0.512
CE	14x14	Std/Gen	0.0280	0.440	5@1.115	5@1.035
CE	14x14	Ft. Calhoun	0.0280	0.440	5@1.115	5@1.035
Exxon/ANF	14x14	WE	0.0300	0.424	16@0.541 1@0.480	16@0.507 1@0.448
WE	14x14	ZCA/ZCB	0.0225	0.422	16@0.539 1@0.422	16@0.505 1@0.392
WE	14x14	OFA	0.0243	0.400	16@0.526 1@0.400	16@0.492 1@0.353

NOTES:

(1) Reload fuel assemblies from other manufacturers with these parameters are also acceptable.
(2) Pellet OD ranges from 0.3510 to 0.3600 inches.
(3) Clad thickness ranges from 0.0240 to 0.0295 inches
(4) Clad OD ranges from 0.4135 to 0.4175 inches
(5) Guide Bars are solid Zircaloy-4 approximately 0.40 inches x 0.45 inches
(6) All dimensions shown are nominal
(7) Design details of sub-components like guide tube and instrument tube oversleeves are not important for criticality and are not provided.

P.8.1.5 TC Downending and Transfer to ISFSI

1. If loading with OS197/OS197H/OS197FC TC, drain the TC neutron shield to an acceptable location as required to meet the plant lifting crane capacity limit.

2. Re-attach the TC lifting yoke to the crane hook, as necessary. Ready the transport trailer and cask support skid for service.

3. Move the scaffolding away from the cask as necessary. Engage the lifting yoke and lift the cask over the cask support skid on the transport trailer.

4. The transport trailer should be positioned so that cask support skid is accessible to the crane with the trailer supported on the vertical jacks.

5. Position the cask lower trunnions onto the transfer trailer support skid pillow blocks.

6. Move the crane forward while simultaneously lowering the cask until the cask upper trunnions are just above the support skid upper trunnion pillow blocks.

7. Inspect the positioning of the cask to insure that the cask and trunnion pillow blocks are properly aligned.

8. Lower the cask onto the skid until the weight of the cask is distributed to the trunnion pillow blocks.

9. Inspect the trunnions to ensure that they are properly seated onto the skid and install the trunnion tower closure plates.

10. Fill the neutron shield, if it was drained in step P.8.1.5.1.

11. Remove the bottom ram access cover plate from the cask. Install the two-piece temporary neutron/gamma shield plug to cover the bottom ram access. Install the ram trunnion support frame on the bottom of the TC. (The temporary shield plug and ram trunnion support frame are not required with integral ram/trailer).

P.8.1.6 DSC Transfer to the HSM

1. Prior to transporting the cask to the ISFSI, remove the HSM door, inspect the cavity of the HSM, removing any debris and ready the HSM to receive a DSC. The doors on adjacent HSMs should remain in place.

   Caution: The insides of empty modules have the potential for high does rates due to adjacent loaded modules. Proper ALARA practices should be followed for operations inside these modules and in the areas outside these modules whenever the door from the empty HSM has been removed.

2. Inspect the HSM air inlet and outlets to ensure that they are clear of debris. Inspect the screens on the air inlet and outlets for damage.

CAUTION: Verify that the requirements of Technical Specification 1.2.14, "TC/DSC Transfer Operations at High Ambient Temperatures" are met prior to next step.

3. Using a suitable vehicle, transport the cask from the plant's fuel/reactor building to the ISFSI along the designated transfer route.

4. Once at the ISFSI, position the transport trailer to within a few feet of the HSM.

5. Check the position of the trailer to ensure the centerline of the HSM and cask approximately coincide. If the trailer is not properly oriented, reposition the trailer, as necessary.

6. Unbolt and remove the cask top cover plate.

   CAUTION: Verify that the applicable time limits of Technical Specification 1.2.18 are met.

7. Back the cask to within a few inches of the HSM, set the trailer brakes and disengage the tractor. Extend the transfer trailer vertical jacks.

8. Connect the skid positioning system hydraulic power unit to the positioning system via the hose connector panel on the trailer, and power it up. Remove the skid tie-down bracket fasteners and use the skid positioning system to bring the cask into approximate vertical and horizontal alignment with the HSM. Using optical survey equipment and the alignment marks on the cask and the HSM, adjust the position of the cask until it is properly aligned with the HSM.

9. Using the skid positioning system, fully insert the cask into the HSM access opening docking collar.

10. Secure the cask trunnions to the front wall embedments of the HSM using the cask restraints.

11. After the cask is docked with the HSM, verify the alignment of the TC using the optical survey equipment.

12. Position the hydraulic ram behind the cask in approximate horizontal alignment with the cask and level the ram. Remove either the bottom ram access cover plate or the outer plug of the two-piece temporary shield plug. Power up the ram hydraulic power supply and extend the ram through the bottom cask opening into the DSC grapple ring.

13. Activate the hydraulic cylinder on the ram grapple and engage the grapple arms with the DSC grapple ring.

14. Recheck all alignment marks in accordance with the Technical Specification 1.2.9 limits and ready all systems for DSC transfer.

15. Activate the hydraulic ram to initiate insertion of the DSC into the HSM. Stop the ram when the DSC reaches the support rail stops at the back of the module.

16. Disengage the ram grapple mechanism so that the grapple is retracted away from the DSC grapple ring.

17. Retract and disengage the hydraulic ram system from the cask and move it clear of the cask. Remove the cask restraints from the HSM.

18. Using the skid positioning system, disengage the cask from the HSM access opening.

19. Install the DSC drop-in retainer through the HSM door opening.

20. The trailer may be moved as necessary to install the HSM door. Install the HSM door and secure it in place. Door may be welded for security. Verify that the HSM dose rates are compliant with the limits specified in Technical Specification 1.2.7c or 1.2.7d as appropriate.

21. Replace the TC top cover plate. Secure the skid to the trailer, retract the vertical jacks and disconnect the skid positioning system.

22. Tow the trailer and cask to the designated equipment storage area. Return the remaining transfer equipment to the storage area.

23. Close and lock the ISFSI access gate and activate the ISFSI security measures.

P.8.1.7 Monitoring Operations

1. Perform routine security surveillance in accordance with the licensee's ISFSI security plan.

2. Perform a daily visual surveillance of the HSM air inlets and outlets to insure that no debris is obstructing the HSM vents in accordance with Technical Specification 1.3.1 requirements OR perform a temperature measurement of the thermal performance, for each HSM, on a daily basis in accordance with Technical Specification 1.3.2 requirements.

P.8.2 Procedures for Unloading the Cask

P.8.2.1 DSC Retrieval from the HSM

1. Ready the TC, transport trailer, and support skid for service and tow the trailer to the HSM.
2. Back the trailer as close to the HSM as compatible with HSM door removal and remove the cask top cover plate.
3. Cut any welds from the door and remove the HSM door using a porta-crane. Remove the DSC drop-in retainer.
4. Using the skid positioning system align the cask with the HSM and position the skid until the cask is docked with the HSM access opening.
5. Using optical survey equipment, verify alignment of the cask with respect to the HSM. Install the cask restraints.
6. Install and align the hydraulic ram with the cask.
7. Extend the ram through the cask into the HSM until it is inserted in the DSC grapple ring.
8. Activate the arms on the ram grapple mechanism with the DSC grapple ring.
9. Retract ram and pull the DSC into the cask.
10. Retract the ram grapple arms.
11. Disengage the ram from the cask.
12. Remove the cask restraints.
13. Using the skid positioning system, disengage the cask from the HSM.
14. Install the cask top cover plate and ready the trailer for transport.
15. Replace the door on the HSM.

P.8.2.2 Removal of Fuel from the DSC

When the DSC has been removed from the HSM, there are several potential options for off-site shipment of the fuel. It is preferred to ship the DSC intact to a reprocessing facility, monitored retrievable storage facility or permanent geologic repository in a compatible shipping cask licensed under 10CFR71.

If it becomes necessary to remove fuel from the DSC prior to off-site shipment, there are two basic options available at the ISFSI or reactor site. The fuel assemblies could be removed and reloaded into a shipping cask using dry transfer techniques, or if the applicant so desires, the initial fuel loading sequence could be reversed and the plant's spent fuel pool utilized. Procedures for unloading the DSC in a fuel pool are presented here. However, wet or dry unloading procedures are

P.9.1.4 Component Tests

No change.

P.9.1.5 Shielding Integrity Tests

No change.

P.9.1.6 Thermal Acceptance Tests

The analyses to ensure that the NUHOMS®-24PTH system is capable of performing their heat transfer function are presented in Section P.4.

P.9.1.7 Poison Plate Acceptance Tests

The poison plates only serve as a neutron absorber for criticality control and as a heat conduction path. The NUHOMS®-24PTH DSC safety analyses do not rely upon their mechanical strength except in through-thickness compression. The radiation and temperature environment in the cask is not sufficiently severe to damage the aluminum matrix that retains the boron-containing particles. To assure performance of the plates' Important-to-Safety function, the only critical variables that need to be verified are thermal conductivity and B10 areal density as discussed in the following paragraphs.

P.9.1.7.1 Thermal Conductivity Testing of Poison Plates

The poison plate material shall be qualification tested to verify that the thermal conductivity equals or exceeds the values listed in Section P.4.3. Acceptance testing of the material in production may be done at only one temperature in that range to verify that the conductivity equals or exceeds the corresponding value in Section P.4.3. Room temperature testing may be performed with acceptance criteria values extrapolated from table.

Testing may be by ASTM E1225 [9.3], ASTM E1461 [9.4], or equivalent method, performed on coupons as defined in Section P.9.1.7.2.1. A lot definition and sampling rate may differ from those used for areal density testing.

P.9.1.7.2 B10 Areal Density Testing of Poison Plates

There are three poison materials qualified for the NUHOMS®-24PTH DSC basket:

- Borated aluminum,
- Boron carbide/aluminum metal matrix composites (MMCs), such as Boralyn® or Metamic®, and
- Boral®

For each poison material, the NUHOMS®-24PTH DSC basket is configured with three alternate basket configurations, depending on the boron loadings analyzed (designated as Type A basket for low B10 loading, Type B basket for moderate B10 loading, and Type C basket for high B10 loading). A summary of the minimum poison loadings considered and the corresponding credit

APPENDIX V

NUHOMS® HSM Model 202

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\\

V.1 General Discussion

Appendix V to the NUHOMS® Updated Final Safety Analysis Report (UFSAR) addresses the Important to Safety aspects of adding the HSM Model 202 to the Standardized NUHOMS® system described in the UFSAR. The HSM Model 202, which is based on the HSM-H (described in Appendix P), is added to the UFSAR as an alternative to the HSM Model 80, Model 102, and Model 152. The primary reason for adding a fourth HSM design (Model 202) is to include an HSM design that offers even greater biological shielding compared to Models 80 and 102, and greater heat rejection capabilities than those currently available in Models 80/102/152.

The Model 202 is a "one size fits all" module, which can accommodate both PWR (187") and BWR (197") length Dry Shielded Canisters (DSCs). The varying lengths of the DSCs are accommodated through the use of rail spacers. Similar to the design basis, function, and operation of the HSM Models 80/102/152, the Model 202 provides an independent, passive system with heat removal capacity sufficient to ensure that peak cladding temperatures during long term storage of spent fuel assemblies remain below acceptable limits to assure fuel cladding integrity.

The format of this appendix follows the guidance provided in NRC Regulatory Guide 3.61 [1.1]. The analyses presented in this appendix demonstrates that the HSM Model 202 system meets all the requirements of 10 CFR 72 [1.2].

Several sections of this appendix have been identified as "No Change." For these sections, the description or analysis presented in the corresponding sections of the UFSAR for the Standardized NUHOMS® system is also applicable to the HSM Model 202. In addition, tables and figures presented in the UFSAR which remain unchanged due to the addition of the HSM Model 202 to the Standardized NUHOMS® system are not repeated in this appendix.

NOTE: References to sections or chapters within this appendix are identified with a prefix V (e.g., Section V.2.3 or Chapter V.2). References to sections or chapters of the UFSAR outside of this appendix (i.e., main body of the UFSAR) are identified with the applicable UFSAR section or chapter number (e.g., Section 2.3 or Chapter 2). The references used in this appendix are identified as [X.X] (e.g., [1.1] is reference 1.1 at the end of Chapter V.1).

V.1.1 Introduction

This appendix adds the HSM Model 202 to the NUHOMS® system. Only those features that are being revised or added to the NUHOMS® system are addressed and evaluated in this appendix. Sections of this appendix which are not affected by the addition of the HSM Model 202 are indicated in this appendix with "No Change." The various DSCs and Transfer Cask (TC) in the Standardized NUHOMS® system remain unchanged.

The HSM Model 202 is based on the HSM-H, which is currently qualified to store only 24PTH DSCs. The HSM Model 202 is qualified to store payloads with a maximum decay heat load of 24.0 kW, similar to the Standardized HSM Models 80 and Model 102. The HSM Model 202 is being added to the UFSAR as an alternative to the HSM Model 80/102/152. The primary reason

for adding the HSM Model 202 is to incorporate an HSM design that offers even greater biological shielding compared to Models 80 and 102, and greater heat rejection capabilities than those currently available in Models 80/102/152.

The HSM Model 80 and Model 102 were the original HSM designs included in the UFSAR. Thus, the addition of HSM Model 202 is being accomplished by qualifying it in comparison to HSM Model 80 and HSM Model 102.

This evaluation focuses solely on comparing HSM Model 202 to HSM Model 80 and HSM Model 102. The major differences between HSM Model 202 and the existing HSM Model 80 and HSM Model 102 are listed in Table V.1-1 and highlighted in Section P.1.2.1.2. Other than a general increase in the overall height of the module to minimize air flow resistance, selected differences in the wall and roof thicknesses, elimination of the gap between adjacent modules, and a change in the vent configuration to facilitate decay heat removal, there are no other significant differences between these three HSM designs -- all of which are passively cooled. Moreover, all three HSM designs still consist of massive reinforced concrete structures that are capable of withstanding all normal condition loads as well as the abnormal condition loads created by earthquakes, tornadoes, flooding, and other natural phenomena hazards, and they still remove decay heat by natural circulation convection and by conduction through the HSM walls and roof.

V.1.2 General Description of the NUHOMS® HSM Model 202

V.1.2.1 NUHOMS® HSM Model 202 Characteristics

An isometric view of the prefabricated NUHOMS® HSM Model 202 is shown in Figure V.1-1. A drawing of the HSM Model 202 is presented in Section V.1.5. Nominal dimensions and the empty weight of the HSM Model 202 are shown in Table V.1-1. The material, geometry and dimensions of the Model 202 are based on the NUHOMS® HSM-H design described in Appendix P.

V.1.2.2 Operational Features

V.1.2.2.1 General Features

The HSM Model 202 is designed to safely store a DSC with a maximum weight up to 110 kips which bounds the weight of the 24P, 52B, 61BT, 24PT2, 32PT, 24PHB and 24PTH-S-LC DSCs. The HSM Model 202 protects the DSC from the potentially adverse effects of natural phenomena hazards, such as earthquake, tornado, tornado missiles, and flood. In addition, the HSM Model 202 dissipates decay heat from the spent fuel by a combination of radiation, conduction, and convection. Natural convection air flow enters the bottom side walls of the HSM, circulates around the DSC, and exits through the flow channels along the top side walls of the HSM. The cross-sectional areas of the air inlet and outlet openings, and the interior flow paths are designed to optimize ventilation air flow for decay heat removal. Furthermore, like the HSM Models 80/102/152, a thermal radiation heat shield is used in the Model 202 to reduce the HSM concrete temperatures to acceptable limits for all thermal conditions.

V.1.2.2.2 Sequence of Operations

The sequence of operations to be performed in loading a DSC containing spent nuclear fuel into the NUHOMS® HSM Model 202 is presented in Chapter V.8.

V.1.2.2.3 Identification of Subjects for Safety and Reliability Analysis

V.1.2.2.3.1 Criticality Prevention

No change.

V.1.2.2.3.2 Chemical Safety

There are no chemical safety hazards associated with operations of the NUHOMS® HSM Model 202 system.

V.1.2.2.3.3 Operation Shutdown Modes

The NUHOMS® HSM Model 202 is a totally passive system so that consideration of operation shutdown modes is unnecessary.

V.1.2.2.3.4 Instrumentation

No change.

V.1.2.2.3.5 Maintenance Techniques

No change.

V.1.2.3 Cask Contents

No change.

V.1.3 Identification of Agents and Contractors

Transnuclear, Inc. (TN) provides the design, analysis, licensing support and quality assurance for the NUHOMS® HSM Model 202 system. Fabrication of the NUHOMS® HSM Model 202 is done by one or more qualified fabricators under TN's quality assurance program described in Chapter V.13. This program is written to satisfy the requirements of Subpart G of 10CFR72, [1.2] and covers control of design, procurement, fabrication, inspection, testing, operations and corrective action. Experienced TN operations personnel will assist in the preparation of generic operating procedures and provide training to utility personnel prior to their first use of the NUHOMS® HSM Model 202 system.

Managerial and administrative controls, which are used to ensure safe operation of the casks, will be provided by the host utility. NUHOMS® HSM Model 202 system operations and maintenance will be 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 CoC 1004.

V.1.4 Generic Cask Arrays

No change.

V.1.5 Supplemental Data

The following Transnuclear drawing is enclosed:

1. NUH-03-7002-SAR Standardized NUHOMS® ISFSI HSM Model 202 Main Assembly

V.1.6 References

[1.1] US 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."

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

ALL DIMENSIONS ARE NOMINAL UNLESS A SPECIFIC TOLERANCE IS INDICATED WITH THE DRAWING DIMENSION

DIMENSIONS ARE IN INCHES AND DEGREES UNLESS OTHERWISE SPECIFIED. DIMENSIONING IN ACCORDANCE WITH ASME Y14.5M

INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4

TRANSNUCLEAR
AN AREVA COMPANY

SAFETY ANALYSIS REPORT
STANDARDIZED® NUHOMS ISFSI
HSM MODEL 202
MAIN ASSEMBLY

DRAWING NO.	SCALE	SHEET	REVISION
NUH-03-7002-SAR	NONE	1 OF 1	0

Table V.1-1
Comparison of Key Parameters of NUHOMS® HSM Model 202 versus HSM Model 80 and Model 102

Characteristic	HSM Model 80	HSM Model 102	HSM Model 202
Overall Length (without Shield Walls)	19'-10" (BWR)	19'-10" (BWR)	20'-8"
Overall Width (without Shield Walls)	9'-8"	9'-8"	9'-8"
Overall Height	15'-0"	15'-0"	18'-6" (without vent cover)
Roof Thickness	3'-0"	3'-0"	3'-8"
End Shield Wall Thickness	2'-0"	2'-0"	3'-0"
Rear Shield Wall Thickness	2'-0"	2'-0"	3'-0"
Side Wall Thickness	1'-6"	1'-6"	1'-0
Back Wall Thickness	1'-0"	1'-0"	1'-0"
Front Wall Thickness	2'-6"	2'-6"	3'-6"
Floor Thickness	1'-0"	1'-0"	N/A
Door Construction	~ 8" thick consisting of concrete core (~ 6") encased by stainless steel (2")	24" thick consisting of reinforced concrete	Min. of 18-1/2" thick reinforced concrete attached to a 7-7/8" thick steel plate
Inlet Vent Configuration	4 along lower side walls	4 along lower side walls	2 along bottom of side walls
Inlet Vent Area	1200 in^2	1200 in^2	2368 in^2
Outlet Vent Configuration	4 along upper side walls	4 along upper side walls	2 along upper side walls
Outlet Vent Area	1680 in^2	1680 in^2	2368 in^2
Gap Between Adjacent Modules Placed Side-By-Side	6"	6"	0"
Bird Screen Type	Wire Cloth 3/4" mesh x 0.080" wire	Wire Cloth 3/4" mesh x 0.080" wire	Wire Cloth 3/4" mesh x 0.080" wire
Weight – Base Unit (including HSM support steel)	164,403 lbs	167,267 lbs	178,424 lbs
Weight – Roof	80,970 lbs	82,486 lbs	107,261 lbs
Weight Door	6,556 lbs	11,200 lbs	21,510 lbs
DSC Support Steel Configuration	Structural steel frame with rails installed to permit sliding of DSC	Structural steel frame with rails installed to permit sliding of DSC	Guide rails bolted to concrete to permit sliding of DSC
Heat Shield Thickness	12 Gauge (0.1054") Galvanized Steel	12 Gauge (0.1054") Galvanized Steel	2" x 1/8" thick Aluminum Plates to form a Louvered Roof Heat Shield and 1/4" thick Anodized Aluminum Side Heat Shields <u>Alternate Heat Shield Configuration:</u> 12 Gauge (0.1054") flat stainless steel top and side Heat Shields

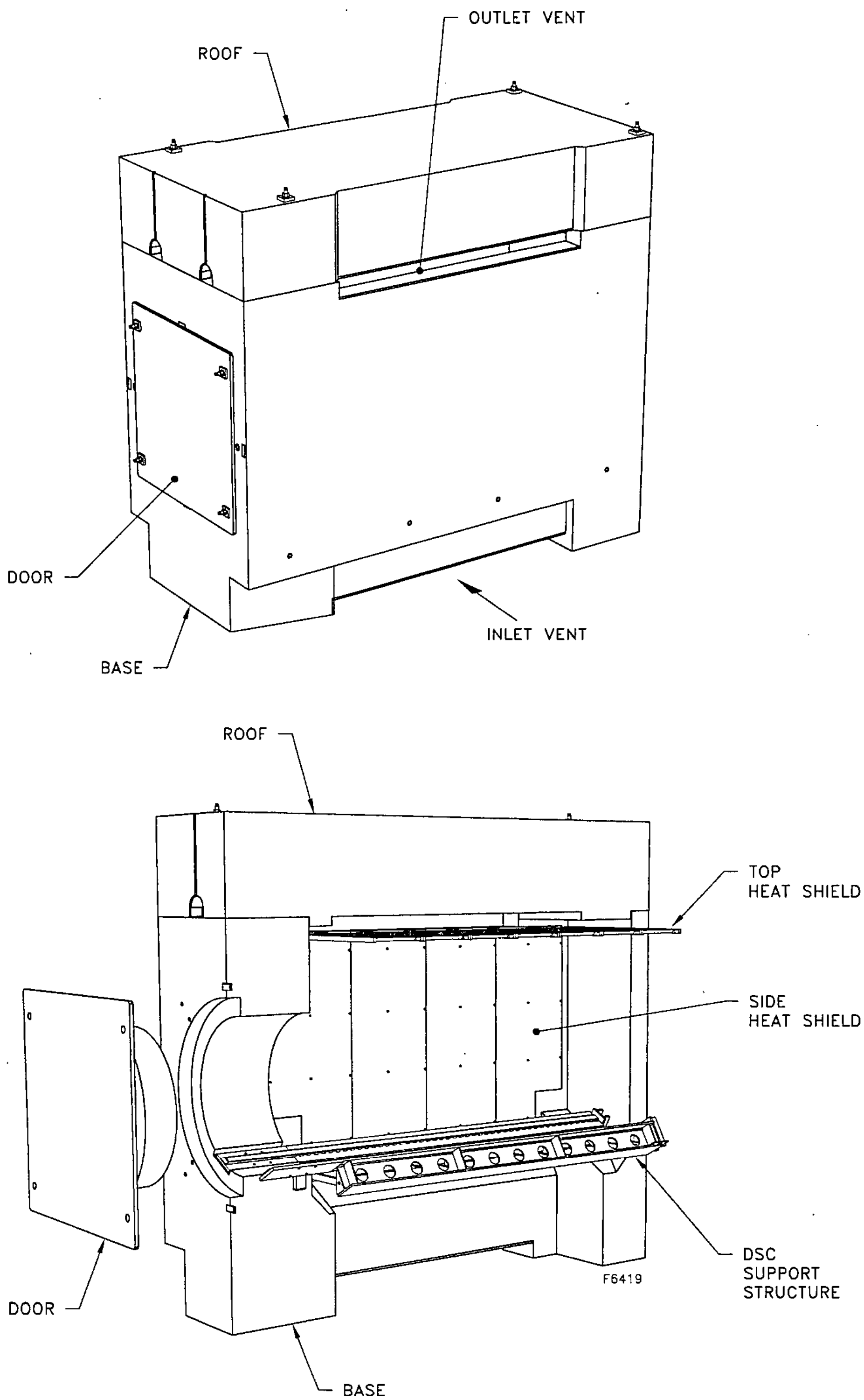

Figure V.1-1
Prefabricated NUHOMS® Horizontal Storage Module (Model 202)

V.2 Principal Design Criteria

This section provides the principal design criteria for the NUHOMS® HSM Model 202 system. With the exception of the seismic design criteria and the tornado wind pressure loads, the principal design criteria for the NUHOMS® HSM Model 202 are the same as the NUHOMS® HSM Model 80 and Model 102 as described in Chapter 3. Section V.2.1 presents a general description of the spent fuel to be stored. Section V.2.2 provides the design criteria for environmental conditions and natural phenomena. Section V.2.3 provides a description of the systems which have been designated as important to safety. Section V.2.4 discusses decommissioning considerations. Section V.2.5 summarizes the NUHOMS® HSM Model 202 design criteria.

V.2.1 Spent Fuel To Be Stored

The NUHOMS® DSCs are designed to store a total of 24 or 32 PWR fuel assemblies and 52 or 61 BWR fuel assemblies with the same characteristics as those described, respectively, in Chapter 3 and Appendices Chapters J.1.1, K.2, L.2, M.2, N.2, and P.2.

V.2.1.1 General Operating Functions

No change.

V.2.2 Design Criteria for Environmental Conditions and Natural Phenomena

The NUHOMS® HSM Model 202 is handled and utilized in the same manner as the existing NUHOMS® HSM Model 80 and Model 102 systems. The environmental conditions, natural phenomena and design criteria are the same as described for the NUHOMS® HSM Model 80 and Model 102 in Chapter 3. Design criteria for the NUHOMS® DSC and TC remain unchanged.

V.2.2.1 Tornado Wind and Tornado Missiles

No change. The applicable maximum design pressures for the design basis tornado evaluations are presented in Sections 3.2.1.1 and 3.2.1.2. The missile criteria used for the HSM Model 202 bounds that provided in Section 3.2.1.2.

V.2.2.2 Water Level (Flood) Design

No change.

V.2.2.3 Seismic Design

No change to the seismic criteria described in Section 3.2.3. However, the HSM Model 202 is designed to withstand a horizontal ground acceleration of 0.30g and a vertical ground acceleration of 0.20g, which bounds the seismic criteria used in designing the NUHOMS® HSM Model 80 and Model 102 systems. The seismic design criteria for the HSM Model 80 and HSM Model 102 are 0.25g horizontal and 0.17g vertical acceleration.

The results of the frequency analysis of the HSM Model 202 structure (which includes a simplified model of the DSC having a bounding weight of 110,000 lbs which results in a lower bound frequency) yields a lowest frequency of 23.2 Hz in the transverse direction and 28.4 Hz in the longitudinal direction. The lowest vertical frequency exceeds 33 Hz. Thus, based on the R.G. 1.60 response spectra amplifications, the corresponding seismic accelerations used for the design of the HSM Model 202 are 0.37g and 0.33g in the transverse and longitudinal directions, respectively, and 0.20g in the vertical direction. These are conservative acceleration values since they are based on amplifications from R.G. 1.60 spectra, anchored at 0.3g horizontal and 0.2g vertical. The corresponding accelerations applicable to the DSC are 0.41g and 0.36g in the transverse and longitudinal directions, respectively, and 0.20g in the vertical direction. The seismic analysis of the HSM-H and 24PTH DSC are further discussed in Section P.3.7.

From Section 3.2.3, the lowest frequency of the HSM Model 80 and Model 102 is 19.1 Hz. Because the lowest frequency of the loaded HSM Model 80 and Model 102 is lower than the lowest frequency of HSM Model 202 (loaded with a bounding DSC weight of 110,000 lbs) of 23.2 Hz, the seismic acceleration used for evaluation of the DSCs remain bounding relative to HSM Model 202 seismic accelerations.

V.2.2.4 Snow and Ice Loading

No change.

V.2.2.5 Combined Load Criteria

No change. The load combination criteria used for the HSM Model 202 has been reconciled and bound that given in Section 3.2.5.1.

V.2.3 Safety Protection Systems

V.2.3.1 General

No change.

V.2.3.2 Protection By Multiple Confinement Barriers and Systems

No change.

V.2.3.3 Protection By Equipment and Instrumentation Selection

No change.

V.2.3.4 Nuclear Criticality Safety

V.2.3.4.1 Control Methods for Prevention of Criticality

No change.

V.2.3.4.2 Error Contingency Criteria

No change.

V.2.3.4.3 Verification Analysis-Benchmarking

No change.

V.2.3.5 Radiological Protection

No change.

V.2.3.6 Fire and Explosion Protection

No change.

V.2.4 Decommissioning Considerations

No change.

V.2.5 Summary of NUHOMS® HSM Model 202 Design Criteria

The principal design criteria for the NUHOMS® HSM Model 202 are based on those presented for the NUHOMS® HSM-H shown in Table P.2-18, and reconciled against the HSM Model 80 and Model 102 criteria in Table 3.2-1. The NUHOMS® HSM Model 202 is designed to store a DSC loaded with PWR or BWR fuel assemblies identical to those stored in a NUHOMS® HSM Model 80 or Model 102 as described in Chapter 3 and Appendices Chapters J.2, K.2, L.2, M.2, N.2, and P.2.

V.3 Structural Evaluation

V.3.1 Structural Design

V.3.1.1 Discussion

This section describes the structural evaluation of the NUHOMS® HSM Model 202 system. The HSM Model 202 is based on to the NUHOMS® HSM-H described in Appendix P.3, and is capable of storing the 24P, 52B, 61BT, 24PT2, 32PT, 24PHB, and 24PTH-S-LC DSCs. Sections that do not have an effect on the evaluations presented in the UFSAR include a statement that there is no change to the UFSAR.

V.3.1.1.1 General Description of the HSM Model 202

The HSM Model 202 is a freestanding reinforced concrete structure designed to provide environmental protection and radiological shielding for the DSC. The HSM Model 202 is designed to accommodate all DSC configurations with a maximum heat-load of 24 kW (24P, 52B, 61BT, 24PT2, 32PT, 24PHB, and 24PTH-S-LC DSC). Each HSM Model 202 provides a self-contained modular structure for the storage of a DSC containing up to 32 PWR spent fuel assemblies (SFAs) or 61 BWR SFAs. The HSM Model 202 is based on the HSM-H described in Section P.3.1.1.2.

V.3.1.2 Design Criteria

The design criteria for the HSM Model 202 are provided in Section V.2.2. The design criteria for the DSCs, as presented in Chapter 3 and Appendices K, L, M, N and P (24PTH-S-LC only); and TC, as presented in Chapter 3, are not changed.

V.3.2 HSM Weights

Table V.3-1 shows the weights of the various components of the NUHOMS® HSM Model 202 system. The dead weights of the components are determined based on the nominal dimensions.

V.3.3 Mechanical Properties of Materials

The material and section properties used for different components of the HSM Model 202 and the internal DSC support structure are identical to those used for the HSM-H as described in Section P.3.3.2.

V.3.4 General Standards for Casks

No change to the evaluation presented in the UFSAR.

V.3.5 Fuel Rods

No change to the evaluation presented in the UFSAR.

V.3.6 Structural Analysis (Normal and Off-Normal Operations)

In accordance with NRC Regulatory Guide 3.48 [3.1] the design events identified by ANSI/ANS 57.9-1984, [3.2] form the basis for the accident analyses performed for the Standardized NUHOMS® system. Four categories of design events are defined. Design event Types I and II cover normal and off-normal events and are addressed in Section 8.1. Design event Types III and IV cover a range of postulated accident events and are addressed in Section 8.2. The purpose of this section of the appendix is to present the structural analyses for normal and off-normal operating conditions for the NUHOMS® HSM Model 202 system using a format similar to the one used in Section 8.1 for analyzing the NUHOMS® HSM Model 80 and Model 102 systems.

V.3.6.1 Normal Operation Structural Analysis

Table 8.1-1 shows the normal operating loads for which the NUHOMS® safety-related components are designed. The table also lists the individual NUHOMS® components which are affected by each loading. The magnitude and characteristics of each load are described in Section V.3.6.1.1.

The method of analysis and the analytical results for each load are described in Section V.3.6.1.4.

V.3.6.1.1 Normal Operating Loads

The normal operating loads for the NUHOMS® system components are:

1. Dead Weight Loads
2. Design Basis Internal and External Pressure Loads
3. Design Basis Thermal Loads
4. Operational Handling Loads
5. Design Basis Live Loads

These loads are described in detail in the following paragraphs.

A. Dead Weight Loads

Table V.3-1 shows the weights of various components of the NUHOMS® HSM Model 202 system. The deadweight of the component materials is determined based on nominal component dimensions.

B. Design Basis Internal and External Pressure

No change.

C. Design Basis Thermal Loads

The normal condition temperature distributions for the HSM Model 202 are presented in Section V.4.4. Stress analysis for normal thermal loads for the HSM Model 202 is provided in Section V.3.6.1.4 C for 40.8 kW heat load which bounds 24 kW.

D. Operational Handling Loads

No change. The evaluation in Chapter 8, Section 8.1.1.1 D uses a DSC weight of 102,000 lbs, which bounds the weight of all DSCs to be stored in the HSM Model 202.

E. Design Basis Live Loads

A live load of 200 pounds per square foot is conservatively selected to envelope all postulated live loads acting on the HSM Model 202, including the effects of snow and ice.

V.3.6.1.2 Dry Shielded Canister Analysis

There is no change to the DSC shell assembly stress analyses for the 24P and 52B (presented in UFSAR Chapter 8) and 61BT, 24PT2, 32PT and 24PHB as documented in UFSAR Appendices K, L, M and N, respectively. Due to the higher thermal efficiency of the HSM Model 202, relative to the HSM Model 80 and Model 102, the DSC shell temperatures (thus, basket component and fuel cladding temperatures) for these DSCs remain bounding with respect to those temperatures when stored in the HSM Model 202. The shell assembly stress analysis for the 24PTH-S-LC DSC stored in the HSM-H, documented in Appendix P, remain applicable for the HSM Model 202.

V.3.6.1.3 DSC Basket Analysis

There is no change to the basket internals stress analyses for the 24P and 52B (presented in UFSAR Chapter 8) and 61BT, 24PT2, 32PT and 24PHB DSCs as documented in Appendices K, L, M and N, respectively. Due to the higher thermal efficiency of the HSM Model 202, the DSC shell temperatures, and thus the basket component temperatures for these DSCs, remain bounding with respect to those when stored in the HSM Model 202. The basket stress analysis for the 24PTH-S-LC DSC stored in the HSM-H and documented in Appendix P, remain applicable for the HSM Model 202.

V.3.6.1.4 NUHOMS® HSM Model 202 Structural Analysis

The reinforced concrete and the support steel structure of the HSM Model 202 are analyzed for the normal, off-normal, and postulated accident conditions using finite element models described in Section V.3.7.8. These models are used to evaluate concrete and support structure forces and moments due to dead load, live load, normal thermal loads, and normal handling loads. The methodology used to evaluate the effects of these normal loads is addressed in the following paragraphs:

A. HSM Model 202 Dead Load Analysis

Dead loads are applied to the analytical model by application of 1.05g where g is the gravitational acceleration in the vertical direction (386.4 in/sec^2). The 5% variation in the dead load is in accordance with ANSI/ANS 57.9 [3.2].

B. HSM Model 202 Live Load Analysis

Live load analysis is performed by applying 200 psf pressure on the roof and the DSC weight as a distributed load on the support structure. The normal handling load of 80 kips during DSC insertion and 60 kips during DSC retrieval is included as a live load for concrete component evaluation.

C. HSM Model 202 Normal Operating Thermal Stress Analysis

Normal operating thermal stress analysis of the concrete structure is performed for the temperatures corresponding to 0°F, 70°F and 104°F (100°F Case) ambient conditions for a 24.0 kW heat load. The maximum temperature in the concrete components corresponding to this case is bounded by the off-normal condition as shown in Table V.4-2.

D. HSM Model 202 Operational Handling Load Analysis

The operation handling loads of 80 kips during DSC insertion and 60 kips during DSC retrieval are applied to the rail support structure in the axial direction. In addition, the DSC weight is applied as a distributed load on both rails of the HSM Model 202.

The normal operating handling loads are considered as live loads for the design of the concrete components.

E. HSM Model 202 Design Basis Wind Load Analysis

The DSC support structure and DSC inside the HSM Model 202 are not affected by wind load. The concrete structure forces and moments due to design basis wind load are bounded by the results of tornado generated wind load.

V.3.6.2 Off-Normal Load Structural Analysis

Table 8.1-2 shows the off-normal operating loads for which the NUHOMS® safety-related components are designed. This section describes the design basis off-normal events for the NUHOMS® system and presents analyses which demonstrate the adequacy of the design safety features of a NUHOMS® HSM Model 202 system with a 24 kW DSC.

For an operating NUHOMS® system, off-normal events could occur during fuel loading, cask handling, trailer towing, canister transfer and other operational events. Two off-normal events are defined which bound the range of off-normal conditions. The limiting off-normal events are defined as a jammed DSC during loading or unloading from the HSM Model 202 and the extreme ambient temperatures of -40°F (winter) and +117°F/125°F (summer). The two off-

normal temperatures are the 117°F off-normal temperature for the 24PHB and 32PT DSC and the 125°F off-normal temperature for all other DSCs. These events envelop the range of expected off-normal structural loads and temperatures acting on the DSC and HSM Model 202. These off-normal events are described in Section 8.1.2.

V.3.6.2.1 Jammed DSC During Transfer

The interfacing dimensions of the top end of the transfer cask and the HSM Model 202 access opening sleeve are specified so that docking of the transfer cask with the HSM Model 202 is not possible should gross misalignments between the transfer cask and HSM Model 202 exist. Furthermore, beveled lead-ins are provided on the ends of the transfer cask, DSC, and DSC support rails to minimize the possibility of a jammed DSC during transfer. Nevertheless, it is postulated that if the transfer cask is not accurately aligned with respect to the HSM Model 202, the DSC binds or becomes jammed during transfer operations.

The interfacing dimensions and design features of the HSM Model 202 access opening, DSC Support Structure and the on-site transfer cask is similar to those described in Section 8.1.2. The insertion and extraction forces applied on the DSC during loading and unloading operations are the same as those specified in Section 8.1.2. Hence the analysis for a jammed canister as described in Section 8.1.2 for the NUHOMS® HSM Model 102 remains applicable to the NUHOMS® HSM Model 202 system, as it relates to HSMs. For a jammed DSC during transfer, DSCs with a 0.5" thick shell, like the 24PTH-S-LC, the stress in the DSC shell is evaluated in P.3.6.2.1 and is shown to be less than the ASME Code allowables as shown in Table P.3.6-3.

V.3.6.2.2 Off-Normal Thermal Loads Analysis

As described in Section 8.1.2, the NUHOMS® system is designed for use at all reactor sites within the continental United States. Therefore, off-normal ambient temperatures of -40°F (extreme winter) and 117°F/125°F (extreme summer) are conservatively chosen. In addition, even though these extreme temperatures would likely occur for a short period of time, it is conservatively assumed that these temperatures occur for a sufficient duration to produce steady state temperature distributions in each of the affected NUHOMS® components. Each licensee should verify that this range of ambient temperatures envelopes the design basis ambient temperatures for the ISFSI site. The NUHOMS® system components affected by the postulated extreme ambient temperatures are the transfer cask and DSC during transfer from the plant's fuel/reactor building to the ISFSI site, and the HSM Model 202 during storage of a DSC.

The off-normal stress analysis results for the HSM Model 202 are presented in Section V.3.6.2.3.

V.3.6.2.3 HSM Model 202 Off-Normal Loads

A. Off-Normal Thermal Loads Analysis

This load case is the same as the normal thermal load but with an ambient temperature range from –40°F to 117°F/125°F. The temperature distributions for the extreme ambient conditions are used in the analysis for the concrete component evaluation.

B. Off-Normal Handling Loads Analysis

This load case assumes that the transfer cask is not accurately aligned with respect to the HSM Model 202 resulting in binding of the DSC during a transfer operation causing the hydraulic pressure in the ram to increase. The ram force is limited to a maximum load of 80 kips during insertion and 80 kips during retrieval. Therefore, for the steel support structure, the off-normal jammed canister load is defined as an axial load on one rail of 80 kips during DSC insertion plus a vertical load of one-fourth the DSC weight (on each rail) at the most critical location. The off-normal operating handling loads are considered as live loads for the design of the concrete components. Specifically, for the concrete module, the maximum 80 kip load during DSC insertion is applied as a live load.

V.3.7 Structural Analysis (Accidents)

The design basis accident events specified by ANSI/ANS 57.9-1984, [3.2] and other credible accidents postulated to affect the normal safe operation of the Standardized NUHOMS® system are addressed in this section. Analyses are provided for a range of hypothetical accidents, including those with the potential to result in an annual dose greater than 25 mrem outside the owner controlled area in accordance with 10CFR72. The postulated accidents considered in the analysis and the associated NUHOMS® components affected by each accident condition are shown in Table 8.2-1.

In the following sections, each accident condition is analyzed to demonstrate that the requirements of 10CFR72.122 [3.3] are met and that adequate safety margins exist for the Standardized NUHOMS® HSM Model 202 design. The resulting accident condition stresses in the NUHOMS® system components are evaluated and compared with the applicable code limits set forth in Section 3.2 and Section V.2, as applicable. Where appropriate, these accident condition stresses are combined with those of normal operating loads in accordance with the load combination definitions in Tables 3.2-5 and 3.2-8. Load combination results for the HSM Model 202 are presented in Section V.3.7.7.

The postulated accident conditions addressed in this section include:

A. Reduced HSM air inlet and outlet shielding (Section V.3.7.1)

B. Tornado winds and tornado generated missiles (Section V.3.7.2)

C. Design basis earthquake (Section V.3.7.3)

D. Design basis flood (Section V.3.7.4)

E. Lightning effects (Section V.3.7.5)

F. Debris blockage of HSM air inlet and outlet opening (Section V.3.7.6)

V.3.7.1 Reduced HSM Air Inlet and Outlet Shielding

This accident condition is addressed in Section V.11.2.1.

V.3.7.2 Tornado Winds/Tornado Missile

The applicable design parameters for the design basis tornado (DBT) are specified in Section V.2.2.1. The determination of the tornado wind and tornado missile loads acting on the HSM Model 202 are also detailed in that section. The end modules of an array utilize shield walls to resist tornado wind and missile loads.

Stability and stress analyses are performed to determine the response of the HSM Model 202 to tornado wind pressure loads. The stability analyses are performed using closed-form calculation methods to determine sliding and overturning response of the HSM Model 202 array. A single HSM Model 202 with both the end and the rear shield walls is conservatively selected for the analyses. The stress analyses are performed using the ANSYS finite element model of a single HSM Model 202 to determine design forces and moments. These conservative generic analyses envelop the effects of wind pressures on the HSM Model 202 array. Thus, the requirements of 10CFR 72.122 [3.3] are met.

In addition, the HSM Model 202 is evaluated for tornado missiles. The adequacy of the HSM Model 202 to resist tornado missile loads is addressed using empirical formulae, described in Section V.11.

V.3.7.2.1 Effect of DBT Wind Pressure Loads on HSM Model 202

The HSM Model 202 is qualified for maximum DBT generated design wind loads of 398 lb/ft^2 and 195 lb/ft^2 on the windward and leeward HSM Model 202 walls, respectively and a pressure drop of 3 psi. The pressure drop has no effect on the HSM Model 202 since the HSM Model 202 is an open structure, due to the presence of the inlet and outlet vents.

V.3.7.2.1.1 HSM Model 202 Overturning Analysis

The maximum Design Basis Tornado (DBT) generated wind loads are 398 psf and 195 psf on the windward and leeward walls in an HSM Model 202 array. For an HSM Model 202 array, the critical module is on the leeward end of an array where it is protected by an end shield wall. The end module in an array will be subjected only to the 195 psf wind suction load.

For the overturning analysis, it is conservatively assumed that 398 psf pressure acts on the windward side and 195 psf suction acts on the leeward side of a module. Also, a suction of 356 psf is applied to the roof of each HSM Model 202 in the array.

The stabilizing moment (M_{st}) for a free standing module with two end shield walls and a rear shield wall is:

$$M_{st} = Wd_d + W_s (2d_d + d_s)$$

Where:
- W = 290+80 = 370 kips, Weight of the HSM Model 202 plus DSC (Conservatively, use minimum DSC weight of 80 kips)
- W_s = 172 kips, Weight of the end shield wall
- d_d = 52 in., Horizontal distance between center of gravity of HSM Model 202 to the outer edge of the side wall

	d_s	=	24 in., Horizontal distance from the module to the shield wall center of gravity
Therefore,	Mst	=	370 x 52 + 172 x (2 x 52 + 24) = 41,256 kip-in

The overturning moment (M_{ot}) for the free standing module with two end shield walls and a rear shield wall due to tornado wind pressure is:

$$M_{ot} = W_1 A_w h/2 + W_3 A_r (d_d + d_p)$$

Where:	W_l	=	Windward plus leeward pressure = (0.398+0.195) = 0.593 kips/ft2
	A_w	=	Wall area = 18.5' x 20.67' = 382.4 ft^2
	h	=	Wall Height + Roof Thickness = 18.5'
	W_3	=	Wind uplift on roof = 0.357 kips/ ft^2
	A_r	=	Roof area including shield wall = 20.67'*(9.67'+3') = 261.88 ft^2
	d_p	=	One half thickness of shield wall +1/2' = 2'
	M_{ot}	=	0.593 x 382.4 x 18.5/2 + 0.357 x 261.88 x (4.33+3)
		=	2689.36 kip-ft = 32,272 kip-in

Therefore, the factor of safety against overturning = 41,256/32,272 = 1.28 > 1.1. Therefore, the HSM Model 202 will not overturn due to tornado wind loads.

V.3.7.2.1.2 <u>HSM Model 202 Sliding Analysis</u>

The potential for a single free standing HSM Model 202 (one module with two end shield walls and a rear shield wall) to slide is evaluated by comparing the sliding force to the resisting force. The resisting force is calculated as the net weight of the loaded module times the coefficient of friction of concrete on concrete (μ) which is 0.6 per ACI 349-85, Reference [3.5], for concrete placed against hardened concrete.

The force (F_{st}) required to slide a free standing module is:

$$F_{st} = [W+2W_s+W_{rs} + L(B+2T_s)W_3]\mu$$

Where:	W	=	290+80 = 370 kips, Weight of the HSM Model 202 plus DSC
	W_s	=	172 kips, Weight of the end shield wall
	W_{rs}	=	(9.67'+2x3')x 18.5'x 3'x 0.15 kips/ft3 = 131 kips, Weight of the rear shield wall
	W_3	=	0.357 kips/ ft^2, Wind uplift on roof
	B	=	9.667', Width of the roof unit
	T_s	=	3' , Thickness of the end shield walls
	L	=	(20.67'+ 3') = 23.67', Length of the side wall + thickness of rear shield wall
	F_{st}	=	[370+2 x 172 + 131 + 23.67(9.667+2x3)0.357]0.6 = 586.4 kips

The sliding force (F_{hw}) generated by wind pressure for a single HSM Model 202 is

$$F_{hw} = W_l (h \times L)$$

Where:

W_l	=	(0.397+0.196) = 0.593 kips/ ft2, Windward plus leeward pressure
h	=	18.5' , Wall Height + Roof Thickness
L	=	(20.67'+ 3') = 23.67', Length of the side wall + thickness of rear shield wall
F_{hw}	=	0.593(18.5x23.67) = 259.67 kips

Therefore, the factor of safety against sliding = 586.4/259.67 = 2.26 > 1.1. Therefore, the HSM Model 202 will not slide due to tornado wind loads.

V.3.7.3 Earthquake

The seismic design criteria described in Section P.3.7.2 for the HSM-H is applicable to the HSM Model 202 since it is based on the HSM-H. As described in Section V.2.2.3, the earthquake loading that the HSM Model 202 is designed to withstand is greater than the earthquake loading used to qualify the HSM Model 80 and Model 102 (R.G. 1.60 anchored to 0.3g horizontal and 0.2g vertical peak ground accelerations).

V.3.7.3.1 HSM Model 202 Earthquake Loads (EQ)

The seismic accelerations affecting the NUHOMS® HSM Model 202 are described in Section P.3.7.2.3.1 since the HSM Model 202 is based on the HSM-H.

V.3.7.3.2 HSM Model 202 Seismic Stress Analysis

The seismic stress analysis described in Section P.3.7.2.3.2 for the HSM-H is applicable to the HSM Model 202 since it is based on the HSM-H.

V.3.7.3.3 HSM Model 202 Seismic Overturning Analysis

The seismic overturning analysis described in Section P.3.7.2.3.3 for the HSM-H is applicable to the HSM Model 202 since it is based on the HSM-H.

V.3.7.3.4 HSM Model 202 Seismic Sliding Analysis

The seismic sliding analysis described in Section P.3.7.2.3.4 for the HSM-H is applicable to the HSM Model 202 since it is based on the HSM-H.

V.3.7.4 Flood

Since the source of flooding is site specific, the exact source, or quantity of flood water, should be established by the licensee. However, for this generic evaluation of the HSM Model 202, bounding flooding conditions are specified that envelop those that are postulated for most plant sites. As described in Section 3.2, the design basis flooding load is specified as a 50 foot static

head of water and a maximum flow velocity of 15 feet per second. Each licensee should confirm that this represents a bounding design basis for their specific ISFSI site.

V.3.7.4.1 HSM Model 202 Flooding Analysis

The flooding analysis described in Section P.3.7.3.1 for the HSM-H is applicable to the HSM Model 202, since the HSM Model 202 is based on the HSM-H.

V.3.7.4.2 HSM Model 202 Flooding Overturning Analysis

The flooding overturning analysis described in Section P.3.7.3.1.1 for the HSM-H is applicable to the Model 202 since the HSM Model 202 is based on the HSM-H.

V.3.7.4.3 HSM Model 202 Flooding Sliding Analysis

The flooding sliding analysis described in Section P.3.7.3.1.2 is applicable to the HSM Model 202 since the HSM Model 202 is based on the HSM-H.

V.3.7.5 Lightning

No change.

V.3.7.6 Blockage of HSM Model 202 Air Inlet and Outlet Openings

This accident conservatively postulates the complete blockage of the HSM Model 202 ventilation air inlet and outlet openings on the HSM Model 202. Since the NUHOMS® HSM Model 202s are located outdoors, there is a remote probability that the ventilation air inlet and outlet openings could become blocked by debris. The NUHOMS® design features such as the perimeter security fence, the above ground location of the air inlet opening and protected location of the outlet vent opening and the vent screens 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.

The structural consequences due to the weight of the debris blocking the air inlet and outlet vent openings are negligible and are bounded by the HSM Model 202 loads induced for a postulated tornado (Section V.3.7.2) or earthquake (Section V.3.7.3).

The thermal effects of this accident for various NUHOMS® DSCs with a 24 kW heat load are described in Sections V.4 and V.11.

V.3.7.7 HSM Model 202 Load Combination Evaluations

The load categories associated with normal operating conditions, off-normal conditions and postulated accident conditions are described and analyzed in previous sections. The load combination results for the NUHOMS® HSM Model 202 are presented in this section. The load combinations used for the evaluation of the HSM Model 202 are as described in Table P.3.7-16 and P.3.7-17, and are equivalent to those shown in Table 3.2-5 and 3.2-8 for the concrete and steel components, respectively.

V.3.7.7.1 HSM Model 202 Concrete Component Evaluation

The HSM Model 202 concrete component evaluation is described in Section P.3.7.11.5.1 since the HSM Model 202 is based on the HSM-H. For additional evaluations to reconcile tornado wind pressure differences between the HSM-H and HSM Model 202, see Section V.3.7.8.3.

V.3.7.7.2 HSM Model 202 Support Structure Evaluation

The HSM Model 202 support structure evaluation is described in Section P.3.7.11.5.2 since the HSM Model 202 is based on the HSM-H.

V.3.7.8 HSM Model 202 Stress Analysis

The HSM Model 202 stress analysis is described in Section P.3.7.11.6 since the HSM Model 202 is based on the HSM-H.

V.3.7.8.1 Finite Element Model of the HSM Model 202 Concrete and Steel Structure for Mechanical Load Analysis

The finite element model of the HSM Model 202 concrete and steel structure for mechanical load analysis is described in Section P.3.7.11.6.1 since the HSM Model 202 is based on the HSM-H.

V.3.7.8.2 Finite Element Model of the HSM Model 202 Concrete Structure for Thermal Stress Analysis

The finite element model of the HSM Model 202 concrete structure for thermal stress analysis is described in Section P.3.7.11.6.2 since the HSM Model 202 is based on the HSM-H.

V.3.7.8.3 Evaluation of HSM Model 202 Concrete Structure

The evaluation of HSM Model 202 concrete structure is described in Section P.3.7.11.6.3 since the HSM Model 202 is based on the HSM-H.

The maximum tornado generated wind pressure for which the concrete components in Section P.3.7.11.6.3 are evaluated is 234 psf. However, the concrete components of HSM Model 202 are subjected to a maximum wind pressure of 398 psf. Therefore, for the HSM Model 202, the tornado wind out-of-plane shear and moment results are obtained from Table P.3.7-19 results by using a conservative scale factor of 2.

For the HSM Model 202, the load combination results for each component are presented in Table V.3-2 for the load combination defined in Table P.3.7-16. Load combination involving tornado wind (COMB2C and COMB5C in Table P.3.7-16) are reevaluated for HSM Model 202 due to the higher pressures associated with the HSM Model 80/102. The result of the analyses and comparison with the HSM Model 202 bending and shear capacities are shown in Table V.3-2. All load combination results are below the computed section capacities.

V.3.7.8.4 Evaluation of HSM Model 202 Support Steel

The evaluation of the HSM Model 202 support steel is described in Section P.3.7.11.6.4 since the HSM Model 202 is based on the HSM-H.

V.3.7.8.5 Evaluation of HSM Model 202 Shield Door

The evaluation of the HSM Model 202 shield door is described in Section P.3.7.11.6.5 since the HSM Model 202 is based on the HSM-H.

V.3.7.8.6 Evaluation of HSM Model 202 Heat Shields

The evaluation of HSM Model 202 heat shields is described in Section P.3.7.11.6.6 since the HSM Model 202 is based on the HSM-H.

V.3.7.8.7 Evaluation of HSM Model 202 Seismic Retainers

The evaluation of HSM Model 202 seismic retainers is described in Section P.3.7.11.6.7 since the HSM Model 202 is based on the HSM-H.

V.3.7.8.8 Thermal Cycling of the HSM Model 202

No change.

V.3.7.8.9 Evaluation of HSM Model 202 Concrete Components with Temperature Exceeding Code Limits

The maximum concrete temperature under off-normal condition for the HSM Model 202 are 238/243°F (for 117°F and 125°F ambient conditions). The normal condition is bounded by the off-normal condition. Although the maximum concrete temperatures exceed 225°F in the off-normal condition, they do not exceed 300°F. Therefore, as specified in [3.4], no tests or reduction in concrete strength are required to demonstrate the capability of the concrete to adequately handle the elevated temperatures provided Type II cement is used and special aggregates are selected which are acceptable for concrete in this temperature range. This approach is consistent with standardized HSM design, for which special aggregates for the roof concrete mix are provided.

The maximum concrete temperature for a 40-hour blocked vent condition is 376/381°F (for 117°F and 125°F ambient conditions), which exceeds the 350°F limit specified in [3.4]. As noted in [3.4], use of any Portland cement concrete where accident temperature exceeds 350°F will require testing be performed on the exact concrete mix. Elevated temperature testing of the exact concrete mix (cement type, additives, water-cement ratio, aggregates, proportions) is to be performed for the HSM Model 202. The use of high temperature concrete testing is explicitly accepted by the NRC, as documented in the NRC's SER [3.4], Section 3.0, Page 3-5. The testing shall demonstrate the level of strength reduction is less than that which was applied, and show that the increased temperatures do not cause deterioration of the concrete.

V.3.8 References

[3.1] U.S. Nuclear Regulatory Commission (U.S. NRC), "Standard Format and Content for the Safety Analysis Report for an Independent Spent Fuel Storage Installation (Dry Storage)," Regulatory Guide 3.48 (Task FP-029-4), (October 1981).

[3.2] American National Standard, "Design Criteria for an Independent Spent Fuel Storage Installation (Dry Storage Type)," ANSI/ANS 57.9-1984, American Nuclear Society, La Grange Park, Illinois (1984).

[3.3] Title 10, Code of Federal Regulations, Part 72 (10CFR72), "Licensing Requirements for the Storage of Spent Fuel in the Independent Spent Fuel Storage Installation," U.S. Nuclear Regulatory Commission, October 31, 1988.

[3.4] "Safety Evaluation Report of the Safety Analysis Report for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel," U.S. Nuclear Regulatory Commission, December 1994.

[3.5] American Concrete Institute, Code Requirements for Nuclear Safety Related Concrete Structures and Commentary, ACI 349-85 and ACI 349R-85, Detroit, MI.

Table V.3-1
Summary of the NUHOMS® HSM Model 202 System Component Weights

HSM Component	HSM Model 202[1]
Base Unit (including HSM support steel)	178,900
Roof	107,300
Door	19,900
HSM Model 202 Single Module Weight Max. (empty)	306,100

Note:

1. All numbers are rounded up to the next hundred pounds.

Table V.3-2
Comparison of Highest Combined Shear Forces/Moments with the Capacities

Component	Load Comb.[1]	Quantity	V_I Kips/ft	V_{o1} kips/ft	V_{o2} kips/ft	M_1 kip-in/ft	M_2 kip-in/ft
Rear Wall (upper)	Comb 1c thru 6c	Computed	14.52	9.91	9.16	147.35	267.10
		Capacity	75.2	14.5	14.5	298.2	298.2
		Ratio	**0.19**	**0.68**	**0.63**	**0.49**	**0.90**
	Comb7c	Computed	18.44	11.37	6.08	131.14	264.5
		Capacity	69.6	13.8	13.8	273.8	273.8
		Ratio	**0.26**	**0.82**	**0.44**	**0.48**	**0.97**
Rear Wall (Lower)	Comb 1c thru 6c	Computed	17.34	13.15	13.25	234.15	327.44
		Capacity	96.8	36.2	36.2	757.9	757.9
		Ratio	**0.18**	**0.36**	**0.37**	**0.31**	**0.43**
	Comb7c	Computed	9.49	6.40	20.84	154.30	251.80
		Capacity	90.1	34.3	34.3	696.3	696.3
		Ratio	**0.11**	**0.19**	**0.61**	**0.22**	**0.36**
Side Walls (Upper)	Comb 1c thru 6c	Computed	18.92	13.30	13.19	189.03	212.78
		Capacity	54.4	14.8	14.8	305.9	305.9
		Ratio	**0.35**	**0.90**	**0.89**	**0.62**	**0.70**
	Comb7c	Computed	22.37	12.08	9.10	120.24	91.05
		Capacity	50.5	14.0	14.0	180.8	180.8
		Ratio	**0.44**	**0.86**	**0.65**	**0.67**	**0.50**
Side Walls (Lower)	Comb 1c thru 6c	Computed	36.17	22.86	21.12	457.83	318.44
		Capacity	63.0	23.4	23.4	494.8	494.8
		Ratio	**0.57**	**0.98**	**0.91**	**0.93**	**0.64**
	Comb7c	Computed	19.28	21.12	15.34	97.25	180.24
		Capacity	58.7	22.2	22.2	289.0	289.0
		Ratio	**0.33**	**0.95**	**0.69**	**0.34**	**0.63**
Roof	Comb1c Thru 6c	Computed	13.18	9.44	28.73	487.01	1022.49
		Capacity	174.6	59.1	59.1	2375.0	2375.0
		Ratio	**0.08**	**0.16**	**0.49**	**0.21**	**0.43**
	Comb7c	Computed	7.69	11.48	28.38	386.48	897.67
		Capacity	162.4	56.1	56.1	2181.7	2181.7
		Ratio	**0.05**	**0.21**	**0.51**	**0.18**	**0.41**
Front Wall (Upper)	Comb 1c thru 6c	Computed	41.82	44.83	37.00	1393.19	1895.08
		Capacity	171.7	56.3	56.3	2257.3	2257.3
		Ratio	**0.24**	**0.80**	**0.66**	**0.62**	**0.84**
	Comb7c	Computed	32.63	48.95	26.29	1853.0	1906.74
		Capacity	159.6	53.4	53.4	2073.5	2073.5
		Ratio	**0.20**	**0.92**	**0.49**	**0.89**	**0.92**
Front Wall (Lower)	Comb1c thru 6c	Computed	29.29	34.24	37.83	1877.58	1203.22
		Capacity	189.0	73.6	73.6	2963.4	2963.4
		Ratio	**0.16**	**0.47**	**0.52**	**0.63**	**0.41**
	Comb7c	Computed	48.04	45.95	41.38	1908.90	507.22
		Capacity	176.0	69.8	69.8	2722.4	2722.4
		Ratio	**0.27**	**0.66**	**0.59**	**0.70**	**0.19**

Note: (1) Comb 1c thru 6c includes normal thermal. Comb 7c includes accident thermal. (See Table P.3.7-16).

V.4 Thermal Evaluation

V.4.1 Discussion

The HSM Model 202 is an enhanced version of the Standardized NUHOMS® HSM Model 80/102 designed to provide increased shielding and heat rejection capabilities.

Although the NUHOMS® HSM Model 80 and Model 102 are proven designs with extensive operational experience, the HSM Model 202 incorporates several design enhancements to the Standardized NUHOMS® HSM design to improve the module's shielding and thermal performance.

The HSM Model 202 is based on the HSM-H described in Appendix P. The thermal performance evaluation of the HSM-H for storage of the 24PTH DSC with heat loads of up to 40.8 kW is described in Appendix P, Section P.4.

This chapter documents the thermal evaluation of the HSM Model 202 for use in storing various DSCs described elsewhere in the UFSAR with a maximum heat load of 24.0 kW (52B, 24P, 61BT, 24PT2, 32PT, 24PHB and 24PTH-S-LC). The thermal evaluation of the 24PTH-S-LC DSC for storage in the HSM Model 202 is documented in Section P.4, since the HSM Model 202 design is based on the HSM-H.

V.4.2 Summary of Thermal Properties of Materials

No change from those reported in the corresponding sections/appendices for each particular DSC (24P, 52B, 61BT, 24PT2, 32PT, 24PHB and 24PTH-S-LC).

V.4.3 Specifications for Components

No change from those reported in the corresponding sections/appendices for each particular DSC (24P, 52B, 61BT, 24PT2, 32PT, 24PHB and 24PTH-S-LC).

V.4.4 Thermal Analysis of an HSM Model 202 Containing a DSC with 24 kW Heat Load

This section describes the analysis performed to assess the thermal load capacity of the HSM Model 202 for storage of DSCs (52B, 24P, 24PT2, 61BT, 32PT, 24PHB and 24PTH-S-LC) currently licensed and included in the UFSAR.

The procedure used to confirm that the maximum DSC shell temperatures and HSM Model 202 concrete temperatures calculated in the corresponding sections/appendices for the various DSCs when stored in the HSM Model 202 do not exceed regulatory limits as listed in the UFSAR, is as follows:

(1) Tabulate the maximum shell temperatures for the PWR DSCs (24P, 24PT2, 32PT and 24PHB DSCs) stored in an HSM Model 80/102 and compare them against the maximum shell temperatures of a 24 kW DSC stored in an HSM Model 202 for normal, off-normal and accident conditions.

(2) Tabulate the maximum concrete temperatures for a 24 kW DSC stored in an HSM Model 202 and compare them against the allowable concrete temperatures for normal, off-normal and accident conditions.
(3) Tabulate the ΔTs (i.e., the difference between the ambient temperature and the vent outlet temperature) for the 24 kW DSC stored in an HSM Model 202 and verify that the ΔTs do not exceed 100°F for ≥ 5 year cooled fuel for a fully loaded DSC with 24 kW heat load at various ambient temperatures.
(4) Repeat the same 3 steps above for the BWR DSCs (52B and 61BT) with heat loads of 19.2 kW and 18.3 kW, respectively.

For the 24PTH-S-LC, the reported temperatures in Section P.4 are adjusted for the flat side heat shield condition of the HSM Model 202.

In addition, the maximum fuel cladding temperature is evaluated for each DSC model when stored in HSM Model 202 to verify that the allowable fuel cladding temperature limits are met.

The analytical methodology used to calculate the DSC shell temperatures inside the HSM Model 202 does not change from that described in the NUHOMS® UFSAR.

The above procedure is used to evaluate the HSM Model 202 with louvered top heat shield (THS) and flat anodized aluminum side heat shields (SHS).

A similar approach is undertaken to evaluate the HSM Model 202 with flat stainless steel THS and SHS. Since the methodology of the analysis and the type boundary conditions remain unchanged for all the DSC types, only 61BT DSC with 18.3 kW and 24PTH-S-LC with 24kW heat load under off-normal and accident conditions are considered as representative samples for this evaluation.

V.4.4.1 Evaluation of DSC Shell Temperatures

To adequately assess the thermal performance of the HSM Model 202, the maximum shell temperatures for various DSCs stored in an HSM Model 80/102 are tabulated and compared against the maximum shell temperatures computed for a 24 kW DSC stored in an HSM Model 202. These maximum shell temperatures are determined for the normal, off-normal and accident (40-hour blocked vent) conditions using the procedure described in Section V.4.4 and are summarized in Table V.4-1.

From a review of the results summarized in Table V.4-1, the following observations can be made:

- For normal and off-normal operating conditions, the maximum shell temperatures of DSCs currently analyzed in the UFSAR bound those computed for the DSCs stored in an HSM Model 202.
- For accident operating conditions, the maximum shell temperatures of all DSCs (with a 24 kW, 19.2 kW, and 18.3 kW heat load) currently analyzed in the UFSAR bound the corresponding temperatures computed for storage in an HSM Model 202.

V.4.4.2 Evaluation of HSM Model 202 Concrete Temperatures

The maximum concrete temperatures for a 24 kW DSC stored in an HSM Model 202 are calculated using the procedure described in Section V.4.4 and tabulated in Table V.4-2, and are compared against the allowable concrete temperatures. Analysis shows that the maximum concrete temperature for HSM Model 202 with flat stainless steel heat shields is bounded by the HSM Model 202 with louvered THS and flat anodized aluminum SHS.

From a review of the results summarized in Table V.4-2 below, the following observations can be made:

- The maximum concrete temperatures for the normal and off-normal thermal conditions are within allowable limits.
- The maximum concrete temperature for the accident condition exceeds 350°F. Therefore, testing is required on the concrete mix (cement type, additives, water-cement ratio, aggregates, proportions, etc.) to acceptably demonstrate the level of strength reduction which needs to be applied, and to show that the increased temperatures do not cause deterioration of the concrete. The use of high temperature concrete testing is acceptable, as documented in the SER [4.3], Section 3.0, Page 3-5. The testing shall demonstrate that the level of strength reduction is less than that which was applied in Section V.3, and show that the increased temperatures do not cause deterioration of the concrete.

V.4.4.3 Evaluation of HSM Model 202 Maximum Fuel Cladding Temperatures

As seen from Table V.4-1, for all conditions, the maximum shell temperatures of all DSCs allowed for storage in the HSM Model 202 are bounded by those analyzed in the UFSAR. Therefore, the maximum basket component and fuel cladding temperatures of all DSCs stored in the HSM Model 202 are bounded by those analyzed in the UFSAR, and no further evaluation of the maximum basket component and fuel cladding temperatures is required.

V.4.4.4 Evaluation of HSM Model 202 Maximum Air Exit Temperature

Table V.4-3 documents the results of an evaluation that shows the equilibrium air temperature difference between the ambient temperature and the vent outlet temperature (ΔT) with a 24 kW DSC stored in HSM Model 202 does not exceed 100°F for 5-year old or greater cooled fuel when the DSC is fully loaded with 24 KW heat load.

V.4.4.5 References

[4.1] Not Used.

[4.2] Certificate of Compliance No. 1004 for Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel, Docket No. 72-1004, Amendment No. 8, Effective Date 12/5/05, Technical Specification 1.2.8, "HSM Maximum Air Exit Temperature."

[4.3] Safety Evaluation Report of Safety Analysis Report for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel, U.S. Nuclear Regulatory Commission, December 1994.

Table V.4-1
Maximum Shell Temperatures of Various DSCs Stored in HSM Model 80/102 and 202

Thermal Loading Condition	Ambient Temperature °F	HSM Model 80/102				HSM Model 102	HSM Model 202 with Louvered aluminum THS and flat anodized aluminum SHS			
		24P/24PT2S/L (24 kW) °F	52B (19.2 kW) °F	61BT (18.3 kW) °F	32PT (24 kW) °F	24PHB (24 kW) °F	24P/24PT2, 24PHB, 32PT (24 kW) °F	52B (19.2 kW) °F	61BT (18.3 kW) °F	24PTH-S-LC (24 kW)
Normal	70	345	300	N/A	345	345	323	291	285	316
	100	374/375	328	318	374	374	347	316	309	338
Off-Normal	-40	BOUNDED BY THE 125/117 °F OFF-NORMAL CASE								
	117 125 (Note 1)	-- 399/398	-- 352	-- 345	382 --	399 --	354 358	-- 328	-- 321	345 --
Accident (40-Hour Blocked Vent Case)	117 125 (Note 1)	-- 640/675	-- ≤ 640	-- 662	574 --	574 --	508 513	-- 473	-- 465	492 --

Thermal Loading Condition	Ambient Temperature °F	HSM Model 80/102				HSM Model 102	HSM Model 202 with Flat Stainless Steel THS and SHS			
		24P/24PT2S/L (24 kW) °F	52B (19.2 kW) °F	61BT (18.3 kW) °F	32PT (24 kW) °F	24PHB (24 kW) °F	24P/24PT2, 24PHB, 32PT (24 kW) °F	52B (19.2 kW) °F	61BT (18.3 kW) °F	24PTH-S-LC (24 kW)
Off-Normal	117 125 (Note 1)	-- 399/398	-- 352	-- 345	382 --	399 --	348 353	--- < 352 (Note 2)	-- 335	348 ---
Accident (40-Hour Blocked Vent Case)	117 125 (Note 1)	-- 640/675	-- ≤ 640	-- 662	574 --	574 --	< 514 < 519	--- < 640 (Note 2)	-- 441	< 514 --

Notes:

1. 125°F is the maximum off-normal ambient temperature for the 24P, 52B, 61BT, and 24PT2 DSCs; 117°F is the maximum off-normal ambient temperature for the 32PT and 24PHB DSC.
2. Based on evaluations for 18.3 kW and 24 kW cases, these values are bounded by those calculated for HSM Model 80 or 102.

Table V.4-2
Maximum Concrete Temperatures for the HSM Model 202

Thermal Loading Condition	Maximum Ambient Temperature (°F)	24kW DSC in HSM 202 Concrete Temperature (°F)	HSM 202 Allowable Concrete Temperature (°F)
Normal	100	N/A (Bounded by Off-Normal)	300[(1)]
Off-Normal	117 125	238 243	300[(1)]
Accident 40 Hour Blocked Vent	117 125	376 381	425[(2)]

Notes:

(1) Use of Type II cement in combination with special aggregates are selected which are acceptable for concrete in this temperature range as specified in the "Discussion of Concrete Constituents and Temperature Suitability" in the Safety Evaluation Report of Safety Analysis Report for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel (Pages 3-4 and 3-5), U.S. Nuclear Regulatory Commission, December 1994 [4.3].

(2) Use of any Portland cement concrete where "accident" temperatures exceed 350°F requires performance of tests on the exact concrete mix used as specified in the Safety Evaluation Report of Safety Analysis Report for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel (Page 3-5), U.S. Nuclear Regulatory Commission, December 1994 [4.3].

Table V.4-3
24 kW DSC in Model 202
Exit Air and Inlet Air Temperature Difference (ΔT)

Inlet Air Temperature (°F)	ΔT with Louvered THS and Flat Anodized Aluminum SHS (°F)	ΔT with Flat Stainless Steel THS and SHS (°F)
-40	40	48
0	44(1)	53
70	52(1)	62(1)
104	55	66(2)
117	56	67
125	57	68(1)

Note:

(1) ΔT computed by interpolation or extrapolation

(2) ΔT is calculated for an inlet air temperature of 100°F

V.5 Shielding Evaluation

The radiation shielding evaluation for the Standardized NUHOMS® system (during storage of the loaded DSC inside an HSM Model 80 and Model 102) is discussed in Sections 3.3.5, 7.0, and 8.0, Appendices H, J, K, L, M, N, P, and R. The following radiation shielding evaluation discussion specifically addresses the storage of a loaded DSC inside an HSM Model 202.

The HSM Model 202 offers superior shielding when compared to either the HSM Model 80 or Model 102. The roof, front wall, rear shield wall, and end shield wall are considerably thicker, and there is no gap between adjacent modules to minimize radiation streaming. Therefore, the calculated dose rates due to the storage of NUHOMS®-24P, 52B, 24PT2, 61BT, 32PT, 24PHB, and 24PTH-S-LC DSCs in HSM Model 80 and Model 102 are bounded when these payloads are stored in the HSM Model 202.

The design of the HSM Model 202 is similar to the HSM Model 80 and Model 102 except the HSM Model 202 offers enhanced shielding performance due to the following design features:

- Elimination of 6" uniform gap between adjacent modules,
- Innovative shielded inlet and outlet ventilation openings,
- Increased concrete thickness in the roof, and front and back walls and shield walls, and
- Increased shielding in the HSM door.

V.6 Criticality Evaluation

There is no change to the criticality evaluation documented in Sections 3.3.4, 3.6, Appendices H.6, J.6, K.6, L.6, M.6, N.6, P.6, and R.6 due to the addition of the HSM Model 202 to the Standardized NUHOMS® system.

V.7 Confinement

There is no change to the confinement evaluation presented in Sections 3.3.2, 7.2.2, Appendices H.7, J.7, K.7, L.7, M.7, N.7, P.7, and R.7 as a result of the addition of the HSM Model 202 to the Standardized NUHOMS® system.

V.8 Operating Systems

The operating procedures for the Standardized NUHOMS® HSM Model 202 system described in previous chapters of Appendix V and shown on the drawings in Section V.1.5 include preparation of the DSC for fuel loading, closure of the DSC, transfer to the ISFSI using the TC, DSC transfer into the HSM, monitoring operations, and DSC retrieval from the HSM. The Standardized NUHOMS® transfer equipment, and the existing plant systems and equipment are used to accomplish these operations.

Chapter 5 provides a description as to how these operations are to be performed for the Standardized 24P and 52B NUHOMS® systems. In general, these operational steps are also applicable to the NUHOMS® HSM Model 202 system. This chapter only lists significant variations, if any, for the NUHOMS® HSM Model 202 system.

The generic NUHOMS® procedures described in Chapter 5 have been developed to minimize the amount of time required to complete the subject operations, to minimize personnel exposure, and to assure that all operations required for DSC loading, closure, transfer, and storage are performed safely. Plant specific ISFSI procedures are to be developed by each licensee in accordance with the requirements of 10CFR72.212(b) and the guidance of Regulatory Guide 3.61 [8.1]. These generic procedures are provided as a guide for the preparation of plant-specific procedures and serve to explain how the NUHOMS® system operations are to be accomplished. They are not intended to be limiting in that the licensee may judge that alternate acceptable means are available to accomplish the same operational objective.

V.8.1 Procedures for Loading the Cask

Process flow diagrams for loading and retrieval of the DSC system are identical to those presented in Figures 5.1-1 and 5.1-2 respectively of Chapter 5.

V.8.1.1 Preparation of the Transfer Cask and DSC

No change. See Section 5.1.1.1 and/or the appropriate appendix for each DSC considered for storage.

V.8.1.2 DSC Fuel Loading

No change. See Section 5.1.1.2 and/or the appropriate appendix for each DSC considered for storage.

V.8.1.3 DSC Drying and Backfilling

No change. See Section 5.1.1.3 and/or the appropriate appendix for each DSC considered for storage.

V.8.1.4 DSC Sealing Operations

No change. See Section 5.1.1.4 and/or the appropriate appendix for each DSC considered for storage.

V.8.1.5 Transfer Cask Downending and Transport to ISFSI

No change. See Section 5.1.1.5 and/or the appropriate appendix for each DSC considered for storage.

V.8.1.6 DSC Transfer to the HSM

No change. See Section 5.1.1.6 and/or the appropriate appendix for each DSC considered for storage.

V.8.1.7 Monitoring Operations

No change. See Section 5.1.1.7 and/or the appropriate appendix for each DSC considered for storage.

V.8.2 Procedures for Unloading the Cask

V.8.2.1 DSC Retrieval from the HSM

No change. See Section 5.1.1.8 and/or the appropriate appendix for each DSC considered for storage.

V.8.2.2 Removal of Fuel from the DSC

No change. See Section 5.1.1.9 and/or the appropriate appendix for each DSC considered for storage.

V.8.3 Identification of Subjects for Safety Analysis

No change. See Section 5.1.3 and/or the appropriate appendix for each DSC considered for storage.

V.8.4 Fuel Handling Systems

No change. See Section 5.2 and/or the appropriate appendix for each DSC considered for storage.

V.8.5 Other Operating Systems

No change. See Section 5.3 and/or the appropriate appendix for each DSC considered for storage.

V.8.6 Operation Support System

No change. See Section 5.4 and/or the appropriate appendix for each DSC considered for storage.

V.8.7 Control Room and/or Control Areas

No change. See Section 5.5 and/or the appropriate appendix for each DSC considered for storage.

V.8.8 Analytical Sampling

No change. See Section 5.6 and/or the appropriate appendix for each DSC considered for storage.

V.8.9 References

[8.1] U.S. Nuclear Regulatory Commission, "Standard Format and Content for a Topical Safety Analysis Report for a Spent Fuel Dry Storage Cask," Regulatory Guide 3.61 (Task 306-4), February 1989.

V.9 Acceptance Tests and Maintenance Program

V.9.1 Acceptance Tests

The addition of the HSM Model 202 to the Standardized NUHOMS® system does not result in any change to the Pre-Operational Tests described in Section 9.2 since the transfer cask involved is not changed and the HSM Model 202 is very similar to the HSM Model 102 from an operations perspective.

Prior to operation of the ISFSI for a particular plant, the licensee should perform functional tests of the in-plant operations, the on-site transfer operations, and DSC insertion and retrieval (operations at the ISFSI). These tests are intended to verify that the storage system components (e.g., DSC, HSM, transfer cask, transfer equipment, etc.) operate safely and effectively. Such a program has been successfully completed for the NUHOMS® ISFSIs at Duke Power Company's Oconee Nuclear Station, Baltimore Gas and Electric Company's Calvert Cliffs Nuclear Power Plant, Toledo Edison's Davis Besse Nuclear Station and Pennsylvania Power and Light's Susquehanna Nuclear Station.

V.9.1.1 Visual Inspection

Visual inspections are performed at the fabricator's facility to ensure that the DSC and the HSM conform to the drawings and specifications. The visual inspections include verifying dimensions and the application of specified coatings and that the DSC is clean and free of defects. Visual inspections are performed in accordance with the requirements and acceptance criteria specified by the codes applicable to the associated components.

Upon arrival at the site, the DSCs and HSMs are again inspected to ensure that they have not been damaged during shipment. Conditions which are not in conformance with the drawings and specifications will be repaired or evaluated, in accordance with 10CFR 72.48, for the effect of the condition on the safety function of the components.

V.9.1.2 Structural Tests

No change associated with the addition of the HSM Model 202.

V.9.1.3 Leak Tests and Pressure Tests

No change associated with the addition of the HSM Model 202.

V.9.1.4 Component Tests

No change associated with the addition of HSM Model 202.

V.9.1.5 Shielding Integrity Tests

No change associated with the addition of the HSM Model 202.

V.9.1.6 Thermal Acceptance Tests

No change associated with the addition of the HSM Model 202. The special requirements for the first system in place, of CofC Section 1.1.7, are applicable.

V.9.1.7 Neutron Absorber Tests

No change associated with the addition of the HSM Model 202.

V.9.2 Maintenance Program

The NUHOMS® HSM Model 202 system is designed to be totally passive and require minimal maintenance. The DSC does not require any maintenance once it is loaded into the HSM Model 202.

V.9.3 Training Program

No change.

V.10 Radiation Protection

Section 7.4.1 discusses the anticipated cumulative dose exposure to site personnel during the fuel handling and transfer activities associated with utilizing a NUHOMS® HSM for storage of one DSC. Chapter 5 describes in detail the NUHOMS® operational procedures, several of which involve potential exposure to personnel. As discussed in Section V.5, "Shielding Evaluation," the dose rates on and around the HSM Model 202 loaded with a DSC are bounded by the HSM Model 80 and Model 102 designs. Also, no operational changes are required. Therefore, the anticipated cumulative dose exposures to site personnel during fuel handling and transfer activities involving the HSM Model 202 design are bounded by the HSM Model 80 and Model 102, because the operating procedures are identical.

The site dose evaluations presented in Section 7.4.2, J.10, K.10, L.10, M.10, N.10, and P.10, also bound the HSM Model 202 designs because the dose rates on and around the HSM Model 202 are bounded by the HSM Model 80 and Model 102 designs.

V.11 Accident Analyses

This section describes the postulated off-normal and accident events that could occur during storage of the DSC inside a NUHOMS® HSM Model 202. Sections which do not affect the evaluation presented in Chapter 8 are identified as "No change." Detailed analysis of the events are provided in other sections and are referenced herein.

V.11.1 Off-Normal Operations

Off-normal operations are design events of the second type (Design Event II) as defined in ANSI/ANS 57.9 [11.1]. Off-normal conditions consist of that set of events that, although not occurring regularly, can be expected to occur with moderate frequency or on the order of once during a calendar year of ISFSI operation.

The off-normal conditions considered for the NUHOMS® HSM Model 202 are off-normal transfer loads and extreme temperatures.

V.11.1.1 Off-Normal Transfer Loads

No change. The limiting off-normal event is the jammed DSC during loading or unloading from the HSM. This event is described in Section 8.1.2.

V.11.1.1.1 Postulated Cause of Event

No change relative to Section 8.1.2. The probability of a jammed DSC does not increase with the NUHOMS® HSM Model 202, since the internal cavity of the HSM Model 202 is similar to the NUHOMS® HSM Model 80 and Model 102.

V.11.1.1.2 Detection of Event

No change. See Section 8.1.2.1.

V.11.1.1.3 Analysis of Effects and Consequences

No change. See Section 8.1.2.1.

V.11.1.1.4 Corrective Actions

No change. See Section 8.1.2.1.

V.11.1.2 Extreme Temperatures

No change. See Section 8.1.2.2.

V.11.1.2.1 Postulated Cause of Event

No change. See Section 8.1.2.2.

V.11.1.2.2 Detection of Event

No change. See Section 8.1.2.2.

V.11.1.2.3 Analysis of Effects and Consequences

The thermal evaluation of the NUHOMS® HSM Model 202 system for off-normal conditions is presented in Chapter V.4.

The NUHOMS® HSM Model 202 was evaluated for a maximum heat load of 24 kW and maximum off-normal ambient temperature of 125°F. The maximum heat load of the DSC in an HSM Model 202 is limited to 24 kW. The evaluations of the HSM Model 202 for off-normal thermal loads are presented in Section V.3.6.2.3.

V.11.1.2.4 Corrective Actions

No change. See Section 8.1.2.2.

V.11.2 Postulated Accidents

Only those accidents affecting the HSM Model 202 are addressed in this section. No change to accident evaluations affecting other NUHOMS® components in Section 8.2.

V.11.2.1 Reduced HSM Air Inlet and Outlet Shielding

This event is described in Section 8.2.1.

V.11.2.1.1 Cause of Accident

For HSM Model 202, this accident is not credible since the layout of HSM Model 202s eliminates the 6-inch gaps between the adjacent HSMs. The HSM Model 202s are placed next to each other and even in the unlikely event of large settlement of the ISFSI foundation, shifting of adjacent HSM Model 202s occurring and causing the HSM Model 202s to separate is not credible.

V.11.2.1.2 Accident Analysis

No change. See Section 8.2.1.2 since it is bounding.

V.11.2.1.3 Accident Dose Calculations

No change. See Section 8.2.1.3 since it is bounding.

V.11.2.1.4 Corrective Actions

No change. See Section 8.2.1.4 since it is bounding.

V.11.2.2 Earthquake

This event is described in Section 8.2.3.

V.11.2.2.1 Cause of Accident

No change. See Section 8.2.3.1.

V.11.2.2.2 Accident Analysis

Section 8.2.3.2 describes the analyses performed to demonstrate that the NUHOMS® system will withstand the design basis seismic event. Section V.3.7.3 presents the seismic evaluation of the NUHOMS® HSM Model 202 (conservatively the seismic analyses of the HSM 202 are for the seismic accelerations of 0.30g horizontal and 0.20g vertical accelerations). The results of this analysis show that seismic stresses are within the allowable criteria.

V.11.2.2.3 Accident Dose Calculations

No change. See Section 8.2.3.3.

V.11.2.2.4 Corrective Actions

After a seismic event, the NUHOMS® HSM Model 202 will be inspected for damage. Any debris will be removed. An evaluation will be performed to determine if the system components are still within the licensed design basis.

V.11.2.3 Extreme Wind and Tornado Missiles

This event is described in Section 8.2.2.

V.11.2.3.1 Cause of Accident

No change. See Section 8.2.2.1.

V.11.2.3.2 Accident Analysis

An evaluation of the HSM Model 202 for the effect of DBT wind pressure loads is presented in Section V.3.7.2. The tornado missile impact evaluation of the HSM Model 202 is presented in the following sections.

V.11.2.3.2.1 HSM Model 202 Missile Impact Analysis

The HSM Model 202 missile impact analysis is described in Section P.11.2.3.2.1.

V.11.2.3.3 Accident Dose Calculations

No change. See Section 8.2.2.3.

V.11.2.3.4 Corrective Actions

After excessive high winds or a tornado, the HSM Model 202s will be inspected for damage. Any debris will be removed. Any damage resulting from impact with a missile will be evaluated to determine if the system is still within the licensed design basis. Evaluation of the HSM Model 202 for damage as a result of tornado missile is to be performed to assess the need for temporary shielding and module repairs to return the module to pre-tornado design conditions.

V.11.2.4 Flood

This event is described in Section 8.2.4.

V.11.2.4.1 Cause of Accident

No change. See Section 8.2.4.1.

V.11.2.4.2 Accident Analysis

The HSM Model 202 is evaluated for flooding in Section P.3.7.3.1 since the HSM Model 202 is based on the HSM-H.

V.11.2.4.3 Accident Dose Calculations

No change. See Section 8.2.4.3.

V.11.2.4.4 Corrective Actions

No change. See Section 8.2.4.4.

V.11.2.5 Lightning

No change. The evaluation presented in Section 8.2.6 is not affected by the addition of the NUHOMS® HSM Model 202. Lightning protection equipment may be installed on the HSM Model 202 to protect it from lightning strikes.

V.11.2.6 Blockage of Air Inlet and Outlet Openings

This accident conservatively postulates the complete blockage of the ventilation air inlet and outlet openings of the HSM Model 202.

V.11.2.6.1 Cause of Accident

No change. See Section 8.2.7.1.

V.11.2.6.2 Accident Analysis

The structural consequences due to the weight of the debris blocking the air inlet and outlet openings are negligible and are bounded by the HSM Model 202 loads induced for a postulated tornado (Section V.11.2.3) or earthquake (Section V.11.2.2).

The thermal analysis of the blocked vent condition is presented in Chapter V.4.

The thermal-induced stresses for the blocked vent case are calculated using the HSM Model 202 structural models discussed in Section V.3.7.6. The resulting elastic forces and moments are modified to account for the concrete cracked section properties in accordance with ACI 349 Appendix A, and combined with the calculated forces and moments from other loads.

V.11.2.6.3 Accident Dose Calculations

No change. See Section 8.2.7.3.

V.11.2.6.4 Corrective Action

No change. See Section 8.2.7.4.

V.11.2.7 Fire and Explosion

This evaluation presented in Section 3.3.6 is not affected by the addition of the NUHOMS® Model 202.

V.11.3 References

[11.1] American Nuclear Society, ANSI/ANS-57.9, Design Criteria for an Independent Spent Fuel Storage Installation (Dry Storage Type), 1992.

V.12 Operating Controls and Limits

The addition of HSM Model 202 to the Standardized NUHOMS® system does not result in any change to the Technical Specifications, Functional and Operating Limits described in NUHOMS® CoC 1004, Amendment 8.

V.13 Quality Assurance

Chapter 11 provides a description of the Quality Assurance Program to be applied to the safety-related and important-to-safety activities associated with the Standardized NUHOMS® system. The addition of the HSM Model 202 to the NUHOMS® system does not require any changes to the Quality Assurance Requirements stipulated in Chapter 11.

V.14 Decommissioning

There is no change from the decommissioning evaluation presented in Section 9.6 due to the addition of the HSM Model 202 to the NUHOMS® system.

APPENDIX W

NUHOMS® OS197L TRANSFER CASK

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LIST OF TABLES

LIST OF FIGURES

W.1 General Description

Appendix W to the NUHOMS® Updated Final Safety Analysis Report (UFSAR) addresses the Important to Safety aspects of adding the OS197L TC to the Standardized NUHOMS® system described in the UFSAR. The OS197L TC is added to the UFSAR as an alternative to the OS197 and OS197H TCs. The primary reason for adding the OS197L TC design is to include a transfer cask that can be used by facilities with a crane capacity of 75 tons.

The addition of the OS197L TC to the Standardized NUHOMS® system results in a change to the Technical Specifications of the NUHOMS® CoC 1004 [1.3]. In addition, the thermal analysis methodology and some operational steps for this modification are different from that described in the UFSAR. Hence, a general licensee shall NOT implement the contents of Appendix W until the NRC has approved TN's application for Amendment 11 to NUHOMS® CoC 1004.

A general licensee shall meet the requirements of applicable Amendment 11 Technical Specifications prior to the use of OS197L TC for transfer of any of the payloads authorized under CoC 1004.

Appendix W shows the modified text (Chapters W.1, W.4, W.8, W.10 and W.12 only) which is being submitted to the NRC for review and approval as a shaded text. This is done to distinguish other miscellaneous changes implemented in Appendix W under the provisions of 10 CFR 72.48.

The OS197L TC accommodates both PWR (187") and BWR (197") length Dry Shielded Canisters (DSCs), including the 24P, 52B, 24PT2, 61BT, 32PT and 24PHB DSCs.

The format of this Appendix follows the guidance provided in NRC Regulatory Guide 3.61 [1.1]. The analyses presented in this Appendix demonstrate that the OS197L TC system meets all the requirements of 10 CFR 72 [1.2].

Several sections of this Appendix have been identified as "No Change." For these sections, the description or analysis presented in the corresponding sections of the UFSAR for the Standardized NUHOMS® system is also applicable to the OS197L TC. In addition, tables and figures presented in the UFSAR which remain unchanged due to the addition of the OS197L TC to the Standardized NUHOMS® system are not repeated in this Appendix. Table W.1-2 provides a summary of the sections of the main body of the UFSAR applicable to the OS197 TC and addresses the impact of the OS197L TC on these sections.

Note: References to sections or chapters within this Appendix are identified with a prefix W (e.g., Section W.2.3 or Chapter W.2). References to sections or chapters of the UFSAR outside of this Appendix (i.e., main body of the UFSAR) are identified with the applicable UFSAR section, chapter number or Appendix number (e.g., Section 2.3, Chapter 2 or Appendix K). The references used in this Appendix are identified as [X.X] (e.g., [1.1] is Reference 1.1 at the end of Chapter W.1).

OS197 and OS197H TCs in the remainder of this Appendix will be referred to as OS197 TC.

W.1.1 Introduction

As stated in Section 1.2.1, the body of this UFSAR is dedicated to three on-site transfer cask types: the Standard cask, NUHOMS®-OS197 and NUHOMS®-OS197H TCs. The purpose of this Appendix is to provide the safety analysis of the design of a fourth type of on-site transfer cask, designated as the NUHOMS® OS197L TC, for use with the standardized NUHOMS® system.

W.1.2 General Description of the NUHOMS® OS197L TC

The 68 metric ton (Te) (75 tons) OS197L TC on-site transfer cask is designed to accommodate plants whose crane capacity cannot accommodate the use of the 94.6 Te (104.25 tons) OS197 TC or the 113.4 Te (125 Tons) OS197H TC cask for fuel transfer. The major differences between the OS197L TC and the OS197 casks are:

- Reduced cask weight
  - No lead shielding (one 2.68" nominal thickness steel shell instead of a combination of a 0.5" nominal thickness steel inner liner, 3.5" nominal thickness lead shield and 1.5" nominal thickness steel structural shell)
- One piece solid trunnion configuration for the upper and lower cask trunnions
- Two piece neutron shield (inner and outer shell of 1/4" nominal thickness versus an outer shell of 3/16" nominal thickness)

The OS197L TC key design parameters are compared to the OS197 TC in Table W.1-1.

The OS197L TC used in the NUHOMS® system provides shielding and protection from potential hazards during the DSC fuel loading/unloading operations and transfer to the Horizontal Storage Module (HSM). The design and configuration of the OS197L TC is a modified version of the NRC approved OS197 and OS197H TCs described in Section 1.3.2.1 of the UFSAR and is limited to on-site use under 10CFR72. The OS197L TC can be configured to meet a gross weight limit of 68 Te (75 tons).

Figure W.1-1 provides an overview of the OS197L TC. The OS197L TC configuration also requires the use of additional shielding in the decontamination area (see Figure W.1-2) and on the skid/trailer (see Figure W.1-3).

W.1.2.1.1 Transfer Equipment

Transport Trailer: The NUHOMS® OS197L TC transport trailer consists of a heavy industrial trailer with a payload capacity of 136 Te (150 tons), including the skid and loaded cask. The OS197L TC transport trailer is the same as the one shown in Figure 1.3-7 of the UFSAR.

Cask Support Skid: The OS197L TC support skid differs from the OS197 TC support skid shown in UFSAR Figure 1.3-8 as described below:

1. The OS197L TC support skid has permanently mounted 2.5" thick side shielding and accommodates an additional 3" thick side shielding bolted to the permanent shielding when transferring the OS197L TC.

2. The OS197L TC also has a 2.5" shielding inner top cover and an additional 3" shielding outer top cover to shield the upper sections of the cask.

The OS197L TC support skid utilized for the standardized NUHOMS® system is illustrated in Figure W.1-3.

Hydraulic Ram: The high capacity hydraulic ram system is similar to the hydraulic ram system described in the UFSAR. The capacity of this ram is increased in order to increase the ram capacity margin (and to accommodate other future DSC designs). There is no change to the maximum ram forces allowed (80 kips) during system operation.

A picture of the OS197L TC system is provided in Figure W.1-4.

W.1.2.2 Operational Features

The primary operations with the OS197L TC (in sequence of occurrence) for the NUHOMS® system are the same as the systems operation described in Section 1.3.3 of the UFSAR except as noted below for operations 8 and 13 (of Section 1.3.3):

Lifting Cask from Pool: The loaded OS197L TC is lifted out of the pool and placed (in the vertical position) in a decontamination area shield on the drying pad in the decon pit. Prior to the lift, the DSC water is pumped out and a helium gas blanket is provided for the fuel assemblies. The OS197L TC neutron shield and the TC/DSC annulus is maintained full. During cask movement from the fuel pool to the decontamination area, remote crane operation and an optical targeting system with remote camera monitoring will be used to minimize personnel exposure due to the reduced shielding configuration of the OS197L TC during this transit movement. The licensee shall meet the specific radiation protection program requirements associated with the use of OS197L TC as specified in applicable Amendment 11 Technical Specifications.

DSC Welding, Drying and Sealing: No DSC blowdown with helium is required since the DSC cavity is filled with helium prior to lifting it out of the pool.

Placement of Cask on Transport Trailer Skid: The OS197L TC is then lifted onto the cask support skid. The neutron shield may be drained (required for 32PT DSC only) during this operation provided water is maintained in the DSC/TC annulus with an interim cask cover. The plant's crane is used to downend the cask from a vertical to a horizontal position. Inner top shielding is added to the skid and the cask is also covered with an additional outer top shielding. The outer top additional shielding is to be installed inside the fuel handling building if the floor loads can accommodate it (if floor loading is a concern, the additional shielding may be placed on the skid outside the fuel handling building). The neutron shield is filled, if previously drained, prior to draining of the annulus and replacement of the interim cover with the standard cask cover. The cask is then secured to the skid and readied for the subsequent transport operations.

W.1.3 Identification of Agents and Contractors

Transnuclear, Inc. (TN) provides the design, analysis, licensing support and quality assurance for the NUHOMS® OS197L TC. Fabrication of the NUHOMS® OS197L TC is done by one or more qualified fabricators under TN's quality assurance program described in Chapter W.13. This program is written to satisfy the requirements of Subpart G of 10CFR72, [1.2] and covers control of design, procurement, fabrication, inspection, testing, operations and corrective action.

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 NUHOMS® CoC 1004 [1.3].

W.1.4 Generic Cask Arrays

No change.

W.1.5 Supplemental Data

The following TN drawings are enclosed:

1. NUHOMS® OS197L Onsite Transfer Cask, Cask Body Assembly, Drawing NUH-03-8008-SAR.
2. NUHOMS® OS197L Onsite Transfer Cask, Light Neutron Shield Assembly, Drawing NUH-03-8009-SAR.
3. NUHOMS® OS197L Onsite Transfer Cask, OS197L Main Assembly, Drawing NUH-03-8010-SAR.

W.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 NUHOMS® Certificate of Compliance for Dry Spent Fuel Storage Casks, Certificate Number 1004, Amendment No. 8, December 2005 (Docket 72-1004).

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

ALL DIMENSIONS ARE NOMINAL UNLESS A SPECIFIC TOLERANCE IS INDICATED WITH THE DRAWING DIMENSION

DIMENSIONS ARE IN INCHES AND DEGREES UNLESS OTHERWISE SPECIFIED. DIMENSIONING IN ACCORDANCE WITH ASME Y14.5M

INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4

TRANSNUCLEAR
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SAFETY ANALYSIS REPORT
NUHOMS® OS197L
ONSITE TRANSFER CASK
CASK BODY ASSEMBLY

DRAWING NO.	SCALE	SHEET	REVISION
NUH-03-8008-SAR	NONE	1 OF 8	0

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

PROPRIETARY AND
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DRAWING NO.	SHEET	REVISION
NUH-03-8008-SAR	3 OF 8	0

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO. NUH-03-8008-SAR SHEET 4 OF 8 REVISION 0

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO.	SHEET	REVISION
NUH-03-8008-SAR	5 OF 8	0

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO.	SHEET	REVISION
NUH-03-8008-SAR	6 OF 8	0

NUH-03-8008-SAR 6 OF 8

PROPRIETARY AND
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DRAWING NO.	SHEET	REVISION
NUH-03-8008-SAR	7 OF 8	0

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO.	SHEET	REVISION
NUH-03-8008-SAR	8 OF 8	0

1 OF 6	NUH-03-8009-SAR

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INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4

TRANSNUCLEAR
AN AREVA COMPANY

SAFETY ANALYSIS REPORT
NUHOMS® OS197L
ONSITE TRANSFER CASK
LIGHT NEUTRON SHIELD ASSEMBLY

DRAWING NO.	SCALE	SHEET	REVISION
NUH-03-8009-SAR	NONE	1 OF 6	0

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO.	SHEET	REVISION
NUH-03-6009-SAR	2 OF 6	0

NUH-03-8009-SAR | SHEET 3 OF 6

8 7 6 5 4 3 2 1

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO.	SHEET	REVISION
NUH-03-8009-SAR	3 OF 6	0

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO.	SHEET	REVISION
NUH-03-8009-SAR	4 OF 6	0

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO.	SHEET	REVISION
NUH-03-8009-SAR	5 OF 6	0

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

NUH-03-8009-SAR 6 OF 6 0

PROPRIETARY AND
SECURITY RELATED INFORMATION
WITHHELD UNDER 10 CFR 2.390

ALL DIMENSIONS ARE NOMINAL UNLESS A SPECIFIC TOLERANCE IS INDICATED WITH THE DRAWING DIMENSION

DIMENSIONS ARE IN INCHES AND DEGREES UNLESS OTHERWISE SPECIFIED. DIMENSIONING IN ACCORDANCE WITH ASME Y14.5M

INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4

TRANSNUCLEAR
AN AREVA COMPANY

SAFETY ANALYSIS REPORT
NUHOMS® OS197L
ONSITE TRANSFER CASK
OS197L MAIN ASSEMBLY

DRAWING NO.	SCALE	SHEET	REVISION
NUH-03-8010-SAR	NONE	1 OF 2	0

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO.	SHEET	REVISION
NUH-03-8010-SAR	2 OF 2	0

Table W.1-1
Comparison of Key Parameters of NUHOMS® OS197 Versus OS197L TCs

Characteristic	OS197 TC	OS197L TC	Same? (Yes/No) Note No.
Physical Data			
Outside Diameter	85.50"	80.36"	No (1)
Outside Length	207.22"	207.22"	Yes
Cavity Diameter	68"	68"	Yes
Cavity Length	197.75"	197.75"	Yes
Ram Access Penetration Diameter	22"	22"	Yes
Weight, Empty	106,670 lbs (includes cask top cover plate assembly and neutron shield without water)	57,400 lbs (includes cask top cover plate assembly and neutron shield without water)	No (2)
Cask Materials			
Outer Jacket	3/16" thick plate, ASTM A240, Type 304	1/4" thick plate, ASTM A240, Type 304	No (3)
Neutron Shielding	3" of Water in annulus	3" of Water in annulus	Yes
Structural Shell	1-1/2" thick plate, ASME SA-240 Type 304	2.68" thick plate, ASME SA-240 Type 304	No (4)
Gamma Shielding	3.56" thick, ASTM B29 Chemical Copper Lead	No lead shielding	No (4)
Inner Liner	1/2" thick plate, ASME SA-240 Type 304	No separate inner liner (consists of structural shell)	No (4)
Top Cover Assembly	Consists of 3" thick ASME SA-240, Type 304 structural plate with a thin 1/4" thick shell encapsulating a solid Neutron Absorbing Material (NS-3)	Consists of 3" thick ASME SA-240, Type 304 structural plate with a thin 1/4" thick shell encapsulating a solid Neutron Absorbing Material (NS-3) During downending inside the fuel building, an interim aluminum cover may be used to reduce crane loading	Yes
Top Flange	ASME SA-182, Type F304N	ASME SA-182, Type F304N	Yes
Upper Lifting Trunnion	ASME SA-564, Grade 630 steel trunnion with sleeve encapsulating a solid Neutron Absorbing Material (NS-3)	Solid monolithic Trunnion made of ASME SA-182, Type FXM-19	No
Lower Support Trunnion	ASME SA-240, Type F304 steel trunnion with sleeve encapsulating a solid Neutron Absorbing Material (NS-3)	Solid monolithic Trunnion made of ASME SA-182, Type F304	No
Canister Rails	ASTM A240 Nitronic 60	ASTM A240 Nitronic 60	Yes
Bottom End Plate	2" thick, ASME SA-240, Type 304	2" thick, ASME SA-240, Type 304	Yes
Bottom Support Ring	ASME SA-182, Type F304N	ASME SA-182, Type F304N	Yes
Ram Access Penetration Ring	ASME SA-182, Type F304N	ASME SA-182, Type F304N	Yes
Cask Payload			
DSC Type	24P, 52B, 61BT, 24PHB, 24PT2, 32PT	24P, 52B, 61BT, 24PHB, 24PT2, 32PT	Yes
Heat Load	24 kW	24 kW	Yes

Notes:
1. The diameter of the OS197L TC is smaller, reflecting the reduced radial shielding. The 2.68" thick SS structural shell replaces the combined thickness of ½" of inner liner, 3.50" of lead, and 1.50" of structural shell, a reduction of approximately 5.5" diametrical.
2. The reduced weight of the OS197L TC reflects the reduced radial shielding. Utilizing the yoke (approximate weight 5,000 lbs.) results in an estimated maximum hook weight of 148-149 kips.
3. The outer panel of the neutron shield is increased in thickness to stiffen the assembly.
4. The reduced shielding is a result of the lead shielding that is eliminated and the combined inner liner and structural shell.

Table W.1-2
OS197L TC UFSAR Sections Affected

Seq	Section/Page	Description	OS197L
1	1.1(3)/1.1-3	Description of TC for transport of DSC	No Change
2	Figures 1.1-2/1.1-6	NUHOMS® System Components including TC	See Section W.1
3	Figures 1.1-3/1.1-7	NUHOMS® System Components including TC	See Section W.1
4	1.2.3/1.2-3	Description of Operating and Handling Systems including TC	Changes addressed in Section W.1.
5	Table 1.2-2/1.2-8	Key Design Parameters for NUHOMS® System	See Section W.1
6	Table 1.2-3/1.2-9	NUHOMS® System Operations Overview	See Section W.8
7	Section 1.3.2.1/1.3-3	Description of On-Site TC	See Section W.1
8	Section 1.3.2.2/1.3-4	Description of Transfer Equipment (Trailer and Skid)	See Section W.1
9	Table 1.3-1/1.3-10	Components, Structures and Equipment for the Standardized NUHOMS® System	See Section W.1
10	Figure 1.3-6/1.3-18	NUHOMS® On-Site TC	See Section W.1
11	Figure 1.3-8/1.3-20	Cask Support Skid for NUHOMS® System	See Section W.1
12	Figure 1.3-10/1.3-22	NUHOMS® System Operational Overview	See Section W.1
13	2.0	Site Characteristics	No Change
14	3.1.2.1/3.1-4	On-Site Transfer Cask	No change to loading conditions See Section W.1 for OS197L description.
15	Table 3.1-7/3.1-13	NUHOMS® Transfer Equipment Criteria	No Change
16	3.2.5.3/3.2-7	On-Site Transfer Cask Load Combinations and Structural Design Criteria	No Change to load combinations or criteria. See Section W.3 for OS197L structural results
17	Table 3.2-1/3.2-11	Summary of NUHOMS® Component Design Loadings	No Change
18	Table 3.2-7/3.2-20	On-Site Transfer Cask Load Combinations and Service Levels	No Change
19	Table 3.2-11/3.2-25	Structural Design Criteria for On-Site Transfer Cask	No Change
20	Table 3.2-12/3.2-26	Structural Design Criteria for Bolts	No Change
21	3.3.5.2/3.3-31	Radiological Protection-Shielding	See Section W.5
22	Table 3.3-1/3.3-36	NUHOMS® System Components Important To Safety	See Table W.2-1.
23	3.4.4.1/3.4-2	Classification of Structures, Components, and Systems- Transfer Cask and Yoke	No Change
24	3.4.4.2/3.4-2	Classification of Structures, Components, and Systems- Other Transfer Equipment	No Change
25	Table 3.4-1/3.4-4	NUHOMS® Major Components and Safety Classification	See Table W.2-1
26	4.2.1/4.2-1	Storage Structures – Structural Specifications	No Change
27	4.2.3.3/4.2-9	Individual Unit Description - On-Site Transfer Cask	See Sections W.1 and W.3 for trunnion load test.
28	Figure 4.2-10/4.2-21	Composite View of NUHOMS® Transfer Cask-24P	See Section W.1
29	Figure 4.2-11/4.2-22	Composite View of NUHOMS® Transfer Cask-52B	See Section W.1
30	Figure 4.2-12/4.2-23	NUHOMS® On-Site Transfer Cask with BWR Collar	No Change
31	Figure 4.2-15a/4.2-26a	NUHOMS® 75 Ton Transfer Cask Lifting Yoke	No Change

Table W.1-2
OS197L TC UFSAR Sections Affected
(Concluded)

Seq	Section/Page	Description	OS197L
32	4.5/4.5-1	Transfer Cask and Lifting Hardware Repair and Maintenance	No Change
33	4.7.3.2/4.7-5	Individual Unit Descriptions - Transfer Cask	See Section W.1
34	4.7.3.8/4.7-10	Individual Unit Descriptions – Cask Support Skid	See Section W.1
35	4.9/4.9-1	ASME Code Exceptions List for the Transfer Cask	See Section W.3
36	Table 4.9-1/4.9-3	ASME Code Exceptions List for the Transfer Cask	See Section W.3
37	5.0/5.1-1	Operation Systems	See Section W.8
38	6.0	Waste Confinement and Management	No Change
39	7.1/7.1-1	Radiation Protection-design Considerations	See Section W.5
40	7.3.2.2.F/7.3-6	Transfer Cask Surface Dose Rates	See Section W.5
41	Tables 7.3-2 through 7.3-5/7.3-9 through 7.3-14	Shielding Analysis Results	See Section W.5
42	7.4.1/7.4-1	Operational Dose Assessment	See Section W.5
43	Table 7.4-1/7.4-3	NUHOMS® System Operations – Occupational Dose Calculations	See Section W.5
44	8.0	Analysis of Design Events	See: Section W.3 – Structural Section W.4 – Thermal Section W.11 – Accident
45	9.0	Conduct of Operations	No Change
46	10.0	Operating Controls and Limits	No Change
47	11.0	Quality Assurance	No Change
48	Appendix A	Details of Shielding Models of the NUHOMS® System	See Section W.5
49	Appendix B	Details of Heat Transfer Analysis of the NUHOMS® System	No Change
50	Appendix C.1	Deleted	No Change
51	Appendix C.2	Transfer Cask Drop Analysis	See Section W.3
52	Appendix C.3	Transfer Cask Side Drop Analysis	See Section W.3
53	Appendix C.4.1	DSC Fatigue Evaluation	No Change
54	Appendix C.4.2	Transfer Cask Fatigue Evaluation	No Change
55	Appendix C.5	Transfer Cask Structural Analysis NRC Question Resolutions	See Section W.3 for DBT events
56	Appendix C.6	References	No Change
57	Appendix D	Review of Concrete Behavior under Sustained elevated Temperature	No Change
58	Appendix E	Drawings	See Section W.1.5
59	Appendix F	NUHOMS® 24P Topical Report – NRC Questions	No Change
60	Appendix G	Deleted	No Change
61	Appendix H	NUHOMS® 24P – Long Cavity DSC Evaluation for Storing PWR fuel Without BPRA's	No Change
62	Appendix I	Deleted	No Change
63	Appendix J	NUHOMS® 24P – Long Cavity DSC Evaluation for Storing PWR fuel With BPRA's	No Change

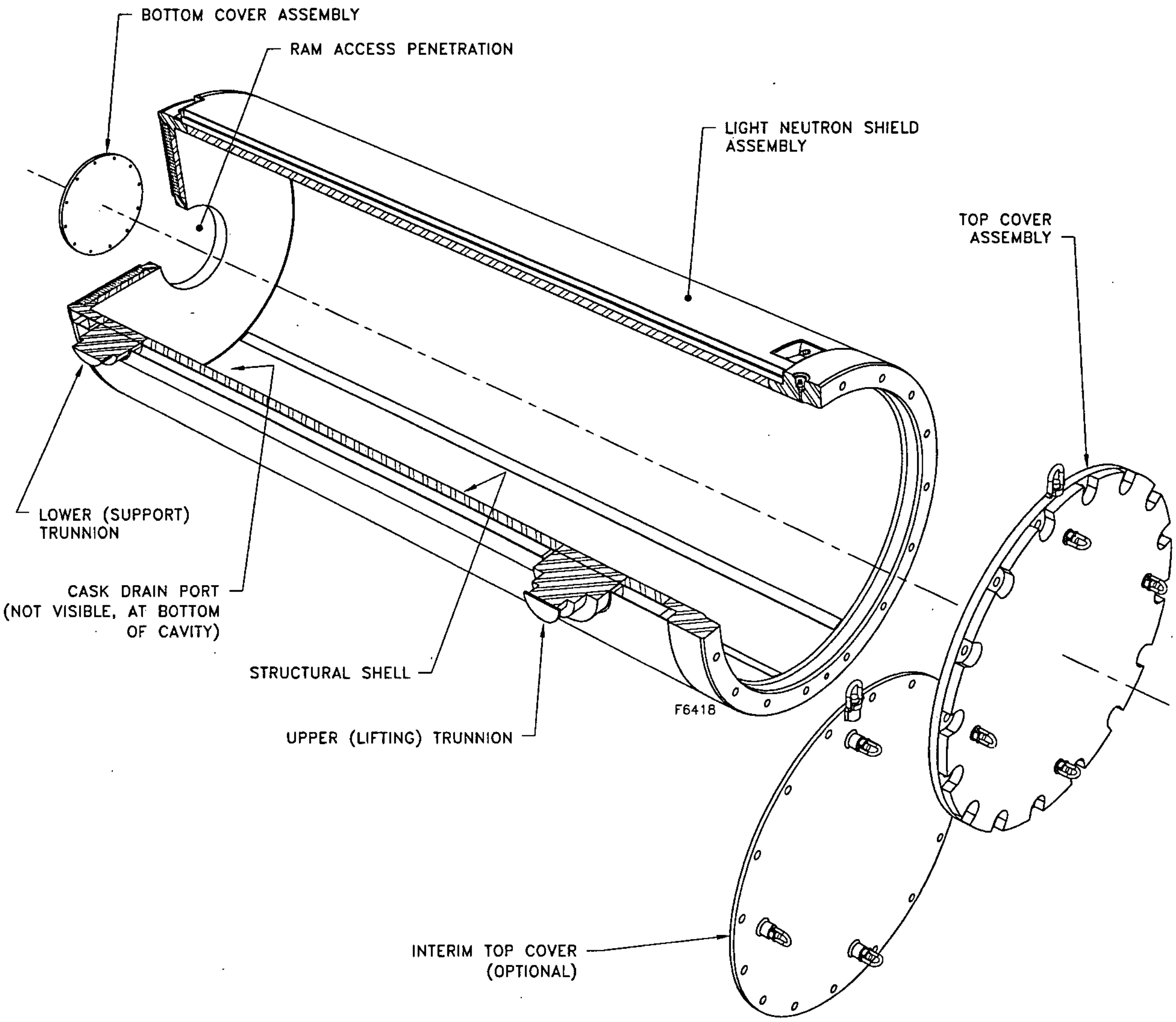


Figure W.1-1
OS197L TC Configuration

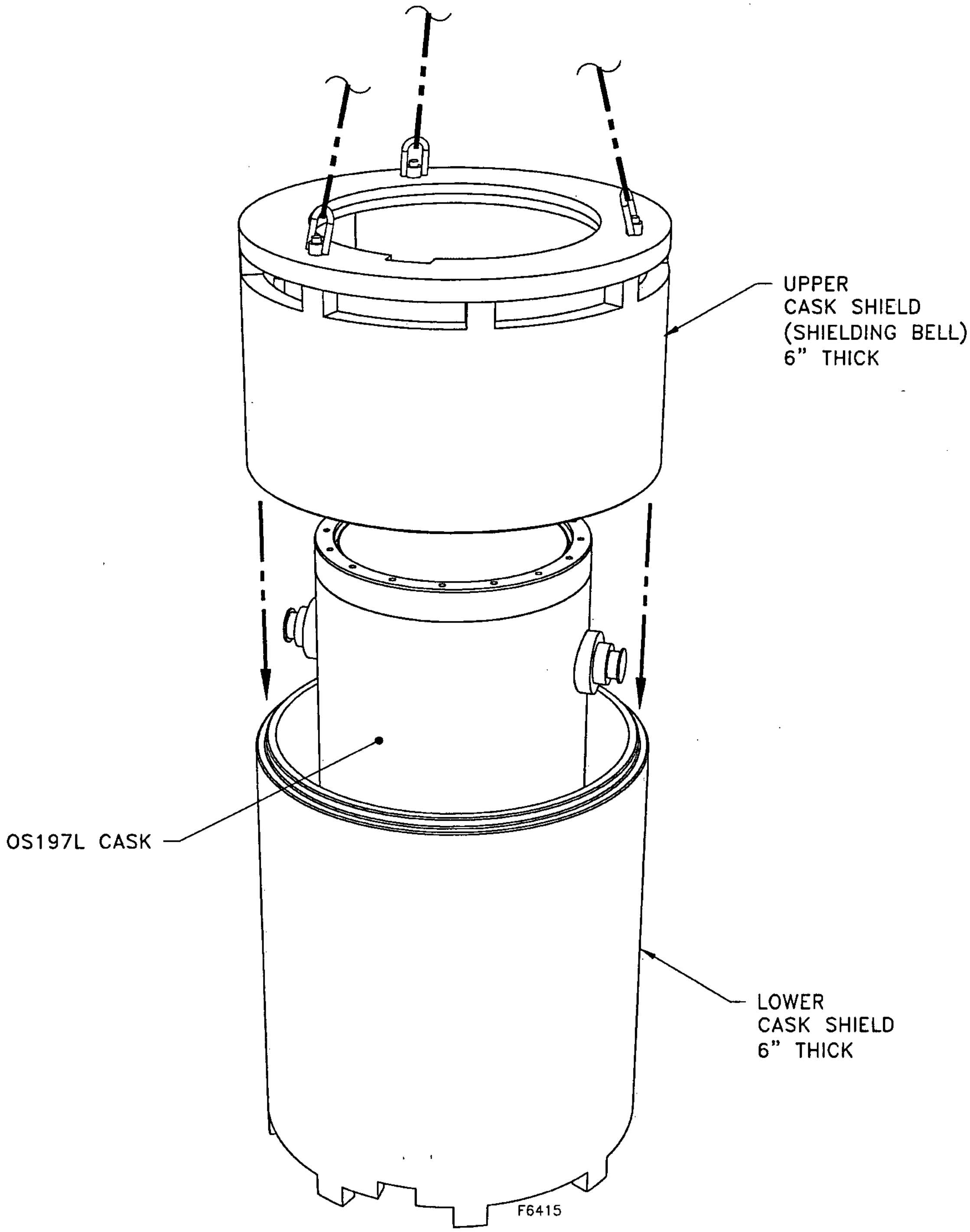


Figure W.1-2
NUHOMS® OS197L TC System Decontamination Area Shielding

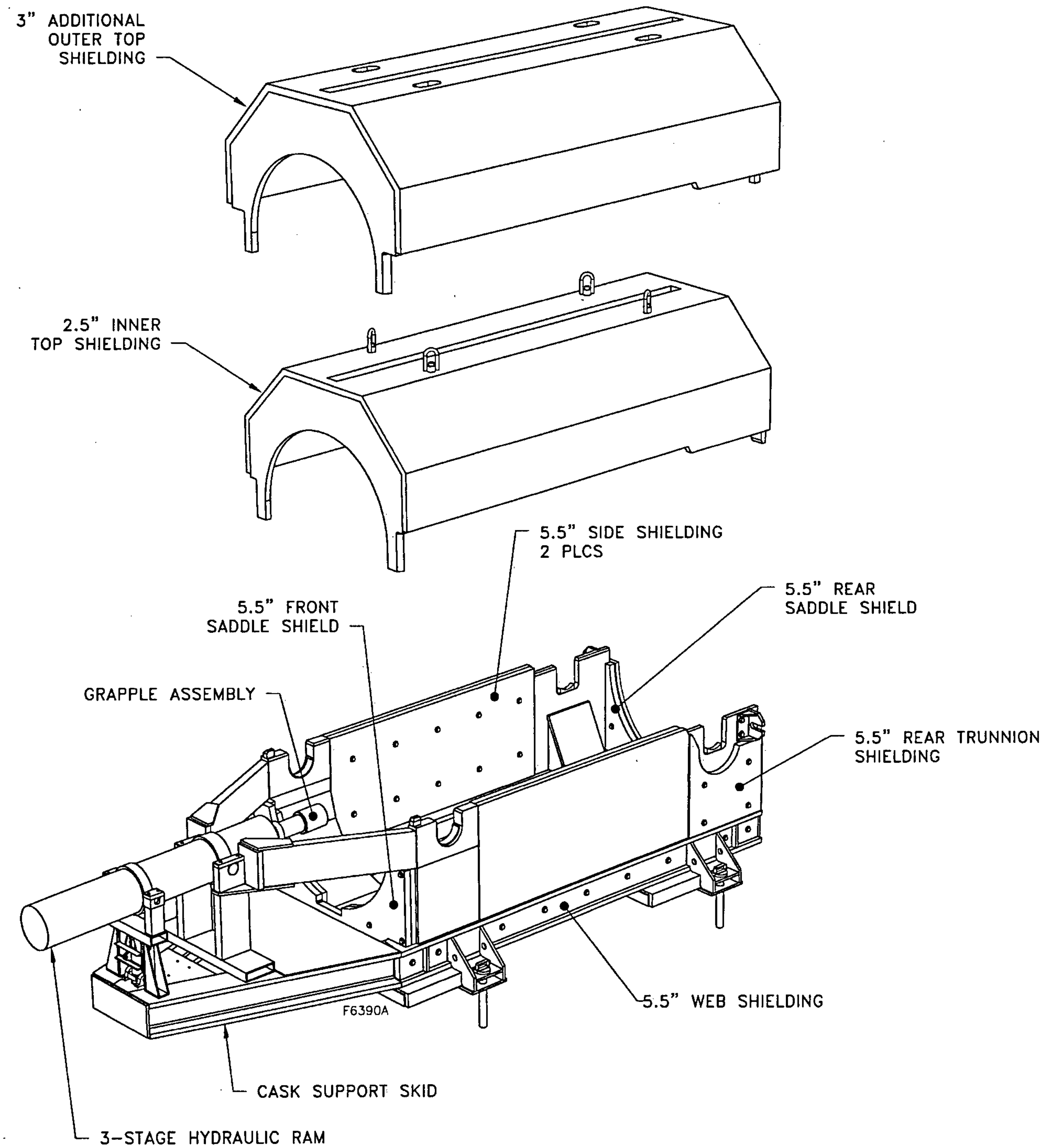


Figure W.1-3
OS197L Transfer Equipment Schematic

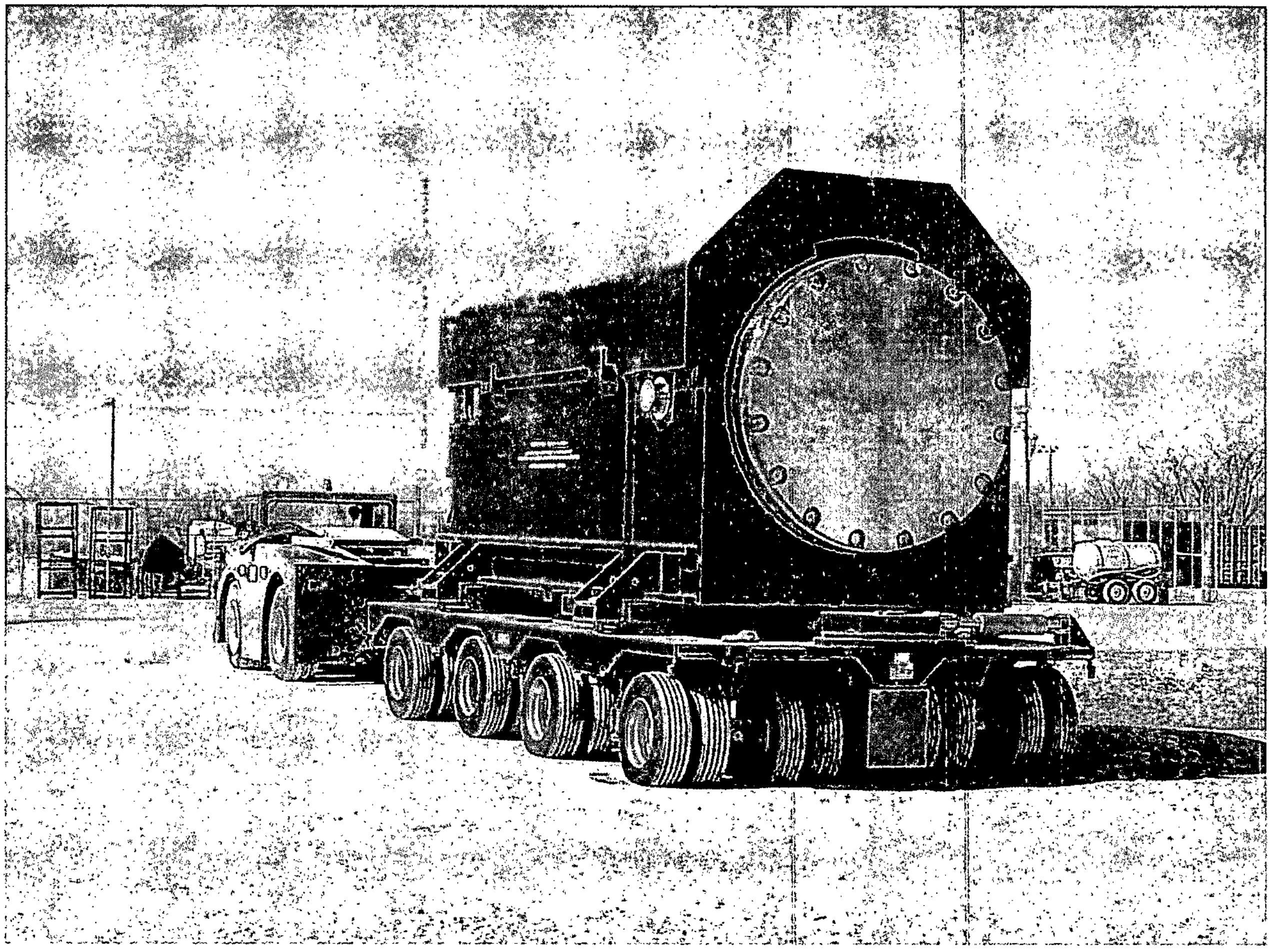


Figure W.1-4
OS197L TC System on Transfer Trailer with Shielding

W.2 Principal Design Criteria

This section provides the principal design criteria for the NUHOMS® OS197L TC System. The principal design criteria for the NUHOMS® OS197L TC are the same as the NUHOMS® OS197 TC as described in Chapter 3. Section W.2.1 presents a general description of the spent fuel to be stored. Section W.2.2 provides the design criteria for environmental conditions and natural phenomena. Section W.2.3 provides a description of the systems which have been designated as important to safety. Section W.2.4 discusses decommissioning considerations. Section W.2.5 summarizes the NUHOMS® OS197L TC design criteria.

W.2.1 Spent Fuel To Be Stored

The NUHOMS® DSCs are designed to handle a total of 24 or 32 PWR fuel assemblies and 52 or 61 BWR fuel assemblies with the same characteristics as those described in Chapter 3 (24P and 52B DSCs) and Appendices K.2 (61BT DSC), L.2 (24PT2 DSC), M.2 (32PT DSC), and N.2 (24PHB DSC).

W.2.1.1 General Operating Functions

No change.

W.2.2 Design Criteria for Environmental Conditions and Natural Phenomena

The NUHOMS® OS197L TC is handled and utilized in the same manner as the existing NUHOMS® OS197 TC System. The environmental conditions, natural phenomena and design criteria are the same as described for the NUHOMS® OS197 TC in Chapter 3. Design criteria for the NUHOMS® DSC and HSM remain unchanged.

W.2.2.1 Tornado Wind and Tornado Missiles

No change.

W.2.2.2 Water Level (Flood) Design

No change.

W.2.2.3 Seismic Design

No change.

W.2.2.4 Snow and Ice Loading

No change.

W.2.2.5 Combined Load Criteria

No change.

W.2.3 Safety Protection Systems

W.2.3.1 General

Table W.2-1 provides the safety classification of the OS197L TC system components.

W.2.3.2 Protection By Multiple Confinement Barriers and Systems

No change.

W.2.3.3 Protection By Equipment and Instrumentation Selection

No change.

W.2.3.4 Nuclear Criticality Safety

W.2.3.4.1 Control Methods for Prevention of Criticality

No change.

W.2.3.4.2 Error Contingency Criteria

No change.

W.2.3.4.3 Verification Analysis-Benchmarking

No change.

W.2.3.5 Radiological Protection

No change.

W.2.3.6 Fire and Explosion Protection

No change.

W.2.4 Decommissioning Considerations

No change.

W.2.5 Summary of NUHOMS® OS197L TC Design Criteria

The principal design criteria for the NUHOMS® OS197L TC are the same as those presented for the NUHOMS® OS197 TC in Chapter 3. The NUHOMS® OS197L TC is designed to handle a DSC loaded with PWR or BWR fuel assemblies identical to those stored in a NUHOMS® OS197 TC as described in Chapter 3 and Appendices K.2, L.2, M.2 and N.2.

Table W.2-1
OS197L TC System Components and Safety Classification

OS197L TC System Components	Safety Classification
Onsite Transfer Cask	
– Structural Shell and Cover Plates	Important to Safety[(1)]
– Upper and Lower Trunnions	Important to Safety[(1)]
– Decontamination Area Shield	Not Important to Safety[(1)]
– Trailer Shielding	Important to Safety[(1)]
Transfer Equipment	
– Cask Lifting Yoke	Safety Related[(2)]
– Transport Trailer/Skid	Not Important to Safety[(1)]
– Ram Assembly	Not Important to Safety[(1)]
– Dry Film Lubricant	Not Important to Safety[(1)]

Notes:

(1) Structures, systems and components "important to safety" are defined in 10CFR 72.3 as those features of the ISFSI whose function is (1) to maintain the conditions required to store spent fuel safety, (2) to prevent damage to the spent fuel container during handling and storage, or (3) to provide reasonable assurance that spent fuel can be received, handled, packaged, stored, and retrieved without undue risk to the health and safety of the public.

(2) Yoke and rigid or sling lifting members are classified as "Safety Related" in accordance with 10CFR50.

W.3 Structural Evaluation

This section describes the structural evaluation of the NUHOMS® OS197L Transfer Cask (TC). The OS197L TC is a modified version of the OS197/OS197H TCs (henceforth referred as the OS197 TC) designed to enable "under-the-hook" lift weights of 75 tons. The OS197L TC may be used for transfer of loaded DSCs currently licensed under CoC 1004 (24P, 52B, 61BT, 24PT2, 32PT and 24PHB) [3.1]. The structural evaluation for the OS197L TC is based on the OS197 TC evaluations documented in Chapter 8, and additional evaluations as described in Appendices K, L, M and N for payloads associated with the 61BT, 24PT2, 32PT and 24PHB DSCs, respectively. The additional evaluations provided in this section address specific design differences between the OS197L TC and the OS197 TC.

W.3.1 OS197L TC Description

The specific design differences in the OS197L TC relative to OS197 TC are summarized below:

- The 1.5" thick structural shell and the 0.5" thick inner liner (both SA-240 stainless steel) are replaced with a single thicker 2.68" thick shell of the same material. This represents an increase in the TC shell structural capacity relative to the OS197 TC.
- The encapsulated 3.56" thick lead thickness in the OS197 TC is eliminated to achieve the desired weight reduction.
- A neutron shield assembly is provided with the inner and outer shells made from ¼" thick plate material instead of a neutron shield assembly that is integral to the structural shell on the inside and a 3/16" thick outer shell. The neutron shield materials (type 304), total annulus water thickness of 3" and the configuration of the internal stiffening elements remain essentially unchanged.
- The two-piece upper trunnions assemblies made from SA-564 Type 630 steel trunnion and welded into a forged Type 304 steel trunnion sleeve with encapsulated NS-3 for the OS197 TC are replaced with one solid trunnion design made from SA-182 Type FXM-19 stainless steel. This modified trunnion design results in a stronger trunnion as it eliminates the SA564, Type 630 to SA 240, Type 304 weld.
- The two-piece lower trunnions made from Type 304 stainless with encapsulated NS-3 are replaced with solid Type 304 forgings.

Specific evaluations are performed to address the modified OS197L TC trunnion configuration. The evaluations also address the effect on local shell stresses. Thermal stresses of the cask are also evaluated. All other structural analyses for the OS197 TC bound the OS197L TC because the cask structural shell capacity of the OS197L TC is higher than that provided by the OS197 and the top and bottom forging assemblies are unchanged.

W.3.2 Design Criteria

The structural design criteria for the OS197L TC are the same as that applicable to the OS197 TC as summarized in Chapter 3. Similar to the OS197 TC, the OS197L TC is designed to meet the stress allowables of the ASME Code [3.2] Subsection NC for Class 2 components. The OS197 TC criteria summarized in Table 3.2-1 (component design loadings, as applicable), Table 3.2-7 (load combinations), Table 3.2-11 (stress criteria) and Table 3.2-12 (bolts design criteria) are applicable to the OS197L TC. The OS197 TC ASME Code exceptions described in Table 4.9-1 are also applicable to the OS197L TC.

The test load criteria for the upper trunnions of the OS197L TC are the same as described in Section 4.2.3.3, except that the test load is conservatively equal to 300% of the design load (instead of 150% for the OS197 TC).

W.3.3 OS197L TC Weight

The dry weight of the OS197L TC is presented in Table W.3-1. The total weight of the cask, including neutron shield water, is approximately 62,000 lbs. This compares with the corresponding weight of 111,250 lbs for the OS197 TC. To provide flexibility during transfer from the decontamination area to the trailer, a 1" thick aluminum cask top lid (cover) that weights approximately 500 lbs may be used in lieu of the stainless cask top lid (cover).

The OS197L TC weights as described in Table W.3-1 are to be used in conjunction with the payload weights for the various DSCs as described in the applicable sections in Chapter 8 (Tables 8.1-4 and 8.1-5 for the 24P and 52B DSCs), and Appendices K.3, L.3, M.3 and N.3. Each specific user is to evaluate the total under-the-hook lift weights against plant specific crane capacity limits in accordance with the requirements of 10CFR72.212.

W.3.4 Mechanical Properties of Materials

The materials properties for the OS197L TC are specified in Section 8.1, Table 8.1-3.

W.3.5 General Standards for Casks

The OS197L is fabricated using the same materials as the OS197 TC. Thus, there are no changes to the documentation in Chapter 4 and Appendices K.3, L.3, M.3 and N.3 relative to chemical and galvanic reactions.

The evaluation of the OS197L TC is based on critical lift weights of 250,000 lbs.

The thermal analysis of the OS197L along with a summary of the effect on pressures and temperatures is described in Chapter W.4.

W.3.6 Normal/Off-Normal Structural Evaluation

W.3.6.1 Evaluation of the One-Piece OS197L Trunnions

As discussed above, the OS197L TC upper trunnions consist of one piece solid trunnion forgings made from SA-182 Type FXM-19 stainless steel which results in a stronger trunnion design as it eliminates the SA564 (trunnion) to Type 304 (trunnion sleeve) weld and associated inconel weld.

Loads considered in the stress evaluation include lifting, transfer handling, HSM loading/unloading and seismic. The trunnions are evaluated for a maximum TC loaded weight during lifting and handling of 125 tons. For critical lifts, the maximum TC loaded weight is increased by a factor of 1.15. This results in critical lift load of 144 kips/trunnion. The trunnion evaluations are performed using hand calculations and applying the ANSI N14.6 [3.3] design criteria, including load testing. In addition, an ANSYS model of the cask, including the upper and lower trunnions, is developed to determine cask shell stresses at the trunnion-shell interface as well as within 3" to 4" away from the trunnions. These stresses are evaluated against the ASME stress criteria in Table 3.2-11. The ANSYS model of OS197L TC is shown in Figure W.3-1 and Figure W.3-2.

In addition, a thermal stress analysis of the OS197L TC with the trunnions is performed. The stresses obtained from the thermal stress analysis are combined with the mechanical stresses to determine total stresses at and near (within 3" to 4") of the trunnion-structural shell interface.

The stress distribution in the region of the upper trunnion is shown in Figure W.3-3. The structural analyses results of the OS197L TC trunnions are summarized in Table W.3-2 through Table W.3-4. The maximum stress ratio is 0.74, therefore the OS197L TC trunnion configuration has significant margin with respect to ASME/ANSI N14.6 code allowables.

W.3.6.2 Thermal Stress Analysis of OS197L

A conservative thermal profile was developed for the purpose of calculating bounding thermal stresses in the OS197L TC components. The thermal stress analysis is performed using the same three-dimensional ANSYS model shown in Figure W.3-1. The calculated maximum thermal stress intensity in the OS197L is 17.4 ksi and occurs in the structural shell away from the trunnion region. Conservatively combining this thermal stress intensity with the maximum mechanical stresses which occur in the trunnion region results in an enveloping (structural shell top and bottom forgings) combined stress intensity for normal and off-normal conditions of 37.5 ksi, which is well below the allowable stress intensity for primary plus secondary stress of 56.1 ksi at temperature.

W.3.7 Applicability of OS197 TC Accident Drop Evaluations to the OS197L TC

The fully loaded weight of the OS197L TC is bounded by the OS197 TC loaded weight. Therefore, an evaluation was performed to determine if the bounding accelerations used for the postulated accident drop evaluations of the OS197 TC remain applicable to the OS197L TC.

As reported in Section 8.2.5.1C, the g loads for the OS197 TC were determined to be 59 g for the end drop, 49 g for the side drop and 25 g for a corner drop. Based on these accelerations, bounding accelerations of 75g for the horizontal (side) and vertical drops and 25g for the corner drop were used for the OS197 TC drop evaluations. The OS197 TC evaluations are documented in Chapter 8. Using the same methodology as that described in Section 8.2.5.1C for the OS197 TC, the equivalent loads for the OS197L TC are 75 g for an end drop, 61 g for a side drop and 25 g for a corner drop. Therefore, the 75g accident drop evaluation results for the side and end drops and the 25g evaluations for the corner drop performed for the OS197 TC and reported in Section 8.2 remain bounding and are applicable to the OS197L TC. These g-loads are conservative with respect to shell stresses since the thicker OS197L TC shell has a higher load capacity than the OS197 TC shell configuration. Hence, all the cask accident drop results reported in Section 8.2, and Appendices K.3, L.3, M.3 and N.3 remain bounding and, thus, are not affected.

W.3.8 Effect of Increased OS197L Temperatures on DSC Shell and Basket Components

Based on the thermal analysis documented in Chapter W.4, the maximum temperature increase applicable to the DSC shell and basket components is approximately on the order of 27°F for normal, off-normal, and accident conditions (except for the 24PHB DSC where the maximum increase for the accident condition is on the order of 87°F, the accident temperature is a post drop accident condition and it does not have an effect on the accident drop evaluations). Thus, the magnitude increases will not appreciable affect the material properties or the allowables used for the evaluations of these DSCs as documented in Chapter 8 and Appendix K, Chapter K.3, Appendix L, Chapter L.3, Appendix M, Chapter M.3 and Appendix N, Chapter N.3. Furthermore, the accident pressures used in the structural evaluations bound those calculated in Chapter W.4.

W.3.9 OS197L TC Interim Cask Cover

The interim top cask cover, is an aluminum plate (nominal 1" thick and 78.62" diameter) that interfaces with the cask top bolting, similar to the standard top cask cover. Following placement of the cask on the trailer, and placement of the inner top shield on the transfer trailer, the interim cask top cover would be removed and the standard top cask cover installed prior to exiting the spent fuel/reactor building. The aluminum cover plate is approximately 4, 000 lbs. lighter than the standard cover. The function of the interim cask top cover is to provide some additional shielding in the axial direction, and to maintain the annulus water in the event that the annulus is maintained essentially full. The interim cask top cover will not be used outside the fuel building. The interim top cover will be placed on the cask with a gasket if the DSC/TC annulus is to be maintained full. The 1" aluminum cover will see minimal stress due to the hydraulic head of the annulus water level.

The interim cover will itself have lifting points that meet ANSI N14.6 and is anticipated to weigh less than 500 lbs.

W.3.10 References

3.1 NUHOMS® Certificate of Compliance for Dry Spent Fuel Storage Casks, Amendment No. 8, December 2005, Docket No. 72-1004.

3.2 American Society of Mechanical Engineers, ASME Boiler and Pressure Vessel Code, Section III, Division 1, 1983 Edition with Winter 1985 Addenda.

3.3 American National Standard, "For Radioactive Materials - Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4500 Kg) or More," ANSI N14.6-1986, American National Standards Institute, Inc. New York, New York (1993)

Table W.3-1
Summary of OS197L TC Weights

Item	Weight (lbs)
OS197L Maximum **Dry** Weight including Neutron Shield Assembly and Top Cask Lid	57,400
Neutron Shield Water	4,600
Top Cask Lid	5,150

Table W.3-2
Summary of Maximum Stress Ratios for Critical Lifts

Enveloping Stress Ratios Critical Lift Load Combinations		P_m Calculated	P_m Allowable	P_m Ratio	$P_m + P_b$ Calculated	$P_m + P_b$ Allowable	$P_m + P_b$ Ratio	$P_m + P_b + Q$ Calculated	$P_m + P_b + Q$ Allowable	$P_m + P_b + Q$ Ratio	Notes
Level A (A1/A2/A3)	**Cask Shell, ANSYS Evaluations / ASME Criteria**										
	at Trunnion(s)	5.86 ksi	18.7 ksi	0.31	18.1 ksi	28.1 ksi	0.65	33.8 ksi	56.10	0.60	Type 304 @
	near Trunnion(s)[(1)]	4.21 ksi	18.7 ksi	0.23	16.6 ksi	28.1 ksi	0.59	28.1 ksi	56.10	0.50	400°F
	Trunnion Evaluations, Hand Calculations (ASME–Lower; ANSI N14.6–Upper)										
		P_m			$P_m + P_b$			$P_m + P_b + Q$			ASME Criteria
	Lower Trunnion	2.55 ksi	20.3 ksi	0.13	4.81 ksi	30.5 ksi	0.16	n/a	n/a	n/a	Type F304N
		Shear Stress			Normal Stress						N14.6 Criteria
	Upper Trunnion	2.86 ksi	4.07 ksi	0.70	5.01 ksi	6.78 ksi	**0.74**	n/a	n/a	n/a	Type FXM-19

Table W.3-3
Summary of Maximum Stress Ratios for Level A Load Combinations

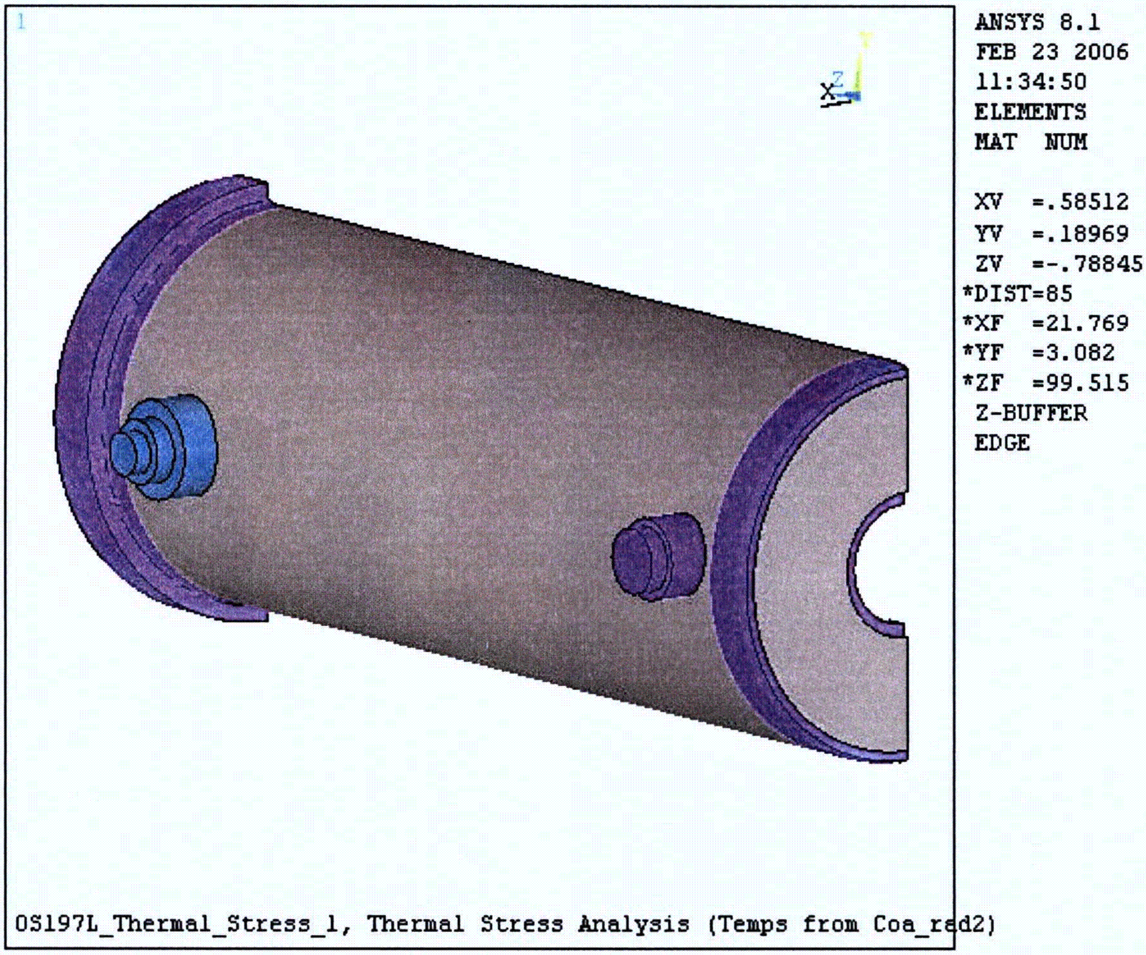
Enveloping Stress Ratios - Level A (non-Critical Lift) Combinations

Enveloping Stress Ratios Non-Critical Level A Comb.		P_m Calculated	P_m Allowable	P_m Ratio	$P_m + P_b$ Calculated	$P_m + P_b$ Allowable	$P_m + P_b$ Ratio	$P_m + P_b + Q$ Calculated	$P_m + P_b + Q$ Allowable	$P_m + P_b + Q$ Ratio	Notes
Level A (A4/A5)	Shell at Upper Trunnion/Lower Trunnion	6.05 ksi	18.7 ksi	0.32	20.1 ksi	28.1 ksi	0.72	35.8 ksi	56.1 ksi	0.64	ANSYS
	Shell near Upper Trunnion/Lower Trunnion[(1)]	4.44 ksi	18.7 ksi	0.24	14.7 ksi	28.1 ksi	0.56	27.4 ksi	56.1 ksi	0.49	Analysis
	Upper Trunnion (FXM-19)	2.51 ksi	30.2 ksi	0.08	2.96 ksi	45.3 ksi	0.07	n/a	n/a	n/a	Hand
	Lower Trunnion (Type F304N)	2.41 ksi	20.3 ksi	0.12	4.55 ksi	30.5 ksi	0.15	n/a	n/a	n/a	Calculations
			Max:	0.32		Max:	0.72		Max:	0.64	

Table W.3-4
Summary of Maximum Stress Ratios for Level C Load Combinations

Enveloping Stress Ratios For Level C Combinations		P_m Calculated	P_m Allowable	P_m Ratio	$P_m + P_b$ Calculated	$P_m + P_b$ Allowable	$P_m + P_b$ Ratio	$P_m + P_b + Q$ Calculated	$P_m + P_b + Q$ Allowable	$P_m + P_b + Q$ Ratio	Notes
Level C (C1/C2)	Shell at Upper Trunnion/Lower Trunnion	5.12 ksi	18.7 ksi	0.27	17.3 ksi	28.1 ksi	0.62	not required for Level C			ANSYS
	Shell near Upper Trunnion/Lower Trunnion[(1)]	3.23 ksi	18.7 ksi	0.17	11.9 ksi	28.1 ksi	0.43	n/a	n/a	n/a	Analysis
	Upper Trunnion (FXM-19)	1.44 ksi	36.2 ksi	0.04	2.33 ksi	54.4 ksi	0.04	n/a	n/a	n/a	Hand
	Lower Trunnion (Type F304N)	1.19 ksi	24.4 ksi	0.05	2.25 ksi	36.5 ksi	0.06	n/a	n/a	n/a	Calculations
			Max:	0.27		Max:	0.62				

Note: (1) 4" from upper trunnion/shell interface and 3" from lower trunnion/shell interface.

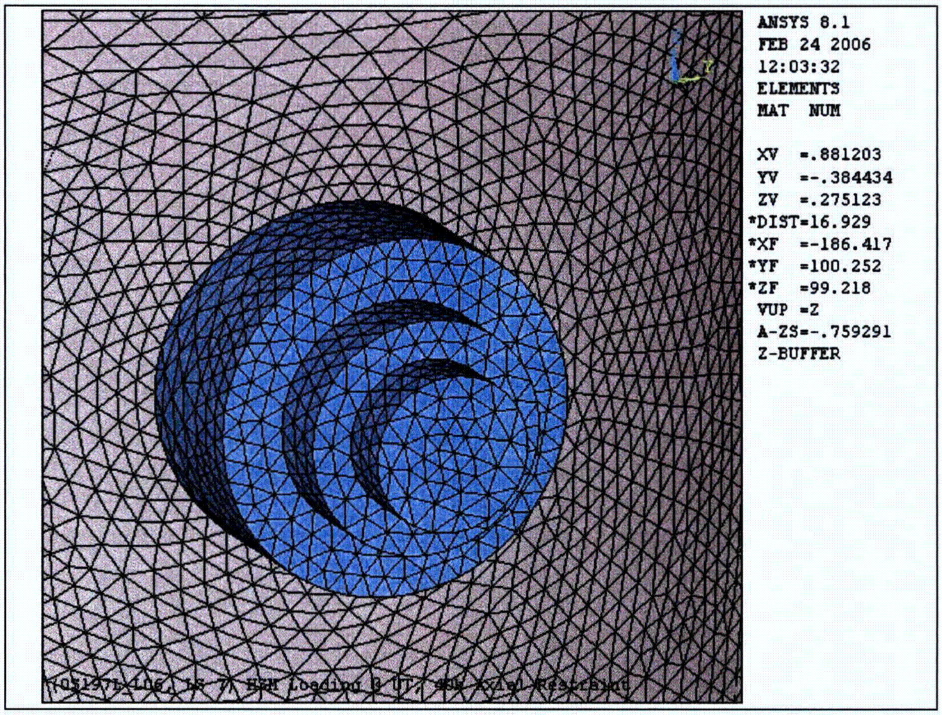


Note:

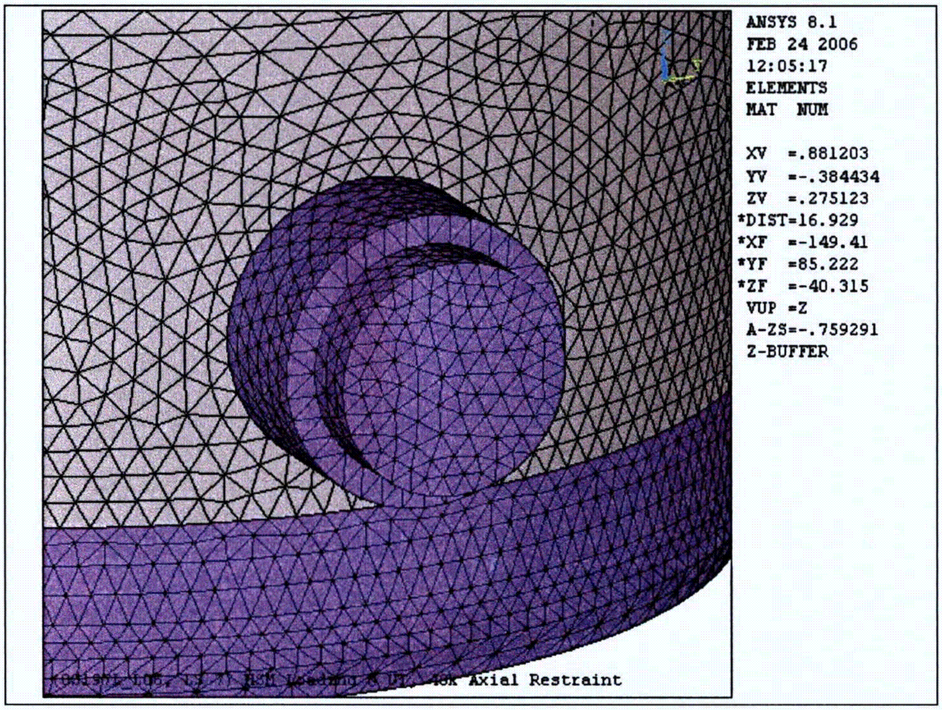
Material properties were assigned as follows:

Purple = SA-182 Type F304N (forgings)
Gray = SA-240 Type 304
Blue= SA-182 Type FXM-19 (Type XM-19 Forging)

Figure W.3-1
OS197L TC ANSYS Stress Analysis Model



Upper Trunnion



Lower Trunnion

Figure W.3-2
OS197L TC ANSYS Analysis Model – Upper and Lower Trunnions Detail

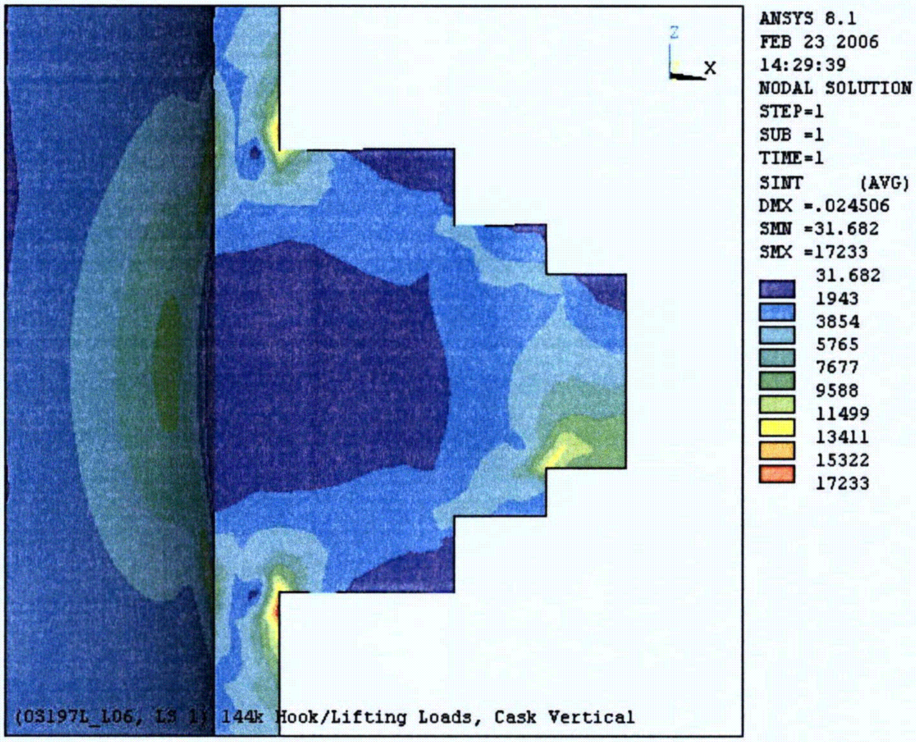


Figure W.3-3
ANSYS Model Stress Analysis Results – Upper Trunnion Region

W.4 Thermal Evaluation

The shaded text portion of Chapter W.4 provided in this FCN is for completeness and information only. It is part of Amendment 11 to be submitted to the NRC for review and approval. Therefore, the OS197L TC shall not be used until Amendment 11 to CoC 1004 is approved by the NRC.

W.4.1 Discussion

This chapter documents the thermal evaluation of the OS197L TC for the loading and transfer of the DSCs currently licensed under CoC 1004 (52B, 24P, 61BT, 24PT2, 32PT and 24PHB).

The OS197L TC is a modified version of the OS197/OS197H TCs (henceforth referred to as OS197 TC) designed to allow use with a crane load limit of 75 tons. From a thermal analyses perspective, the following relevant modifications are implemented in the OS197L TC relative to the OS197 TCs:

- The 1.5" thick structural shell, the encapsulated 3.56" thick lead and the 0.5" thick inner liner (both SA-240, Type 304 stainless steel) in the OS197 are replaced with a single 2.68" thick shell made of SA-240, Type 304 stainless steel material.
- The neutron shield assembly that is integral to the structural shell on the inside and includes a 3/16" thick outer shell in the OS197 TC is replaced with a neutron shield assembly consisting of inner and outer shells made from ¼" thick plate material in the OS197L TC. The neutron shield materials, total water annulus thickness of 3" and the configuration of the internal stiffening elements remain essentially unchanged.
- Supplemental shielding is used around the OS197L TC as part of the OS197L TC system, when the TC is in the vertical orientation in the decontamination area and when the TC is in the horizontal orientation on the transfer trailer/skid.
- The supplemental OS197L TC shielding system in the decontamination area consists of a two-part assembly, with 6" thick cylindrical shaped upper and lower shields made from A-36 steel with rectangular openings at the top and at the bottom that allow free convection boundary layer development along the DSC shell. The decontamination area supplemental shielding is shown in Figure W.1-2.
- The supplemental OS197L TC shielding system used on the transfer skid consists of a series of plates that are attached to the sides and ends of the transfer skid. Two upper sections fit like a clamshell over the cask and skid after the cask is placed on the transfer skid. Clearances provided at the support legs of the skid and other openings at the ends of the skid permit cooling airflow to enter the enclosure and pass around the enclosed cask and exit via a long slot opening at the top of the upper sections of the shielding. The transfer skid supplemental shielding is shown in Figure W.1-3.

- The loading procedures when using the OS197L TC are modified. Prior to lifting a loaded OS197L TC out of the pool, the DSC cavity water is pumped out (up to a maximum of 13,600 lbs) while providing a helium blanket around the fuel assemblies. In addition, prior to lifting the OS197L TC from the decontamination area for transfer to the trailer, the neutron shield may be drained (required for 32PT DSC only) while maintaining the DSC/TC annulus filled with water using a temporary aluminum cover for the TC. See Section W.4.8 for the effects of these modifications.

The applicable normal, off normal and accident conditions for the transfer of 24P, 52B, 61BT, 24PT2L, 32PT and 24PHB DSC when using OS197L TC remain unchanged from those defined in the UFSAR for the transfer of these payloads when using OS197 TC.

The OS197L TC without the supplemental shielding have less radial thermal resistance than the OS197 TC since the thermal resistance associated with the lead to shell gaps and the combination of lead and steel in the OS197 TC is larger than the thermal resistance due to the gap between the neutron shield assembly and the structural shell in the OS197L TC. Therefore, OS197L TC will result in lower DSC shell temperatures compared to the OS197 TC for the same heat load and ambient conditions.

W.4.2 Summary of Thermal Properties of Materials

The thermal properties of the materials (including the effective thermal conductivity of fuel with helium backfill) used in the thermal evaluation presented in this section are the same as those specified in Appendix M, Section M.4.2 for 32PT DSC, Appendix K, Section K.4.2 for 61BT DSC, and Appendix N, Section N.4.2 for 24PHB DSC.

The effective thermal conductivity of water and air-filled neutron shield of OS197L TC, are calculated based on the same methodology as described in Appendix M, Section M.4-9 and are listed in Table W.4-1.

W.4.3 Specifications for Components

The mechanical properties of the materials applicable to OS197L TC are the same as those described in Section 8.1, Table 8.1-3 for OS197 TC.

W.4.4 Effect of the Decontamination Shield on OS197L TC Thermal Performance

An evaluation is performed to confirm that the radial gap between the OS197L TC and the inner diameter of the decontamination shield is sufficiently large, and that the size of the top and bottom cut out openings are of sufficient size as to not adversely affect the thermal performance of the OS197L TC. The evaluation is based on analysis of the free convection turbulent boundary layer development along the outer OS197L TC surface during vacuum drying and helium backfilling operations. The results of the evaluation confirm that the DSC shell-decontamination shield gap and the area of the inlet and outlet openings are adequate and, thus, the decontamination area shield does not adversely impact the cask boundary conditions assumed in the thermal analysis.

W.4.5 Effect of the Supplemental Skid Shielding on OS197L TC Thermal Performance

As discussed above, supplemental shielding is installed on the OS197L skid to compensate for the reduced shielding capability of the OS197L TC. Three-dimensional views of the supplemental skid shielding are shown in Figure W.4-1. The shielding enclosure is provided with openings between the skid beams and the trailer deck to allow air to enter the enclosure, flow around the OS197L TC, and exit the enclosure through an opening at the top.

To address the potentially offsetting effect of the supplemental skid shielding on the thermal performance of the OS197L TC with a 24 kW heat load or an 18.3 kW heat load DSC payload, a computational fluid dynamics (CFD) analysis is performed for the OS197L TC with the supplemental shielding.

The FLUENT™ and GAMBIT™ codes [4.1] are used for this analysis. The FLUENT™ code is a general-purpose computational fluid dynamics (CFD) code that is recognized internationally as one of the premier codes in its class. The general modeling capabilities of the code as they relate to this application include:

- Meshing flexibility using structured and unstructured mesh generation with hexahedra, non-hexahedra, and tetrahedral mesh types
- Capability to model low speed, buoyancy driven flow regimes
- Steady-state and transient flows
- Inviscid, laminar, and turbulent flows
- Heat transfer including forced, natural, and mixed convection, conjugate heat transfer, and radiation
- Custom materials property database
- Integrated problem set-up and post-processing

GAMBIT™ is an interactive, object-based software code that allows complex geometries to be modeled and meshed using a combination of shapes. Quadrilateral and triangular elements are used for 2D simulations, while hexahedra, tetrahedra, prisms, and pyramid shaped elements are available for 3D simulations. The GAMBIT™ module does not perform any CFD related numerical calculations itself, but serves as a preprocessor to the FLUENT™ code to generate a computational mesh. GAMBIT™ has many automated features for building or joining hybrid meshes with attention to boundary layers, non-uniform sizing, and core regions of hexahedral cells.

The verification and validation of the FLUENT™ and GAMBIT™ codes for the computation of generic buoyancy driven convection heat transfer within an enclosure is documented in [4.2].

The FLUENT CFD methodology is used to compute the neutron shield shell temperatures for the OS197L TC while on the shielded transfer trailer. The computed neutron shield shell temperatures are then used as boundary temperatures for the detailed ANSYS model of the OS197L TC described in Section W.4.6.

CFD Model of OS197L (75-ton) Cask and Transfer Skid

A three-dimensional model of the OS197L cask and transfer skid was created using GAMBIT™ using the drawings provided in Section W.1.5. For the purposes of this analysis, the cask is represented as a surface with a uniform heat flux simulating the outer shell of the liquid neutron shield. As described in Section W.4.6, a separate model of the cask is used to evaluate the heat transfer within the cask using the computed temperatures on the neutron shield as a boundary condition. Based on a 183.85-inch length for the water cavity in the neutron shield, an outside radius of 40.18-inches for the neutron shield shell, and a design decay heat loading of 24 kW for the 32PT DSC, the uniform heat flux applied over the surface area of the shell is computed as:

$$\dot{q} = \frac{24\text{kW} \cdot 3412.1415 \frac{\text{Btu}/\text{hr}}{\text{kW}}}{\left(2 \cdot \pi \cdot 40.18\,\text{in} \cdot 183.85\,\text{in}/144 \frac{\text{in}^2}{\text{ft}^2}\right)} = 254.07 \frac{\text{Btu}}{\text{hr} \cdot \text{ft}^2}$$

Similarly, for a design 18.3 kW decay heat for the 61BT DSC, the uniform heat flux applied over the surface area of the shell is computed as:

$$\dot{q} = \frac{18.3\,\text{kW} \cdot 3412.1415 \frac{\text{Btu}/\text{hr}}{\text{kW}}}{\left(2 \cdot \pi \cdot 40.18\,\text{in} \cdot 183.85\,\text{in}/144 \frac{\text{in}^2}{\text{ft}^2}\right)} = 193.73 \frac{\text{Btu}}{\text{hr} \cdot \text{ft}^2}$$

The CFD modeling for this condition assumes a conservative surface heat flux of 194.784 Btu/hr-ft^2 (i.e., 18.4 kW).

A 12-inch long segment at the center of the OS197L TC on the shielded transfer trailer (see Figure W.4-2) is used to compute the flow field around the TC. Radiation exchange is modeled using the discrete ordinate methodology.

The computational mesh extends 150-inches in the x-direction and 200-inches in the y-direction Figure W.4-3 illustrates perspective and plane views of the computational mesh at the centerline Figure W.4-4 presents enlarged views of the computation mesh illustrating the boundary layer mesh on the cask shell and the inner surface of the shields. A grid sensitivity study, conducted as part of the analysis for a variant of the OS197L TC design, demonstrated that the meshing used for this evaluation was appropriate.

While the computational model is 3-D in its construction, the resulting analysis is effectively 2-D since symmetry conditions are assumed at the axial ends of the model and a uniform heat flux is assumed at the inner surface.

Assumptions Used in CFD Modeling

The general assumptions used in the CFD modeling are:

1. Heat removed through the cask end plugs and by conduction via trunnion contact with the transfer skid is conservatively neglected.

2. The total decay heat is considered to be evenly distributed over the outer surface of the cask's liquid neutron shield shell. The assumption of uniform heat flux is consistent with previous OS197 analysis methodology (See Chapter M.4) and reflects the axial spreading of the decay heat load due to the high axial conductivity of the DSC basket and rails, and the water filled neutron shield.

3. The CFD modeling need only address the geometry of the OS197L TC and its shielded transport skid as it exists between the front and rear trunnion towers. See the justification of this assumption provided below.

4. The outer surfaces of the auxiliary shielding on the transfer skid are assumed to be finished with a 'dark blue' color coating that yields a solar absorptivity of 0.90 or less and an emissivity of 0.85 or greater. Similarly, the inner surface of the auxiliary shielding is assumed to have a similar finish that yields an emissivity of 0.85 or greater.

5. The regulatory insolation [10CFR Part 71] averaged over 24 hours is applied to the outer surfaces of the auxiliary shielding. The thickness of the auxiliary shielding, combined with the thermal mass of the OS197 cask and payload, justifies the use of 24-hour averaged values. The 24-hour average insolation on the roof of the transfer skid is assumed to be 122.9 Btu/hr-ft^2, 30.75 Btu/hr-ft^2 on the vertical surfaces, and 61.45 Btu/hr-ft^2 on the angled portion of the auxiliary shielding. These incident heating values are reduced by 10% to account for the assumed solar absorptivity of 0.90 for the coating used on the shields (see Assumption 4).

6. The ground is conservatively treated as an adiabatic surface.

The analysis for the off-normal ambient condition of 117°F is conducted assuming a 24 hour average steady-state ambient temperature of 107°F. A steady-state analysis at this temperature level has been shown by previous analyses to bound the transient thermal performance achieved using a diurnal cycle for ambient air with a peak temperature of 117°F.

Justification of CFD Model Segmentation

The use of a quasi 2-D thermal model located at the center of the OS197L TC to evaluate the bounding thermal performance of the OS197L TC on its shielded transport skid is justified for the following reasons:

1. Heat transfer near the center of the OS197L TC is via radiation and convection, while heat transfer near the ends of the cask also involves direct heat transfer through the trunnions to the transfer skid. In addition, the cask's lid and end closures add additional heat transfer area. As such the peak temperatures on the OS197L TC will occur near its center.

2. A flow area clearance of approximately 3.8 inches will exist in the vicinity of the cask trunnions vs. approximately 3.3 inches at the center of the cask.

3. The 113.5 inches between the front and rear trunnion towers spans 62% of the liquid neutron shield length, over which the majority of the heat rejection occurs.

4. The assumption of a uniform heat flux means there will be no significant variation in thermal conditions between the front and rear trunnion towers. Thus, modeling a short segment will yield similar results to modeling the entire length.

The airflow through the shielded transfer skid is driven by buoyancy forces which, in turn, are driven by the temperature on the shell of the neutron shield. As such, the convective airflow over the surface of the TC is self-correcting, with the level achieved representing a balance between the local flow resistance and surface heat flux. For this reason the use of a relatively short axial segment to represent the flow regime within the transfer skid enclosure does not entail a risk of over-estimating the prototypic airflow since the computed airflow results from the computed local temperatures and not as the result of airflow occurring at another axial location.

CFD Analysis Results

The FLUENT™ model of the OS197L cask and transfer skid described above was used to compute the flow and temperature distribution for the bounding normal and off-normal hot conditions of transfer and with decay heat loads of 24 and 18.4 kW. The 18.4 kW used for the CFD analysis bounds the 18.3 kW design heat load assumed for the 61BT DSC. A second order discretization scheme for energy, momentum, turbulence, and the discrete ordinate calculation, and the PRESTO solution scheme for pressure are used for the solution. Since the boundary layer mesh yields y+ values of approximately 1.0, the realizable turbulence model with enhanced wall functions is used to compute the turbulent heat transfer at the surface of the cask.

Figure W.4-5 and Figure W.4-6 present the temperature distribution for the surface of the cask exterior shell and the transfer skid shields, respectively, for normal ambient condition of 100°F with insolation and with a 24 kW decay heat loading. The peak temperature on the cask shell is predicted to occur back from the centerline of the cask, at the point where the flow separates from the cask and heads towards the exit. The fact that the cask shell temperature reaches a peak and then decreases slightly at the very top of the cask is attributed to the presence of flow recirculation in this region. Because of this recirculation, the surface flow does not stagnate at the top, center of the cask as it would for an isolated cask and a lower surface temperature is achieved. Instead, the peak temperature point occurs away from the centerline of the cask, where the flow separation point is predicted to occur.

Figure W.4-7 illustrates the velocity profiles at the centerlines of the model. The minimum cask-shield gap for the modeled section of the OS197L cask and transfer skid combination is approximately 3.3-inches. Figure W.4-8 illustrates an enlarged view of the velocity profile at the exit from the auxiliary shielding enclosure. The predicted region of flow stagnation and flow recirculation under the hat section of the enclosure can be seen in the figure.

The peak neutron shield shell temperature with a 24 kW decay heat loading and a normal 100°F ambient condition is predicted to be 307°F, while the area-weighted average temperature is predicted to be 280°F.

The evaluation was repeated for the bounding off-normal hot condition of 117°F ambient with insolation. Figure W.4-9 presents the temperature distribution for the surface of the cask exterior shell. The peak cask shell temperature predicted for this condition is 313°F, while the area-weighted average temperature over the cask's exterior shell is predicted to be 285°F. The velocity profiles developed are similar to those presented in Figure W.4-7 and Figure W.4-8.

Figure W.4-10 and Figure W.4-11 illustrate the predicted temperature distribution for the combined cask-transfer skid assembly for an ambient condition of 100°F with insolation and with an 18.4 kW decay heat loading. As expected, the resulting temperature distributions are similar to those seen for the 24 kW decay heat load, but over a lower temperature range. In addition, the flow stagnation point on the neutron shield shell occurs at the same location and velocity profiles developed within the enclosure are similar to those presented in Figure W.4-7 and Figure W.4-8.

The peak neutron shield shell temperature with an 18.4 kW decay heat loading is predicted to be 275°F, while the area-weighted average temperature is predicted to be 249°F. Repeating the evaluation for the off-normal hot condition of 117°F ambient with insolation yields a peak neutron shield shell temperature of 281°F, while the area-weighted average temperature is predicted to be 254°F (see Figure W.4-12).

The computed temperatures on the neutron shield from the CFD analysis are used as boundary conditions for the thermal analysis of the OS197L TC using the ANSYS model described in Section W.4.6.

W.4.6 Thermal Analysis of OS197L TC with 24 kW and 18.3 kW Heat Loads

A two-dimensional model of the OS197L TC and DSC shell is developed using ANSYS Computer Code [4.3]. The 2D model considers the hottest cross-section of the fuel and conservatively neglects heat transfer in the axial direction. The model represents the neutron shield, the cask structural shell, cask rails, and the DSC shell. The OS197L TC model is shown in Figure W.4-13. The TC thermal model and analysis methodology are consistent with the methodology described in Appendix M, Section M.4.4.1.6 for the OS197 TC with a 32PT DSC payload with changes implemented to account for the configuration changes in the OS197L TC relative to the OS197 TC. The heat flux for the 24 kW heat load case applied to the OS197 TC model is identical to that described in Appendix M, Section M.4.4.1.6 for OS197 TC with a 32PT DSC.

The following table summarizes the OS197L TC dimensions (See OS197L TC Drawings included in Section W.1.5) used in the thermal analyses.

Dimensions used in OS197L TC ANSYS Thermal Analysis Model

DSC/Cask Component	OS197L
DSC Shell Outside Diameter, in.	67.1/67.25(1)
DSC Shell Thickness, in.	0.5(2)
Cask Inner Radius, in.	34.0
Structural Shell Thickness, in.	2.68
Structural Shell Outside Radius, in.	36.68
Structural Shell-Neutron Shield Inner Panel Gap, in.	0.01
Neutron Shield Inside Radius, in.	36.39
Neutron Shield Inner Panel Thickness, in.	0.25
Neutron Shield Inner Radius, in.	36.94
Neutron Shield Thickness, in.	3.0
Neutron Shield Outside Radius/Neutron Shield Outer Panel Inner Radius, in.	39.94
Neutron Shield Outer Panel Thickness, in.	0.25
Neutron Shield Outer Panel Outside Radius, in.	40.19

Note:

1) 67.19 in. is used for the 32PT DSC and 67.25 in. is used for the 61BT DSC.
2) The DSC shell temperature obtained from the OS197L model for 24 kW heat load are based on a DSC shell thickness of 0.5". The DSC shell thickness for 24PHB DSC is 0.625". Since the decay heat load is applied as a uniform heat flux on the DSC shell in the OS197L TC model, the model is not sensitive to the DSC shell thickness and the obtained temperatures are applicable for the 24PHB basket.

As discussed in Section W.4.5, the CFD analyses consider the effect of the supplementary shielding and insolance on the OS197L TC thermal performance. A separate analysis of the OS197L TC loaded with a 24 kW heat load (32PT DSC or 24PHB DSC) and 18.3 kW heat load (61BT DSC) is performed using the temperature distribution over the neutron shield outer skin of the OS197L calculated from the CFD analysis (which incorporate the effect of the supplemental skid shielding and insolence as discussed in Section W.4.4 above) as boundary conditions.

The temperatures of the neutron shield outer skin obtained from the CFD analysis are applied as boundary conditions over the outermost nodes of the 2D model of the OS197L TC and analyses are performed for normal, off-normal and accident conditions. Conservatively, the CFD analysis for off-normal 117°F ambient temperature case includes the effect of insolation on the supplemental shielding.

Based on operational procedures described for OS197L cask in Chapter W.8, the openings in the trailer shields are visually monitored for the presence of steam to detect a leakage of neutron shield water during the transfer operation. In addition, the OS197L TC will not remain within the supplementary shielding for an extended period of time after an accident. Therefore, the loss of liquid neutron shielding by itself is not a credible accident.

The loss of sun shield and liquid neutron shield in the OS197L TC represents the controlling accident transfer case under maximum ambient temperature and insolation when the supplementary shielding is removed.

The results of the analysis in terms of maximum TC component temperatures are summarized in Table W.4-2 for the 24 kW case and Table W.4-3 for the 18.3 kW case. The maximum temperatures at the top, side, and bottom of the DSC shell retrieved from the 2D model of the TC are also summarized in Table W.4-2 and Table W.4-3. These temperatures are used to define the boundary conditions for the analysis of the 3D models of the DSC shell/basket assemblies as discussed in Section W.4.7.

The 2D model analysis results of the 117°F ambient with insolence and accident case for the OS197L TC are also shown in Figure W.4-14 for the 24 kW case and Figure W.4-15 for the 18.3 kW case.

W.4.7 Thermal Analysis of NUHOMS® DSCs

W.4.7.1 Thermal Analysis of 32PT DSC inside the OS197L TC

The maximum temperatures at the top, side, and bottom of the DSC shell calculated in Section W.4.6 above define the boundary conditions for the analysis of the 3D ANSYS model of the DSC shell and basket assembly described in Appendix M, Section M.4.4.1.1. The methodology used for the analysis, including the application of the temperature boundary conditions on the DSC shell, is identical to that used for the 32PT DSC and documented in Appendix M.

Based on the results documented in Appendix M, heat load zoning configuration No. 1 is the bounding configuration. Hence, this configuration is used in this analysis to determine the bounding basket components and fuel cladding temperatures.

The fuel cladding and DSC components maximum temperatures for the controlling (bounding) conditions are summarized in Table W.4-4. Typical component temperatures are shown in Figure W.4-16 for the off-normal 117°F ambient condition.

The average cavity gas temperatures are determined from the analysis model results using the same methodology as that used in Appendix M. Based on the ideal gas law, the DSC internal pressure is proportional to the absolute temperature. Thus the 32PT DSC pressures evaluated in Appendix M are multiplied by the ratio of the absolute temperatures obtained from this analysis (OS197L) to those in Appendix M (OS197) to determine the pressures when the DSC is transferred in the OS197L TC. The resulting maximum pressures are tabulated in Table W.4-5.

W.4.7.2 Thermal Analysis of 61BT DSC Inside the OS197L TC

The maximum temperatures at the top, side, and bottom of the DSC shell calculated in Section W.4.6 above define the boundary conditions for the analysis of the 3-dimensional, 180° symmetric model of the DSC shell and basket assembly documented in Appendix K, Section K.4.4.1. The same maximum decay heat load of 0.3 kW per assembly (18.3 kW total per DSC) and peaking factor profile used in Appendix K is used in this analysis to provide bounding basket and fuel cladding temperatures. The thermal analysis methodology used, including the

application of the temperature boundary conditions on the DSC shell in the 3D model, is identical to that used for the 32PT DSC and documented in Appendix M.

The fuel cladding and DSC components maximum temperatures for the controlling (bounding) conditions are summarized in Table W.4-6. Typical component temperatures are shown in Figure W.4-17 for the off-normal 117°F ambient condition.

The average cavity gas temperatures are determined from the analysis model results using the same methodology as that used in Appendix K. Based on the ideal gas law, the DSC internal pressure is proportional to the absolute temperature. Thus the 61BT DSC pressures evaluated in Appendix K are multiplied by the ratio of the absolute temperatures obtained from this analysis (OS197L) to those in Appendix K (OS197) to determine the pressures when the DSC is transferred in the OS197L TC. The resulting maximum pressures are tabulated in Table W.4-7.

W.4.7.3 Thermal Analysis of 24PHB Inside the OS197L TC

The maximum temperatures at the top, side, and bottom of the DSC shell obtained from the 2D model of the OS197L TC define the boundary conditions for the analysis of the 3-dimensional, 180° symmetric model of the DSC shell and basket assembly documented in Appendix N, Section N.4.4.1.

Based on the results documented in Appendix N, heat load zoning configuration No. 1 is the bounding configuration. Hence, this configuration is used in this analysis to determine the bounding basket components and fuel cladding temperatures.

The thermal analysis methodology used, including the application of the temperature boundary conditions on the DSC shell in the 3D model, is identical to that used for the 24PHB DSC and documented in Appendix N.

The fuel cladding and DSC components maximum temperatures for the controlling (bounding) conditions are summarized in Table W.4-8. Typical component temperatures are shown in Figure W.4-18 for the off-normal 117°F ambient condition.

The average cavity gas temperatures are determined from the analysis model results using the same methodology as that used in Appendix N. Based on the ideal gas law, the DSC internal pressure is proportional to the absolute temperature. Thus the 24PHB DSC pressures evaluated in Appendix N are multiplied by the ratio of the absolute temperatures obtained from this analysis (OS197L) to those in Appendix N (OS197) to determine the pressures when the DSC is transferred in the OS197L TC. The resulting maximum pressures are tabulated in Table W.4-9.

W.4.7.4 Thermal Analysis of Other NUHOMS® DSCs (24P, 52B, 24PT2) inside the OS197L TC

Based on the detailed thermal analysis of the plate/tube-type baskets (32PT and 61BT, respectively) and the spacer disc-type basket (24PHB), the maximum increase in the fuel cladding temperatures is on the order of 16°F for normal and off-normal conditions and 74°F for accident conditions (for 24PHB only). It is expected that the increase in basket component and fuel cladding temperatures for the 24P, 52B and 24PT2L DSCs (which have a spacer disc-type

basket design) is of a similar magnitude. The increase in fuel cladding temperatures is not significant relative to the allowable criteria of 1058°F.

W.4.8 Effect of Modification of Loading Procedures on OS197L TC Thermal Performance

When the OS197L TC is not inside the supplemental decontamination area shield or the supplemental trailer shields, its thermal performance during such operations including vacuum drying operations, is bounded by the thermal analysis presented in the revised pages of Sections 8.1, 8.2, K.4.7, L.4.7, M.4.7 and N.4.7 included with Application for Amendment 11 of CoC 1004.

To reduce cask weight during transfer from the decontamination area to the trailer, the neutron shield may be drained. To maintain DSC shell temperatures within previously analyzed conditions for the DSC vacuum drying, backfilling, and welding operations, the DSC/TC annulus is maintained full during this transfer. The DSC/TC annulus is maintained at atmospheric pressure by venting.

W.4.9 Thermal Performance of Various DSCs during Vacuum Drying Operation

As described in Chapter W.8, helium will be used for the blowdown/draindown of water in the DSC cavity. Therefore, subsequent vacuum drying operations occur with a helium environment in the DSC cavity. Water will be maintained in the DSC/TC annulus during vacuum drying operations. Therefore, the fuel cladding temperatures calculated when the OS197L TC is loaded with a DSC during transfer conditions and with the supplemental trailer shields in place will bound the vacuum drying condition.

W.4.10 Thermal Performance of OS197L TC during Fire Accident Conditions

Based on the operating procedures described in Chapter W.8, the OS197L TC will be transferred back to the handling building after any accident case and will not remain within the supplementary shielding for an extended period of time.

The analysis performed for OS197 TC in Appendix K, Chapter K.4, Appendix L, Chapter L.4, Appendix M, Chapter M.4, and Appendix N, Chapter N.4 shows that the bounding temperatures for accident conditions occur after an extended period of time during post accident steady state conditions.

As discussed in Appendix W, Section W.4.1, the thermal resistance of the OS197 TC is larger than the thermal resistance of the OS197L TC. Therefore, the maximum temperatures for OS197L TC after an extended period of time are bounded by the steady state temperatures obtained for accident conditions of the OS197 TC discussed in Appendix K, Chapter K.4, Appendix L, Chapter L.4, Appendix M, Chapter M.4, and Appendix N, Chapter N.4.

W.4.11 References

4.1 FLUENT™ CFD Code Version 6.2, and Gambit Version 2.2, Fluent Inc., 10 Cavendish Court, Lebanon, NH 03766.

4.2 V&V Test Report, FLUENT™ *Version 6.2 / GAMBIT™ Version 2.2*, Transnuclear, Inc., File Number QA040.231.0001, Revision 0.

4.3 ANSYS *Computer* Code *and On-line User's Manuals, Version 8.1 and Version 10.0A1.*

Table W.4-1
Effective Thermal Conductivity for Water and Air-Filled Neutron Shield of the OS197L TC

For 24 kW		
Angle from the Top of Neutron Shield	**$K_{eff\ water\ filled\ NS}$, Btu/(min-in-°F)**	**$K_{eff\ air\ filled\ NS}$, Btu/(min-in-°F)**
0	0.019	0.0004
30	0.018	0.0004
60	0.019	0.0004
90	0.020	0.0004
120	0.017	0.0004
150	0.010	0.0003
180	0.001	0.0002
For 18.3 kW		
Angle from the Top of Neutron Shield	**$K_{eff\ water\ filled\ NS}$, Btu/(min-in-°F)**	**$K_{eff\ air\ filled\ NS}$, Btu/(min-in-°F)**
0	0.0166	0.0003
30	0.0155	0.0004
60	0.0159	0.0004
90	0.0179	0.0004
120	0.0156	0.0004
150	0.0093	0.0003
180	0.0006	0.0002

K_{eff} – Effective thermal conductivity

Table W.4-2
Maximum Component Temperatures for OS197L TC with 24 kW Heat Load
(Supplemental Skid Shielding Effect Included)

Operating Conditions	Cask Components			DSC Shell Temperatures		
	$T_{str\ sh}$, (°F)	$T_{NS,\ max}$ (°F)	$T_{NS\ avg}$, (°F)	T_{top}, (°F)	T_{side}, (°F)	T_{bot}, (°F)
Normal, transfer OS197L	327	314	284	456	432	387
Off-normal, transfer OS197L	332	320	290	460	435	392
Accident, transfer OS197L (Loss of sun shade and liquid neutron shield – without supplementary shielding)	575	561	370	584	586	616

where

T_{top}, T_{side}, T_{bot} – DSC shell top, side, and bottom maximum temperature, respectively,

$T_{str\ sh}$ – cask structural shell maximum temperature,

T_{NS} – neutron shield maximum temperature (water or air),

$T_{NS\ avg}$ – neutron shield average temperature (water or air).

Table W.4-3
Maximum Component Temperatures for OS197L TC with 18.3 kW Heat Load
(Supplemental Skid Shielding Effect Included)

Operating Conditions	Cask Components			DSC Shell Temperatures		
	$T_{str\ sh}$, (°F)	$T_{NS,\ max}$ (°F)	$T_{NS\ avg}$, (°F)	T_{top}, (°F)	T_{side}, (°F)	T_{bot}, (°F)
100°F Normal, transfer OS197L	288	280	253	405	380	340
Off-normal, transfer OS197L	294	286	259	409	384	346
Accident, transfer OS197L (Loss of sun shade and liquid neutron shield – without supplementary shielding)	486	471	327	523	514	521

where

T_{top}, T_{side}, T_{bot} – DSC shell top, side, and bottom maximum temperature, respectively,

$T_{str\ sh}$ – cask structural shell maximum temperature,

T_{NS} – neutron shield maximum temperature (water or air),

$T_{NS\ avg}$ – neutron shield average temperature (water or air).

Table W.4-4
Maximum Temperatures for 32PT DSC inside OS197L TC
(Supplemental Skid Shielding Effect Included)

Operating Conditions	Maximum Fuel Cladding Temperatures	
	$T_{max,fuel}$ (°F)	Limit (°F)
Normal, transfer, 0°F without insolation	683	752
Normal, transfer, 100°F with Insolation	728	752
Off-normal, transfer, 117°F without insolation	731	752
Accident, transfer (Loss of sun shade and liquid neutron shield – without supplementary shielding)	862	1058

Operating Conditions	Maximum Component Temperatures			
	$T_{max,bskt}$ (°F)	$T_{max,Al}$ (°F)	$T_{max,rail}$ (°F)	$T_{max,DSC}$ (°F)
Normal, transfer, 0°F without insolation	668	668	428	401
Normal, transfer, 100°F with Insolation	714	714	481	456
Off-normal, transfer, 117°F without insolation(1)	717	717	484	460
Accident, transfer (Loss of sun shade and liquid neutron shield – without supplementary shielding)	851	851	634	616

Note:

(1) Conservatively the CFD analysis included insolation on the supplemental shielding.

Table W.4-5
Maximum 32PT DSC Pressures in OS197L TC

Operating Conditions	DSC Pressure in OS197L TC (psig)	Design Pressure (psig)
Normal	6.5	15.0
Off-normal	14.2	20.0
Accident	101.3	105.0

Table W.4-6
Maximum Temperatures for 61BT DSC inside OS197L TC
(Supplemental Skid Shielding Effect Included)

Operating Conditions	Maximum Fuel Cladding Temperatures	
	$T_{max,fuel}$ (°F)	Limit (°F)
Normal, transfer, 0°F without insolation	589	752/1058[1]
Normal, transfer, 100°F with Insolation	634	752/1058[1]
Off-normal, transfer, 117°F without insolation	638	752/1058[1]
Accident, transfer (Loss of sun shade and liquid neutron shield – without supplementary shielding)	757	1058

Note:
(1) Using the same 61BT DSC Appendix K fuel cladding temperature limits

Operating Conditions	Maximum Component Temperatures		
	$T_{max,bskt/Al}$ (°F)	$T_{max,rail}$ (°F)	$T_{max,DSC}$ (°F)
Normal, transfer, 0°F without insolation	568	455	351
Normal, transfer, 100°F with Insolation	614	503	405
Off-normal, transfer, 117°F without insolation[1]	617	521	409
Accident, transfer (Loss of sun shade and liquid neutron shield – without supplementary shielding)	734	618	618

Note:
(1) Conservatively the CFD analysis included insolation on the supplemental shielding.

Table W.4-7
Maximum 61BT DSC Pressures in OS197L TC

Operating Conditions	DSC Pressure in OS197L TC (psig)	Design Pressure (psig)
Normal	7.9	10.0
Off-normal	10.4	20.0
Accident	41.2	65.0

Table W.4-8
Maximum Component Temperatures for 24PHB DSC inside OS197L TC
(Supplemental Skid Shielding Effect Included)

Operating Conditions	Maximum Fuel Cladding Temperatures	
	$T_{max,fuel}$ (°F)	Limit (°F)
Normal, transfer, 0°F without insolation	682	752
Normal, transfer, 100°F with Insolation	713	752
Off-normal, transfer, 117°F without insolation	715	752
Accident, transfer (Loss of sun shade and liquid neutron shield – without supplementary shielding)	812	1058

Operating Conditions	Maximum Component Temperatures			
	$T_{max,sleeves}$ (°F)	$T_{max,spacer\ disc}$ (°F)	$T_{max,support\ bar}$ (°F)	$T_{max,DSC}$ (°F)
Normal, transfer, 0°F without insolation	682	671	499	407
Normal, transfer, 100°F with Insolation	712	704	542	462
Off-normal, transfer, 117°F without insolation(1)	714	706	545	466
Accident, transfer (Loss of sun shade and liquid neutron shield – without supplementary shielding)	812	806	670	623

Note:

(1) Conservatively the CFD analysis included insolation on the supplemental shielding.

Table W.4-9
Maximum 24PHB DSC Pressures in OS197L TC

Operating Conditions	DSC Pressure in OS197L TC (psig)	Design Pressure (psig)
Normal	5.8	15.0
Off-normal	10.1	20.0
Accident	53.6	68.0

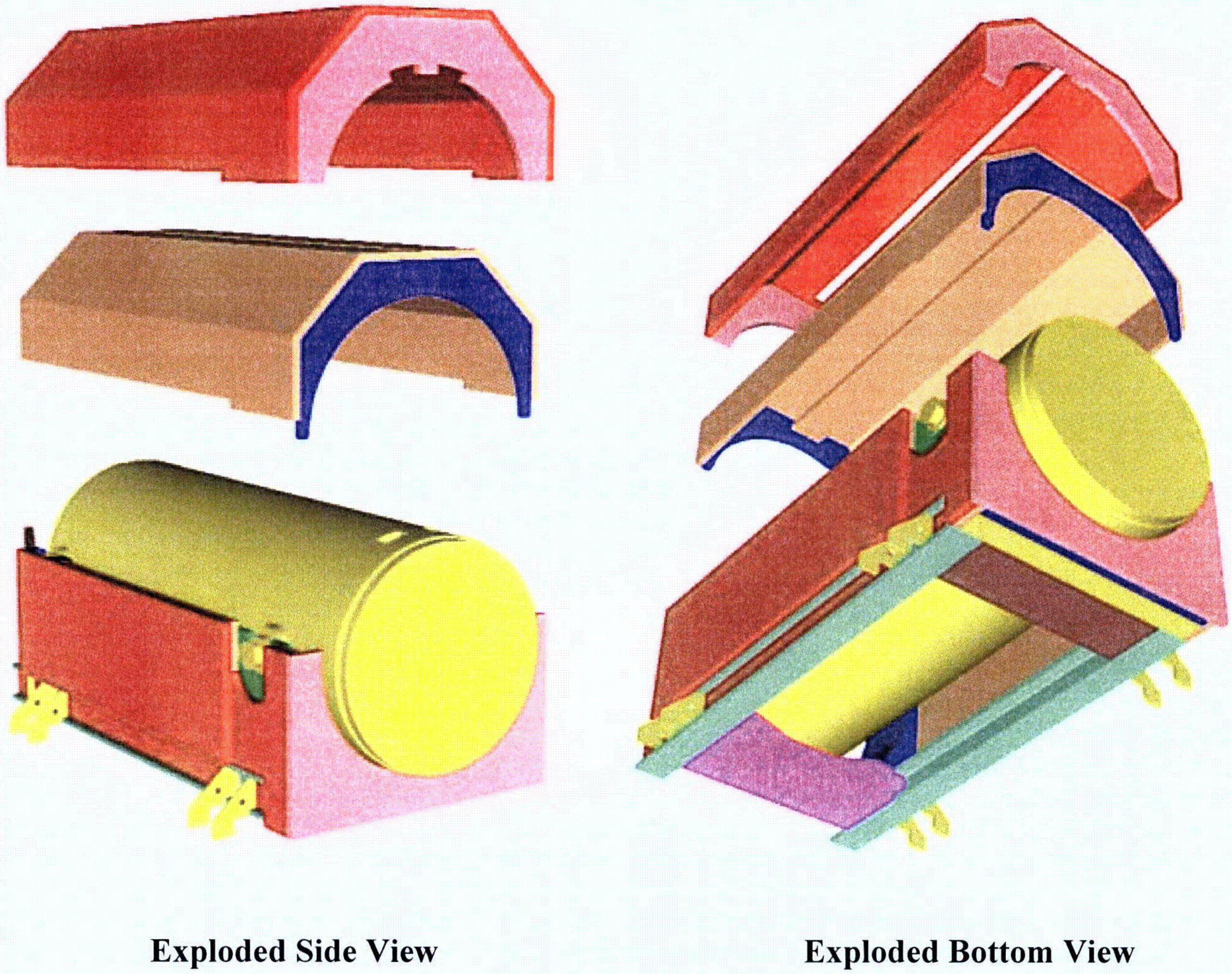


Figure W.4-1
OS197L TC ANSYS Model

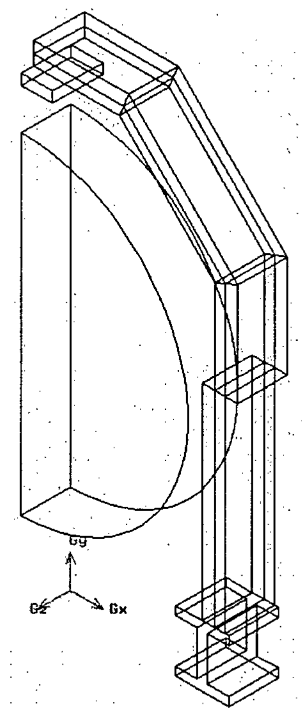


Figure W.4-2
Wire Frame Representation of OS197L Cask and Transfer Skid CFD Model

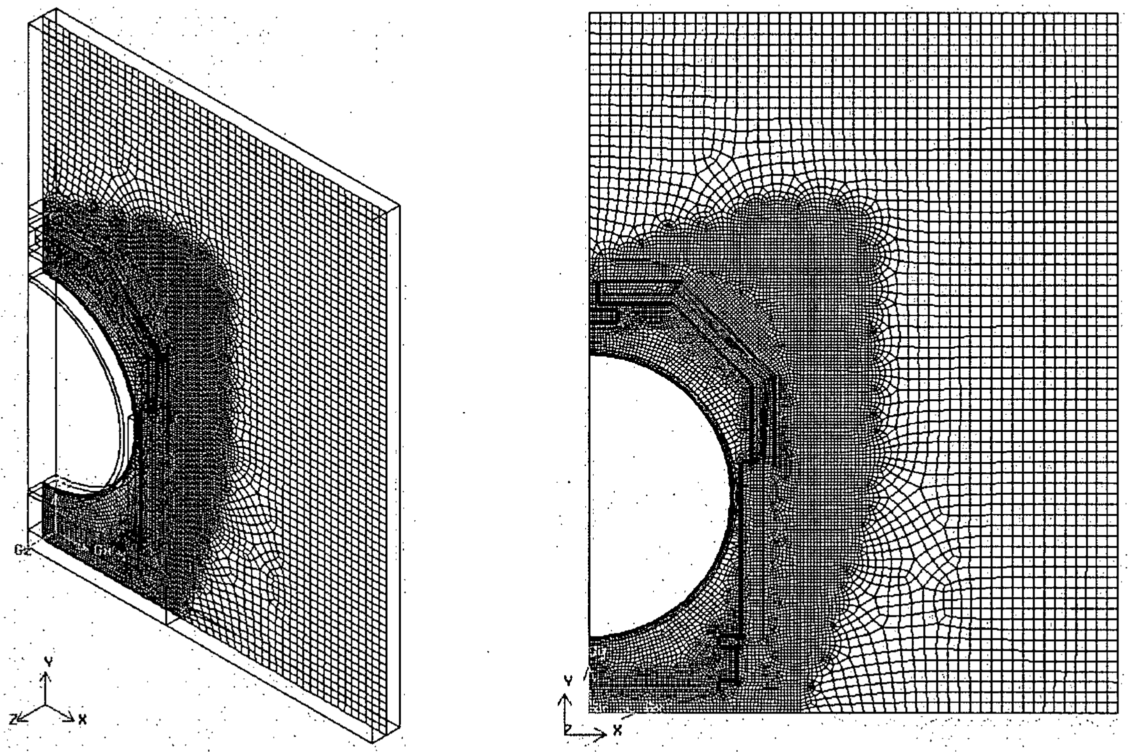
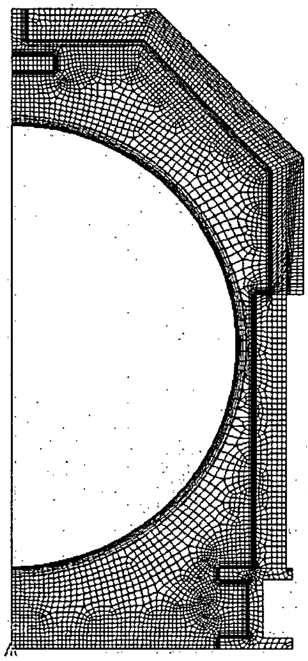
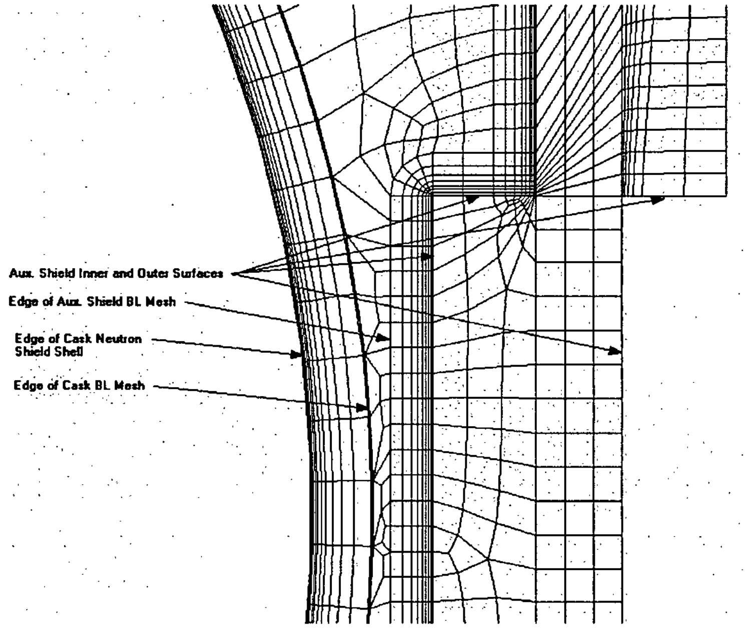


Figure W.4-3
Perspective and Plan Views of OS197L Cask/Transfer Skid Mesh

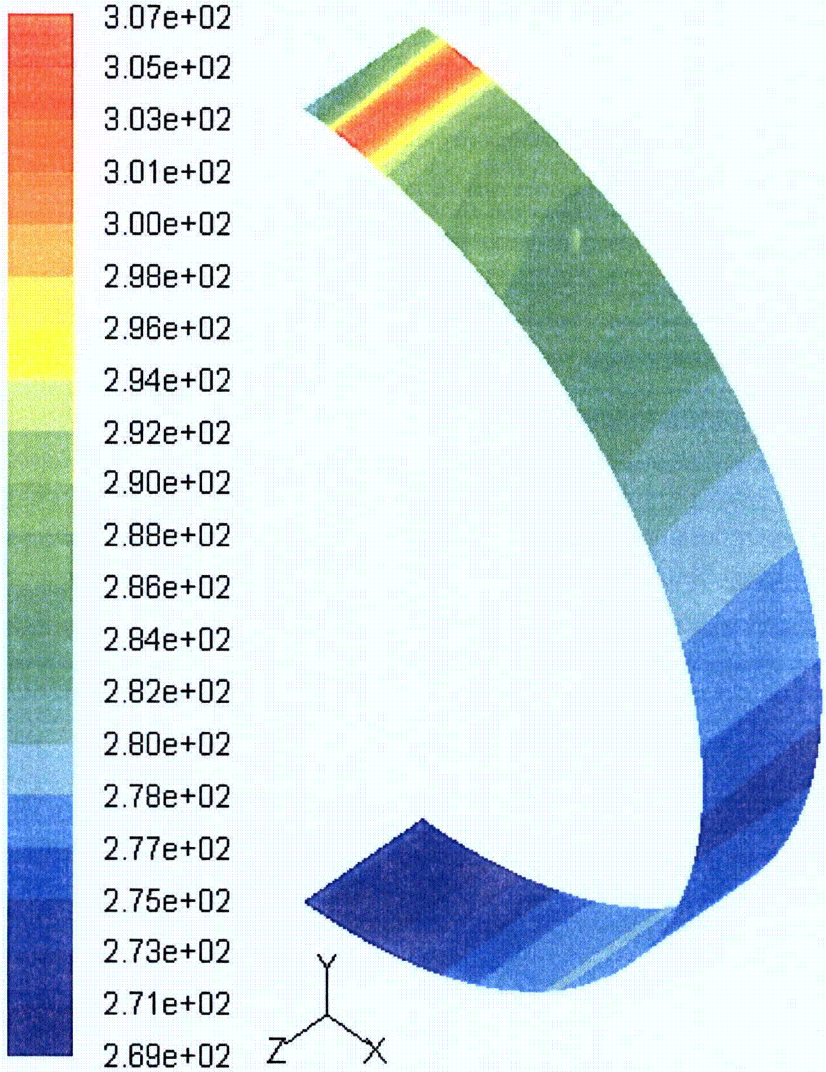


Interior Mesh



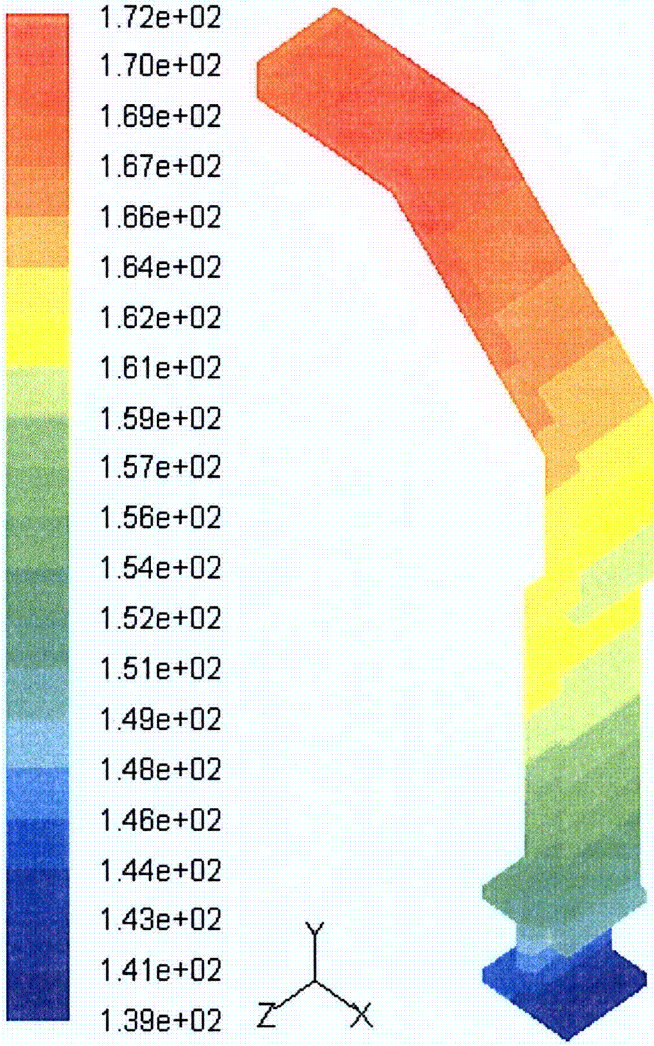
Enlarged View at Side of Cask

Figure W.4-4
Enlarged Views of OS197L Cask/Transfer Skid Mesh



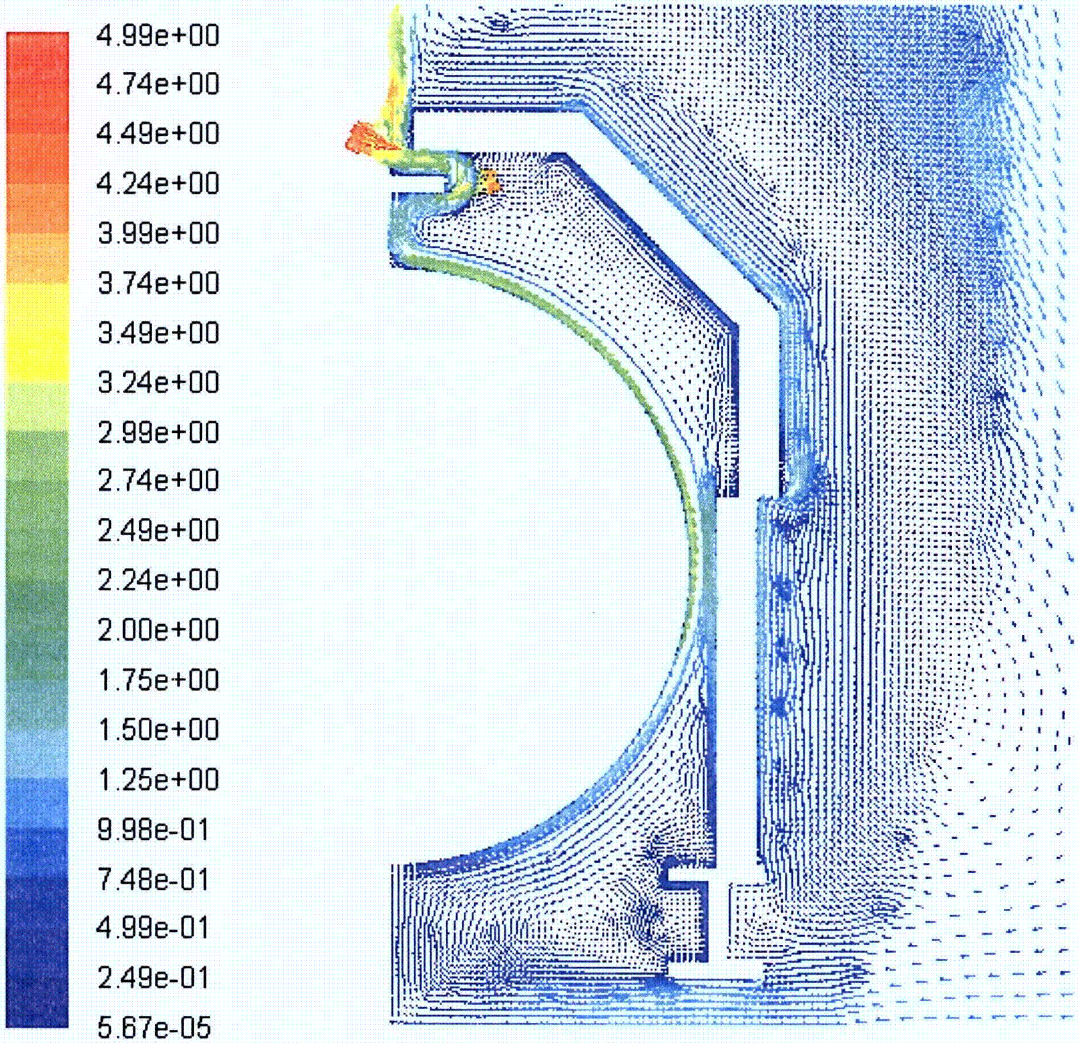
Note: Temperature is in units of °F

Figure W.4-5
Temperature Distribution over OS197L Cask Exterior Shell with 24 kW, 100°F Ambient



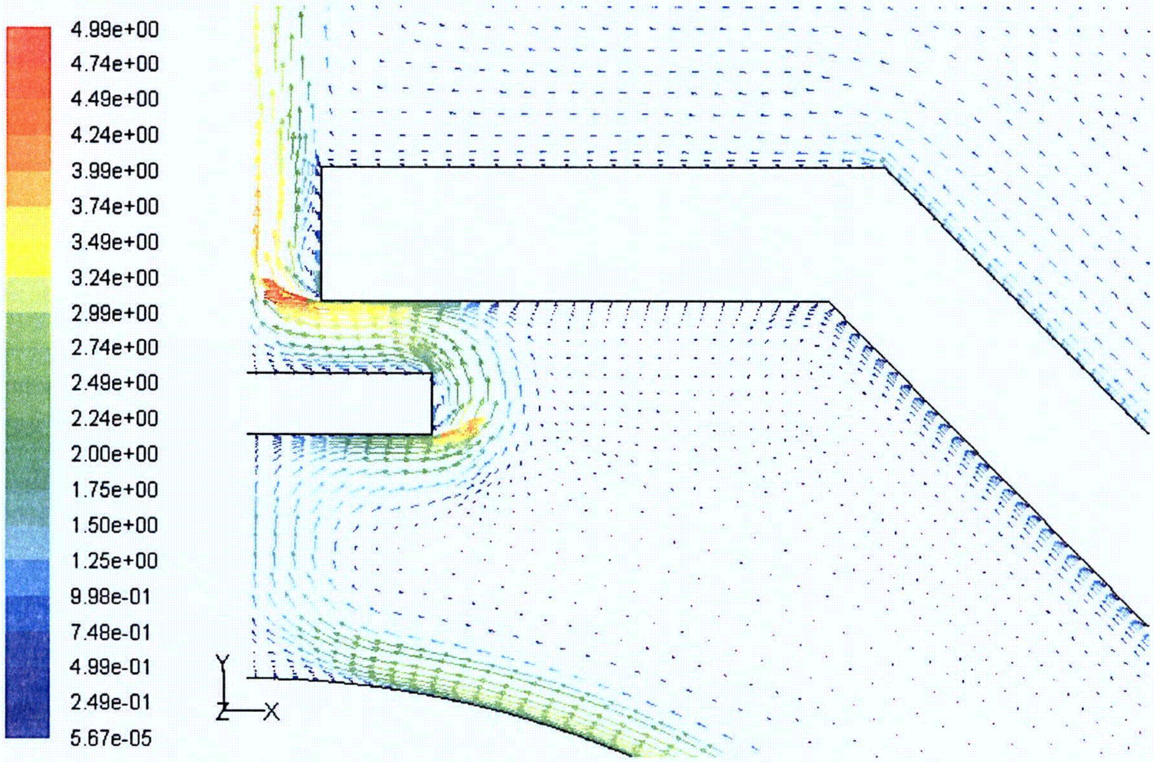
Note: Temperature is in units of °F

Figure W.4-6
Temperature Distribution for OS197L Transfer Skid Shields with 24 kW, 100°F Ambient



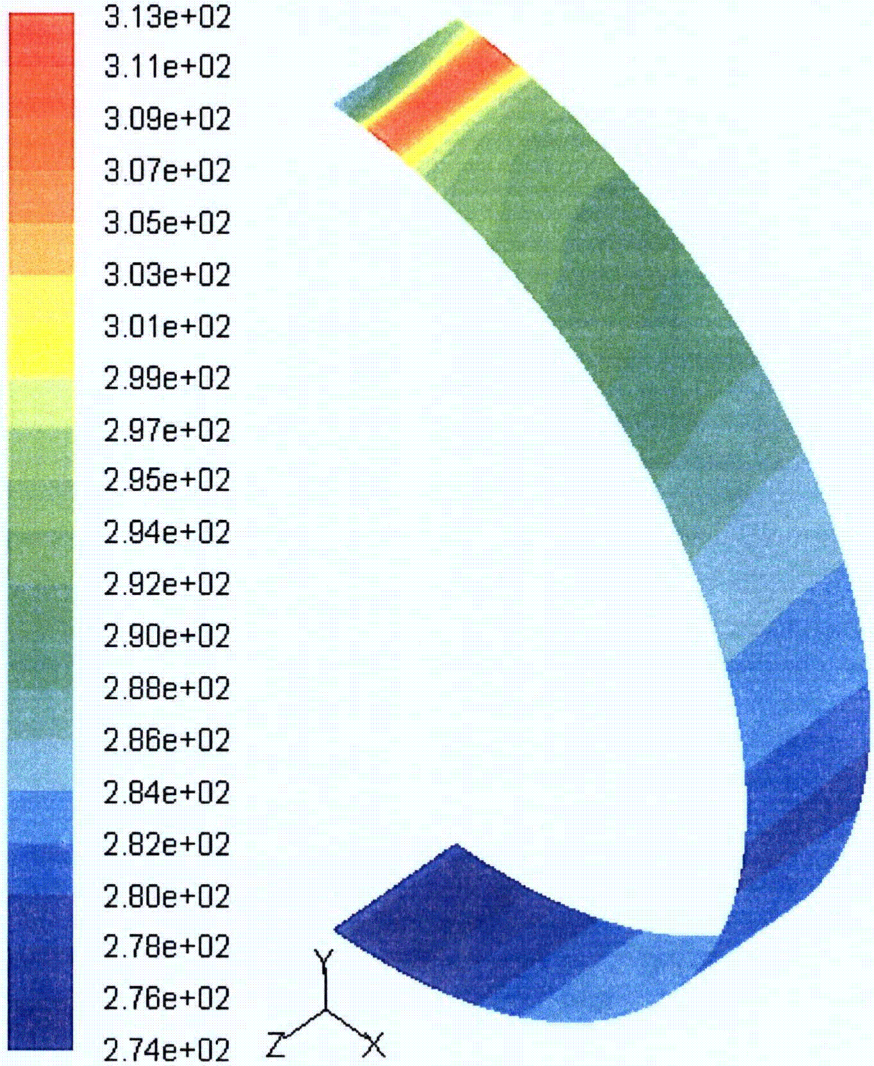
Note: Velocity is in units of ft/sec

Figure W.4-7
Velocity Distribution at OS197L Model Centerline for 24 kW, 100°F Ambient, Plan View



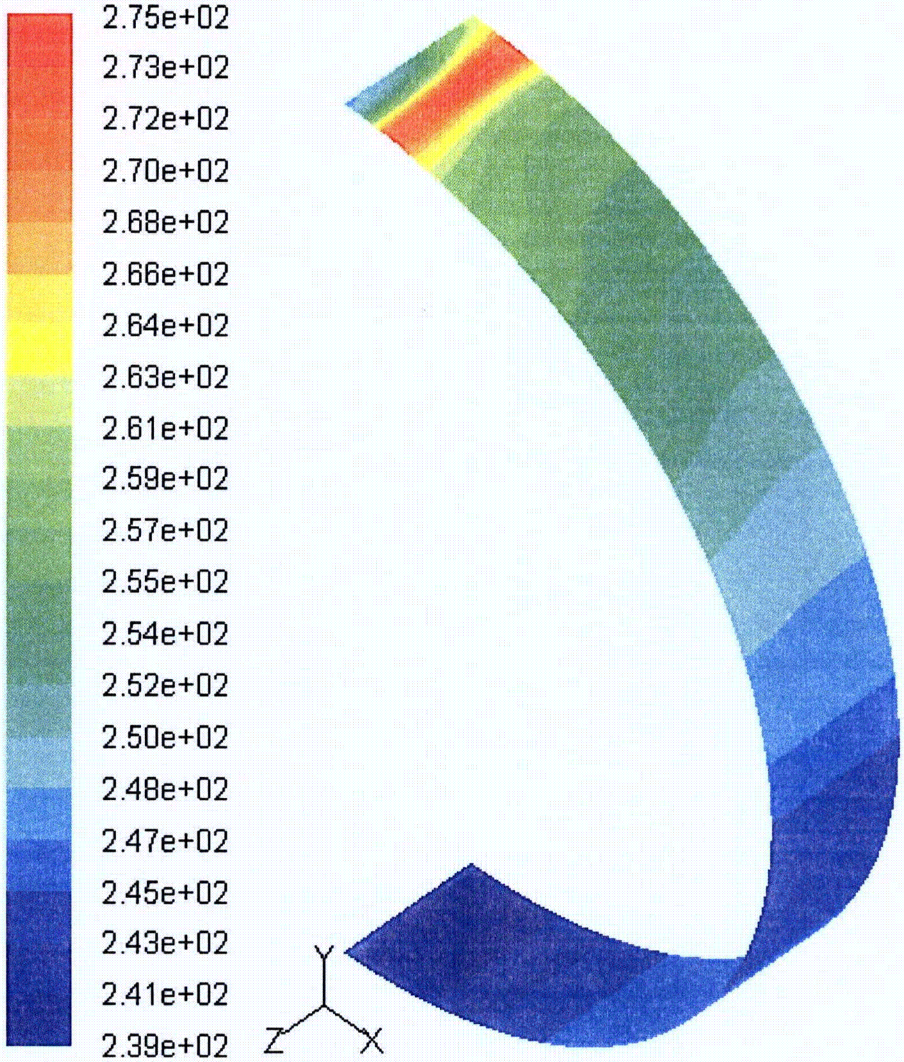
Note: Velocity is in units of ft/sec

Figure W.4-8
Velocity Distribution at OS197L Exit for 24 kW, 100°F Ambient, Plan View



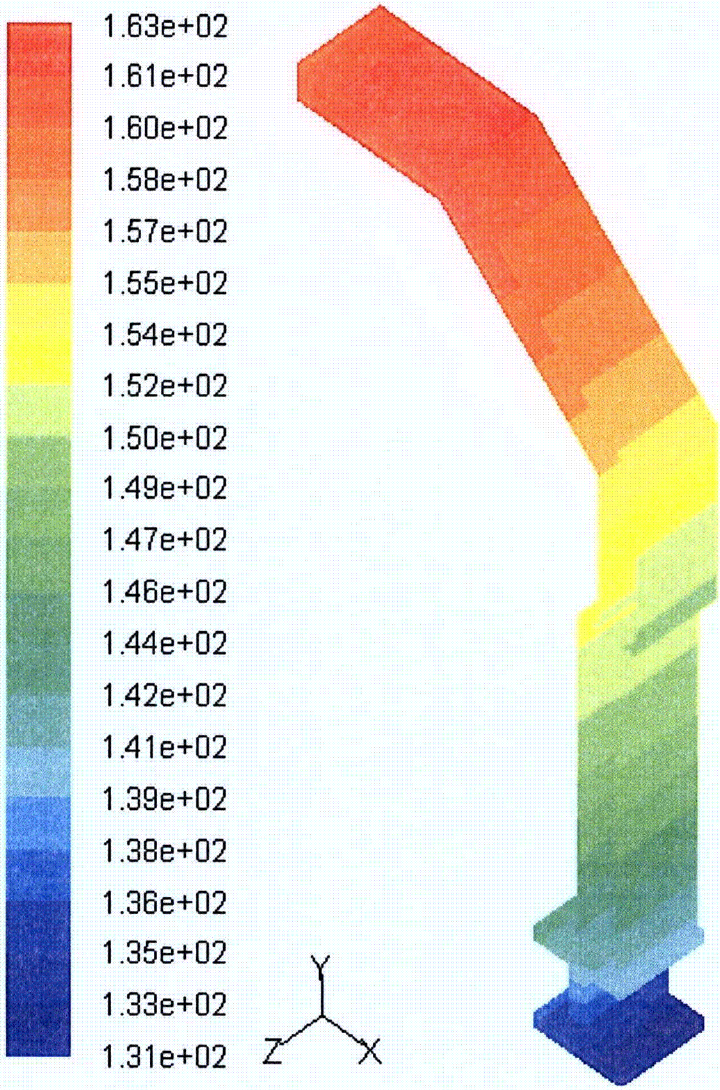
Note: Temperature is in units of °F

Figure W.4-9
Temperature Distribution over OS197L Cask Exterior Shell with 24 kW, 117°F Ambient



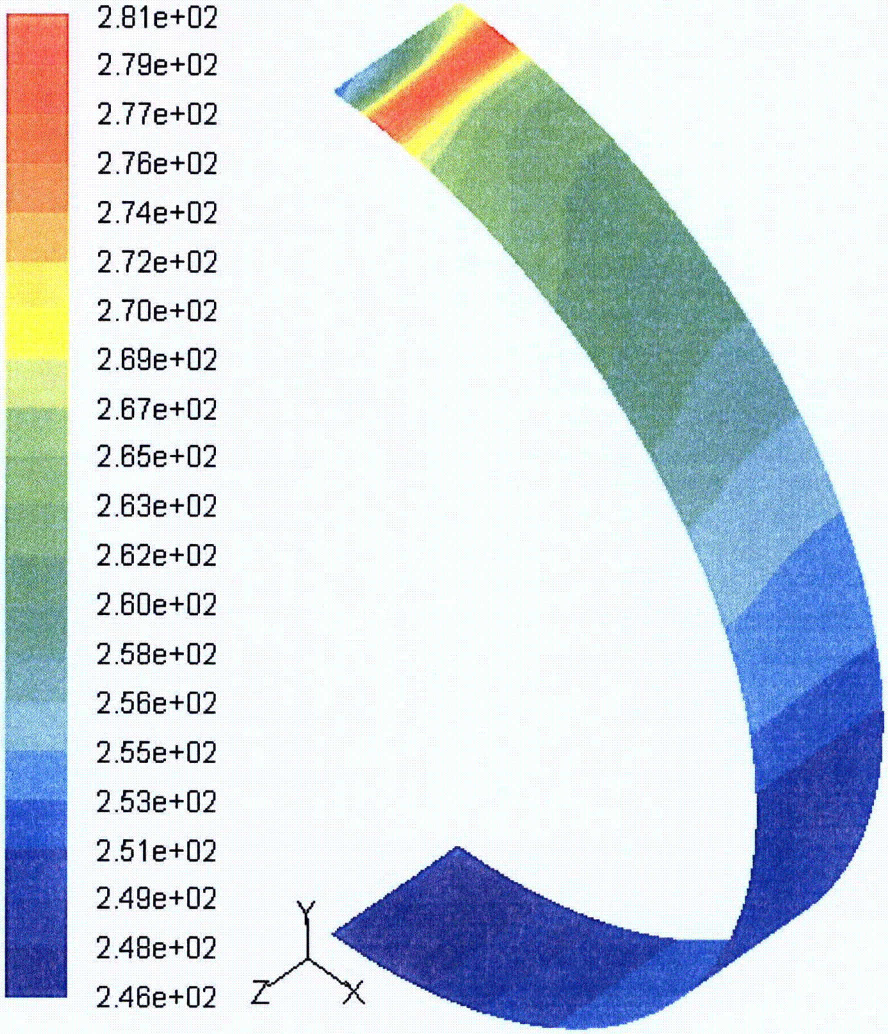
Note: Temperature is in units of °F

Figure W.4-10
Temperature Distribution over OS197L Cask Exterior Shell with 18.4 kW, 100°F Ambient



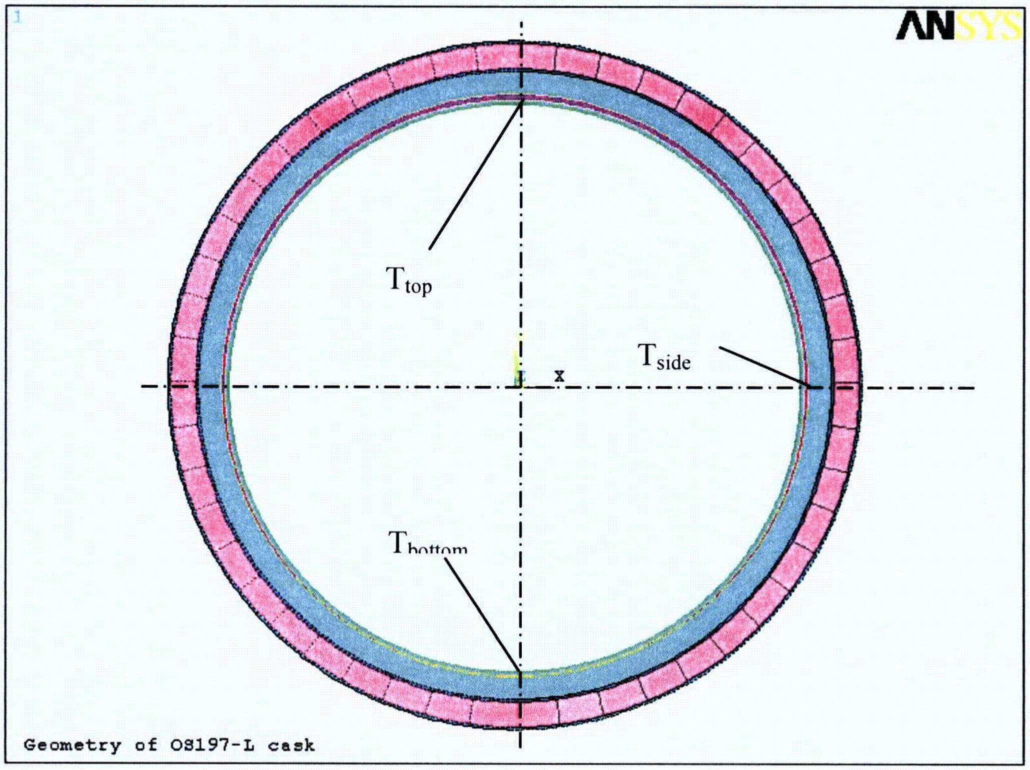
Note: Temperature is in units of °F

Figure W.4-11
Temperature Distribution for OS197L Transfer Skid Shields with 18.4 kW, 100°F Ambient



Note: Temperature is in units of °F

Figure W.4-12
Temperature Distribution over OS197L Cask Exterior Shell with 18.4 kW, 117°F Ambient



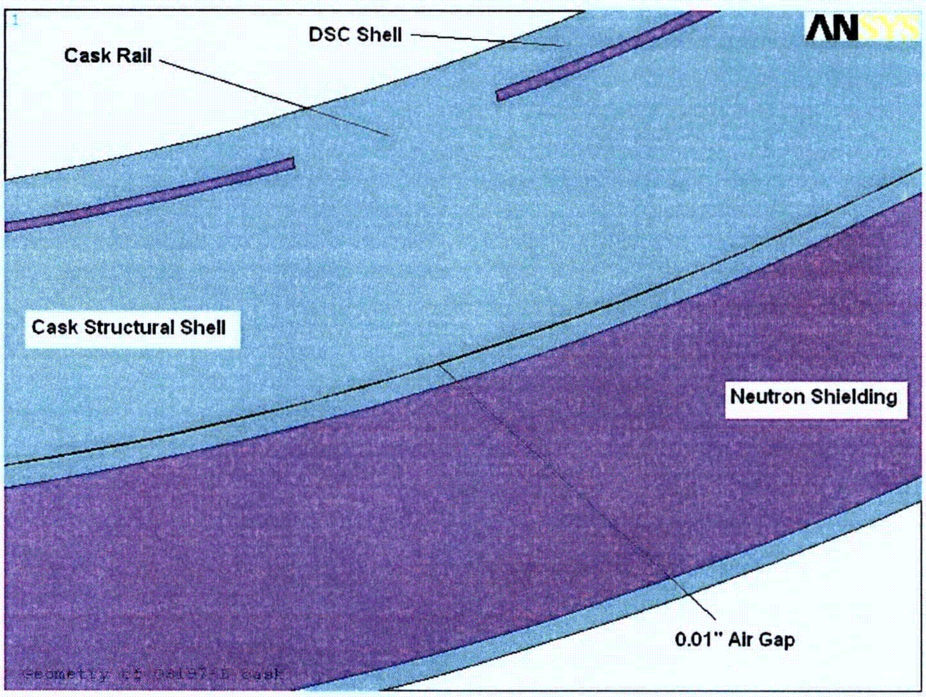
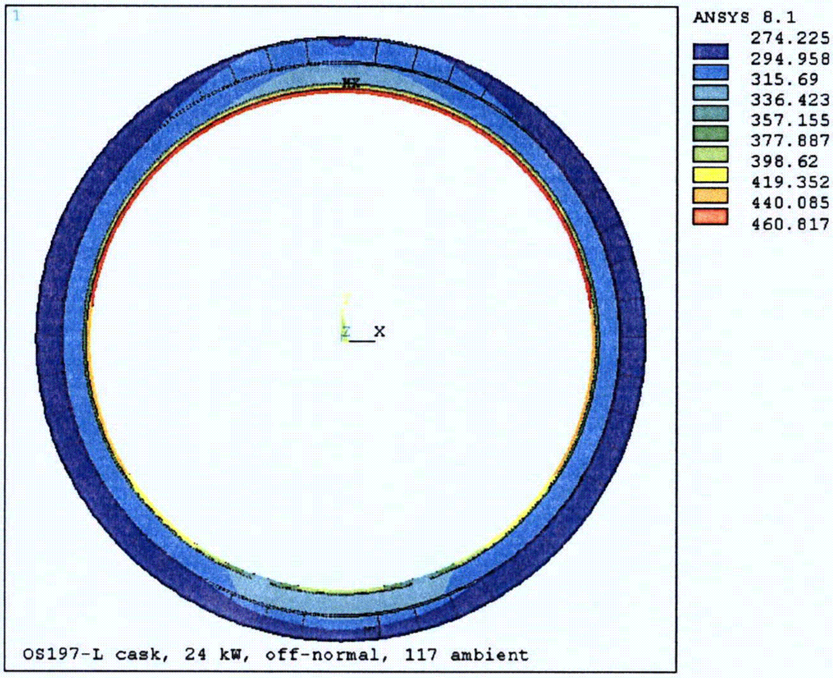


Figure W.4-13
OS197L TC ANSYS Model



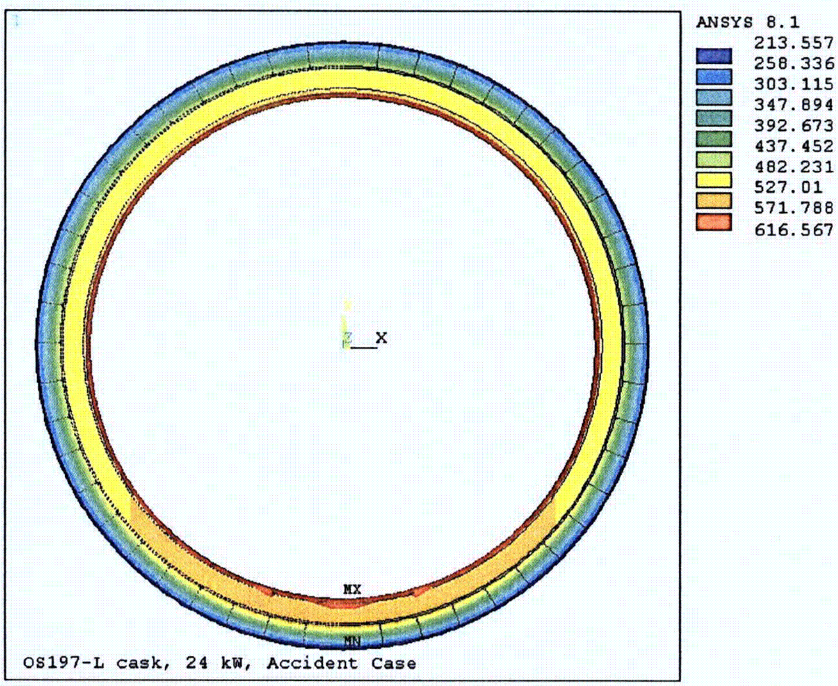
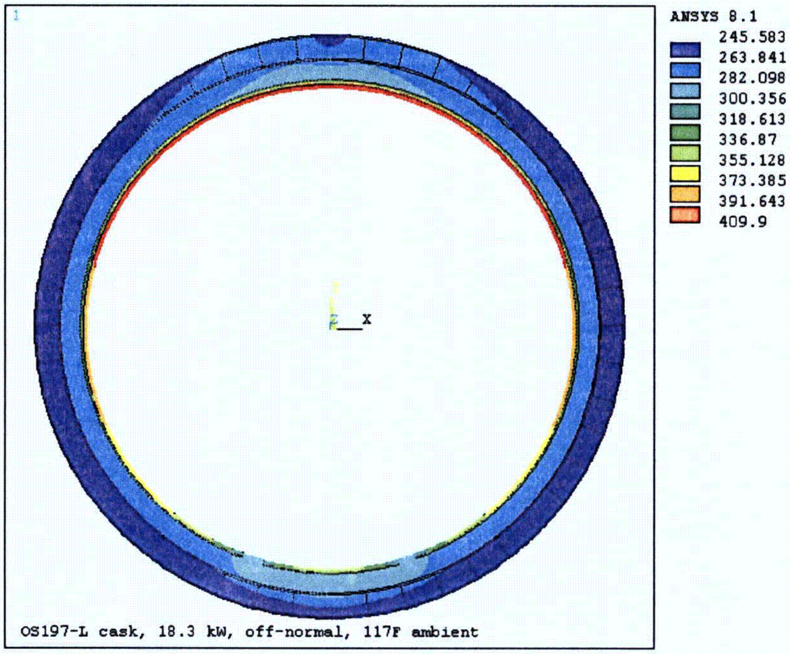


Figure W.4-14
Temperature Distribution on OS197L TC with 24 kW DSC and Supplemental Shielding, T_{amb}=117°F, Insolation



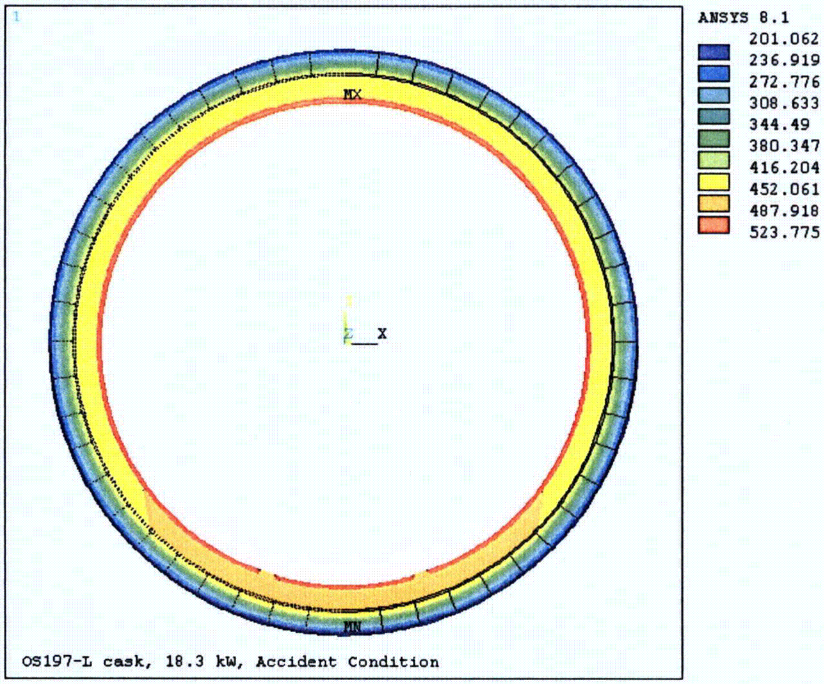
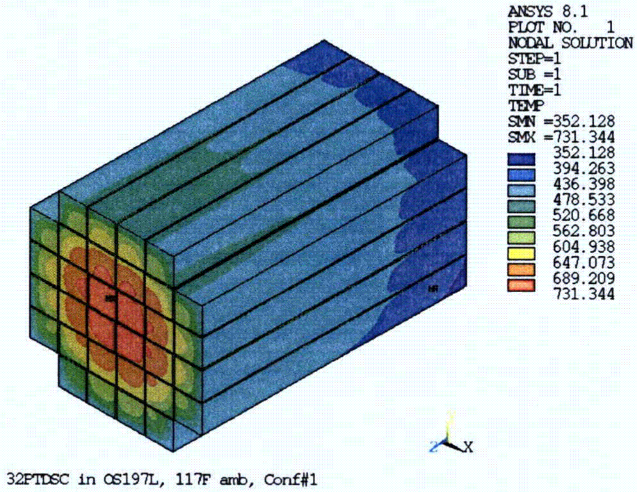
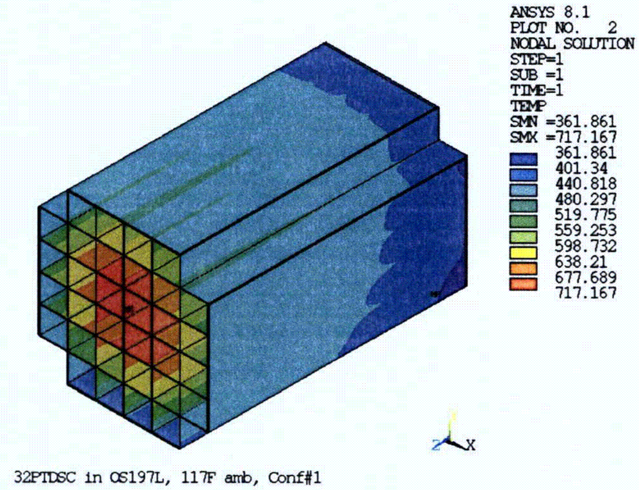


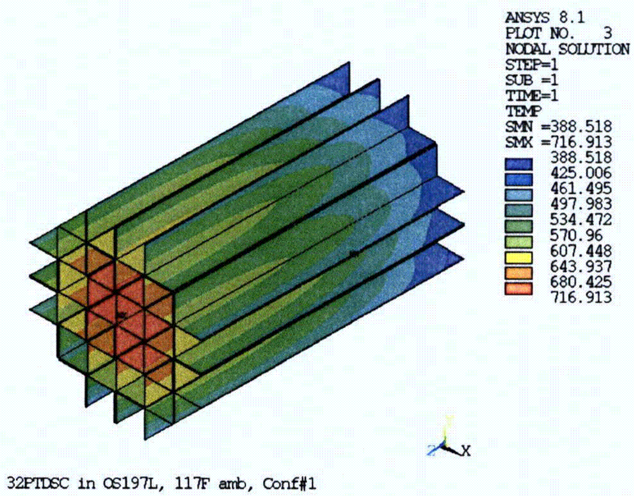
Figure W.4-15
Temperature Distribution on OS197L TC with 18.3 kW DSC and Supplemental Shielding, T_{amb}=117°F, Insolation



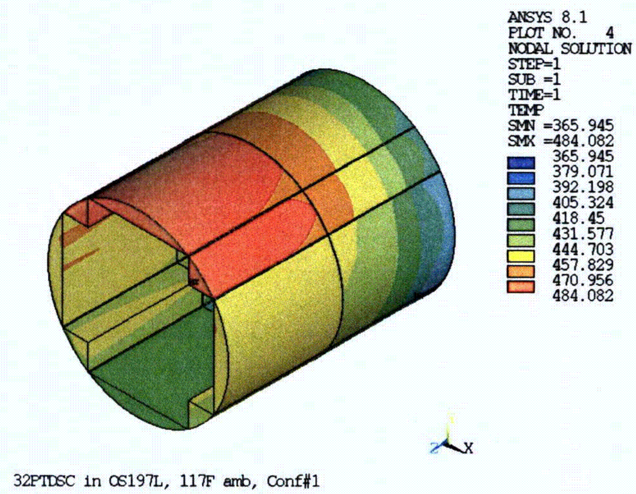
Fuel Assemblies



Basket Grid

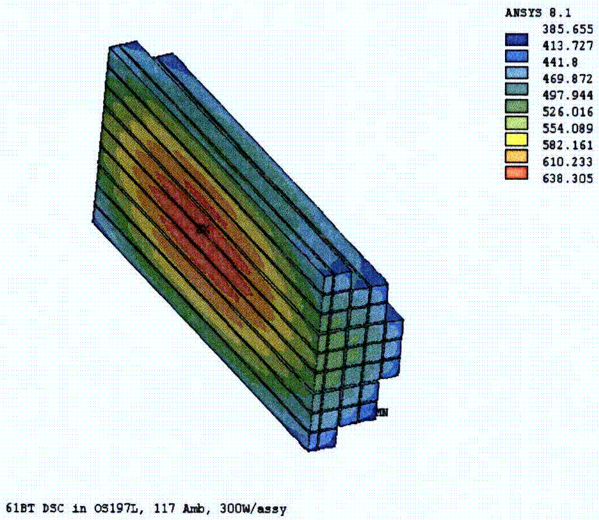


Basket Aluminum / Poison

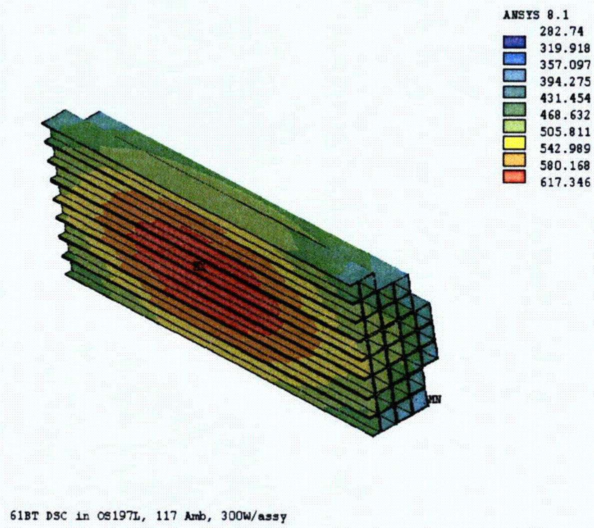


Basket Rails

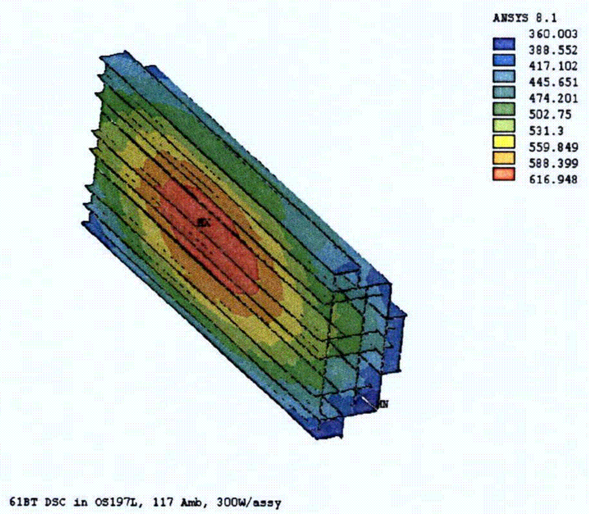
Figure W.4-16
Temperature Plots for 32PT DSC (24 kW) in OS197L TC with Supplemental Shielding, T_{amb}=117°F, Insolation



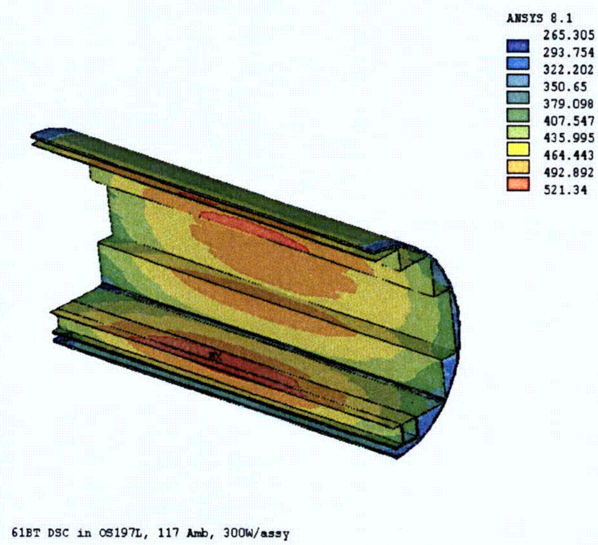
Fuel Assemblies



Basket Grid

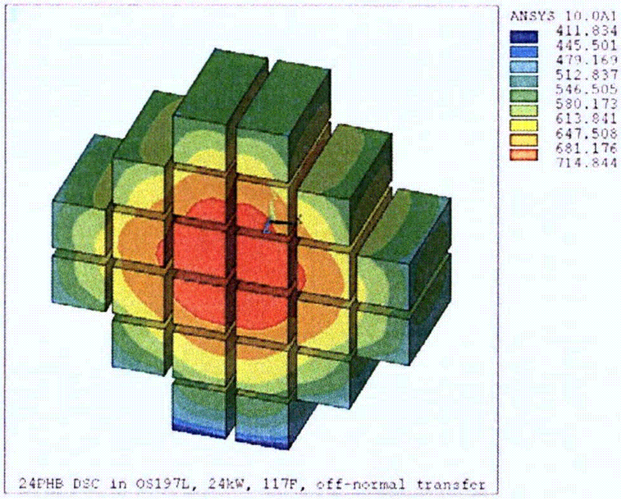


Basket Aluminum / Poison

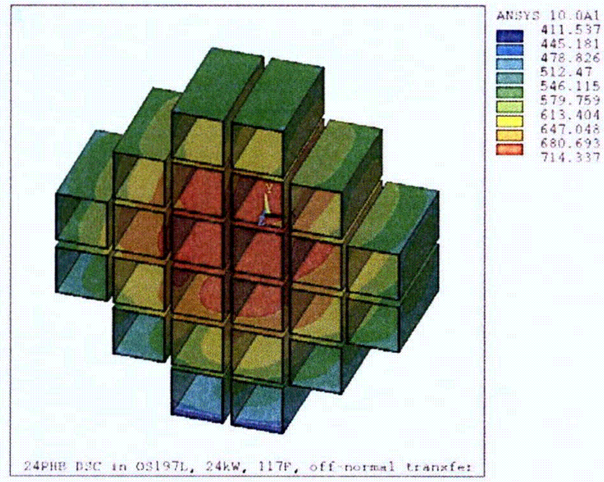


Basket Rails

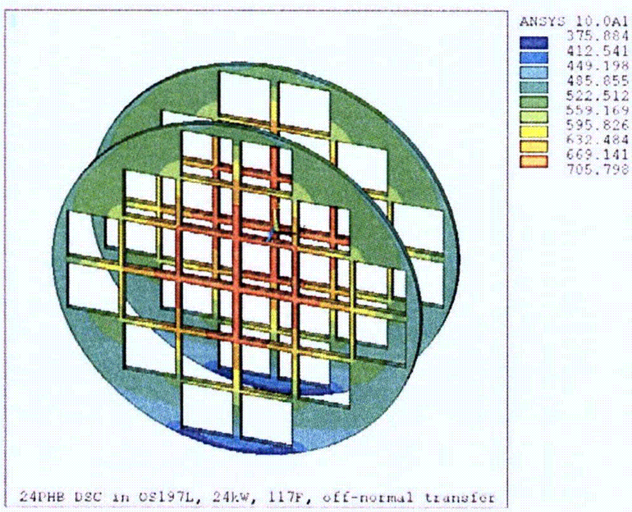
Figure W.4-17
Temperature Plots for 61BT DSC (18.3 kW) in OS197L TC with Supplemental Shielding, T_{amb}=117°F, Insolation



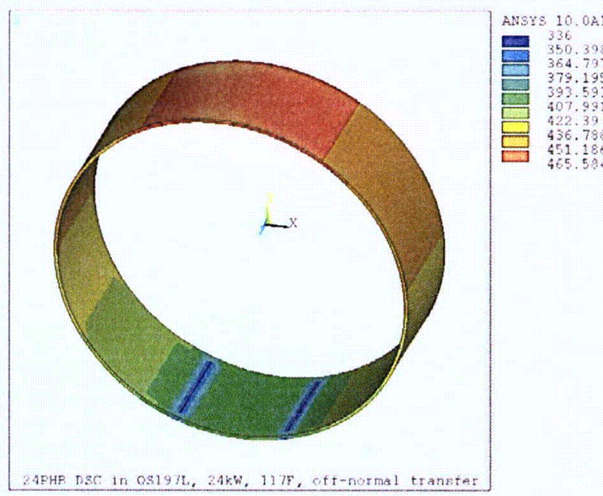
Fuel Assemblies



Guide Sleeves



Spacer Discs



DSC Shell

Figure W.4-18
Temperature Plot for 24PHB DSC (24 kW) in OS197L TC with Supplemental Shielding, T_{amb}=117°F, Insolation

W.5 Shielding Evaluation

This Appendix presents the shielding evaluation of the OS197L TC when used for fuel loading and transfer of the DSCs currently licensed under CoC 1004 (52B, 24P, 61BT, 24PT2, 32PT and 24PHB).

The shielding analysis is performed for the 32PT DSC design basis source terms. The results for normal operations demonstrate that exposures for OS197L TC activities with operational personnel present are bounded by OS197 TC exposures (remote crane operation is used and no personnel are present while the cask is on the crane hook during normal operations).

W.5.1 Methodology

Two radiation transport codes are used in the shielding analysis performed in the OS197L TC calculation: ANISN [5.1] and MCNP 5 [5.2]. ANISN is primarily used for the scoping analysis to determine (a) spectral distribution on the side of the transfer cask, (b) burn-up, enrichment, cooling time combination(s) which would result in the highest dose rate, and (c) optimum layout of shielding materials to meet certain restrictions on dose rates, etc. After desired optimal parameters are established with ANISN calculations these parameters are incorporated in a more rigorous, 3 dimensional models used in MCNP runs to calculate the final results.

The MCNP analysis is performed for the 32PT-DSC as a typical payload in order to quantify the effect on dose rates of the use of the OS197L TC. The resulting analysis demonstrates that the OS197L TC dose rates with the decontamination area shielding and the trailer shielding are similar and less than the dose rates for the OS197 TC.

W.5.2 Model Specification

See Figure 5.1 for a description of the 3-D OS197 TC model which used a 3" steel shell which corresponds to the cask shell and the neutron shield inner shell. The OS197L TC neutron shield outer shell is also 1/16" thicker than that used in the model. The 3-D MCNP analysis model of a 32PT DSC inside an OS197L TC is similar to that used in Appendix P.5 for the OS197 TC with a 24PTH DSC. In this model, the 32PT DSC design basis source terms are used as a baseline analysis for the OS197L TC. The data obtained is compared against a 2-D DORT model for the OS197 TC with the 32PT DSC source terms as described in Appendix M.5. This comparison is used to document that the additional decontamination area and trailer shielding, in conjunction with the OS197L TC, provide an equivalent level of shielding as the OS197 TC. The increased surface dose rates for the OS197L TC while on the crane hook will not impact normal operational dose rates since crane operations will be performed by remote crane control and using cameras and laser alignment systems.

W.5.3 Shielding Evaluation

The use of the OS197L (75 ton) TC is not expected to have any significant adverse impact on personnel dose rates during normal operation since crane operations will be performed remotely. The maximum dose rates on the side of the cask for normal conditions (neutron shield in place

and filled with water) are shown in Table W.5-1. For the transfer from the decon area to the trailer with an empty neutron shield and a filled DSC/TC annulus, the dose rates are conservatively estimated using the dose rates for the accident condition (no neutron shield), shown in the first table in Section W.11.1.4 for accident dose rates.

The dose rates associated with the OS197L TC during the short time duration lifts from the pool to the decontamination area (54 rem/hr surface dose) and from the decontamination area to the trailer (57 rem/hr surface dose rate, obtained as the sum of the maximum accident condition neutron dose rate and the normal condition gamma dose rate) are significantly higher compared to OS197 TC operational doses (346 mrem/hr surface dose). All operations associated with these two cask movements will be performed using remote crane operation using a laser/optical targeting system and cameras for confirmation of the cask location without the need for personnel in the vicinity of the cask. Should a failure of the crane occur during these operations, procedures will be in place to either repair the crane using proper ALARA practices and resume remote operations, or manually position the load in a safe, shielded location. Therefore, the dose received by operations personnel resulting from this high dose operation will be minimal as these operations are short duration and are performed remotely with no personnel in the vicinity.

The dose rates associated with the cask in the decontamination area and on the trailer (122 mrem/hr surface dose), are approximately one-third of the dose rates for the current configuration and relative to the precision of the shielding analysis, can be considered to have similar shielding (346 mrem/hr surface dose, identified as OS197 TC in Table W.5-1). The data provided for the UFSAR configuration above is the data using the specific model used in the UFSAR. The data provided for the OS197 TC configuration credits some additional shielding that was not credited in the UFSAR analysis. The above data is for a 32PT-DSC payload but is provided for evaluation of relative doses. The relative effect of the OS197L TC configuration and the decontamination area/trailer shielding configurations with respect to the OS197 TC configurations shown above is representative of the relative effect for all CoC 1004 licensed DSC payloads for the OS197L TC.

The loss of neutron shield accident dose rates are addressed in Appendix W.11. These dose rates bound the doses from accident fire condition because the shielding on the trailer is not affected by the fire condition.

W.5.3.1 Solid One Piece Trunnion Dose Rate Evaluation

Analyses are performed to compare the effect of the solid steel trunnion design to the original trunnion design (multiple pieces) which used NS-3 neutron absorber to reduce neutron dose. The result of this analysis indicates that this change does result in an increase in neutron dose, however, since the majority of the dose contribution is gamma; the overall dose is reduced in the solid steel trunnion configuration. A comparison of the dose rates is provided in Table W.5-2.

In summary, the use of a one-piece trunnion reduces the total calculated dose rate by a factor greater than ten, thus providing a beneficial impact on occupational dose rates.

W.5.3.2 Removable Two Piece Neutron Shield Dose Rate Evaluation

The two piece neutron shield provides the same level of shielding as the OS197 TC neutron shield. The water cavity thickness is unchanged. The outer shell of the OS197L TC neutron shield is slightly thicker than that used in the OS197 TC (.25" versus .18"). The addition of the seam between the two halves would reduce gamma dose in the vicinity of the seam but would increase neutron dose due to less water in the vicinity. As discussed for the trunnion modification above, since the total dose is primarily gamma, the increase in steel will result in a net decrease in total dose in the vicinity of the seams.

W.5.4 References

5.1 One-Dimensional Discrete Ordinates Transport Code System with Anisotropic Scattering," CCC-254, Oak Ridge National Laboratory, RSICC Computer Code Collection, April 1991.

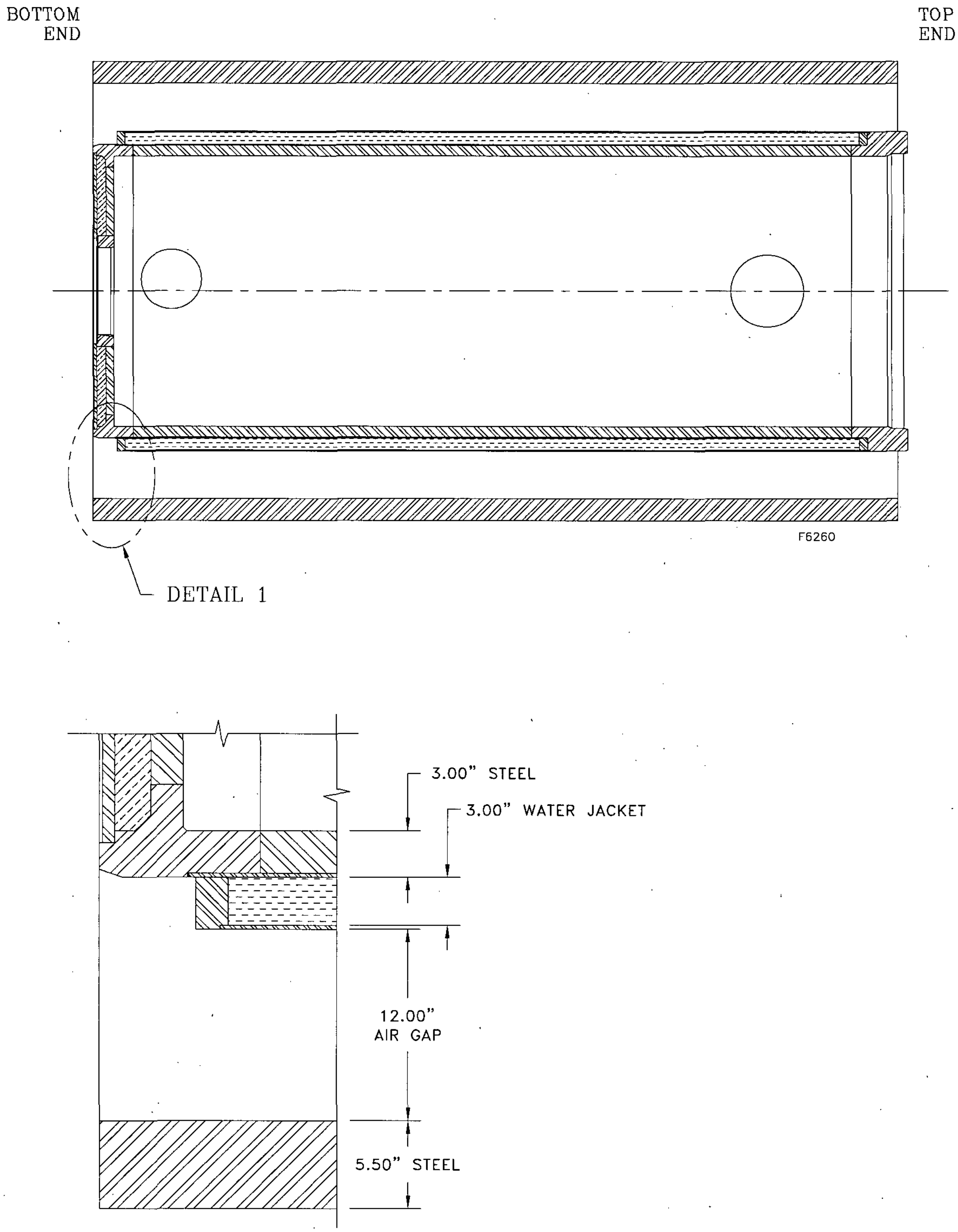
5.2 A General Monte Carlo N-Particle Transport Code, Version 5, Volume II: User's Guide, LA-CP-03-0245, 2003.

Table W.5-1
OS197L TC Normal Condition Dose Rates

Transfer Cask Configuratio n	Dose Rate Component	Dose Rates at Different Distances from Side Surface – Normal Condition Neutron Shield Filled			
		On Side Surface	4.57 meters (15')	100 meters	609.9 meters (2000')
		Dose Rate, mrem/hr	Dose Rate, mrem/hr	Dose Rate, mrem/hr	Dose Rate, mrem/hr
UFSAR (Table M.5-5 and Section M.11.2.5.3)	Neutron	261	Not Calc.	Not Calc.	Not Calc.
	Gamma	784	Not Calc.	Not Calc.	Not Calc
	Total	950	Not Calc	Not Calc	0.01
OS197 TC	Neutron	102	7.20	0.006	7.09e-6
	Gamma	248	20.3	0.03	5.29e-5
	Total	346	25.9	0.03	5.67e-5
OS197L TC Bare Cask	Neutron	247	18.2	0.018	2.19e-5
	Gamma	53,031	3906	4.52	9.70e-3
	Total	53,249	3922	4.53	9.70e-3
OS197L TC with Decon Area or Trailer Additional Shielding	Neutron	28	2	0.002	1.31e-6
	Gamma	94	11	0.02	2.44e-5
	Total	122	13	0.02	2.57e-5

Table W.5-2
Dose Rate Results for Two Trunnion Designs (mrem/hr)

Trunnion Type	Neutron Dose Rate	Gamma Dose Rate	Total Dose Rate
Original Upper	0.2	621	**621.2**
Solid Steel Upper	51.1	.14	**51.24**
Original Lower	1.0	1702	**1703**
Solid Steel Lower	79.5	1.3	**80.8**



DETAIL 1

Figure W.5-1
OS197L TC and Decontamination Area Shielding Model Geometry

W.6 Criticality

The modifications associated with the OS197L TC will not have a significant adverse impact on the criticality analyses performed for the OS197 TC. The changes are in an area of relatively insignificant importance to criticality – no change in the fuel geometry / poison loading / or borated water concentration. The changes only affect the outer surface of the cask. The UFSAR shows that a reflective boundary, simulating an infinite cask array, was employed that further reduces the sensitivity of the analysis to TC design changes. Therefore, these changes will have a negligible impact on the criticality analyses.

W.7 Confinement

There are no confinement features associated with the OS197L TC on-site transfer cask since the cask is designed as a non-pressure retaining system. The DSC is the confinement system.

W.8 Operating Procedures

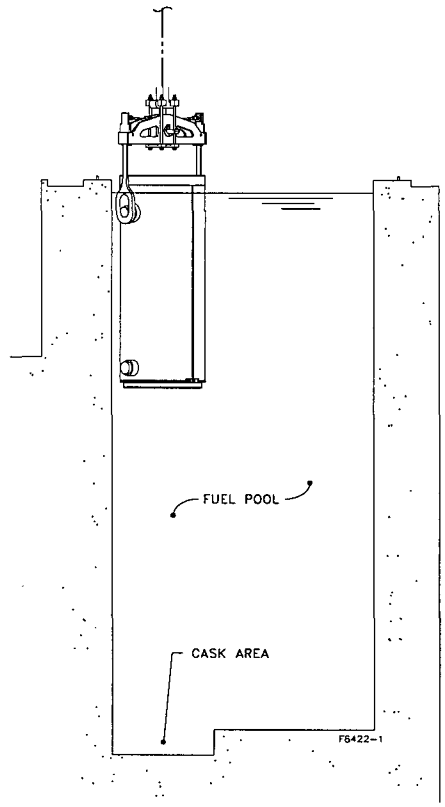
The shaded portion of Chapter W.8 provided in this FCN is for completeness and information only. It is part of Amendment 11 to be submitted to the NRC for review and approval. Therefore, the OS197L TC shall not be used until Amendment 11 to CoC 1004 is approved by the NRC.

The following is a description of the operational sequences for use of the OS197L TC. In general, the steps are similar to those for the OS197 TC, described in detail in Chapter 5 of the UFSAR, and Chapter 8 of the canister-specific appendices (e.g., M.8 for the 32PT DSC). This chapter highlights the differences in operational steps when using OS197L TC relative to the OS197 TC. Figures are provided to illustrate these steps.

Notes: The applicable Technical Specification requirements for loading/unloading operations as listed in UFSAR Chapter 5 or Chapter 8 of the canister specific appendix are also applicable for this chapter when using OS197L TC.

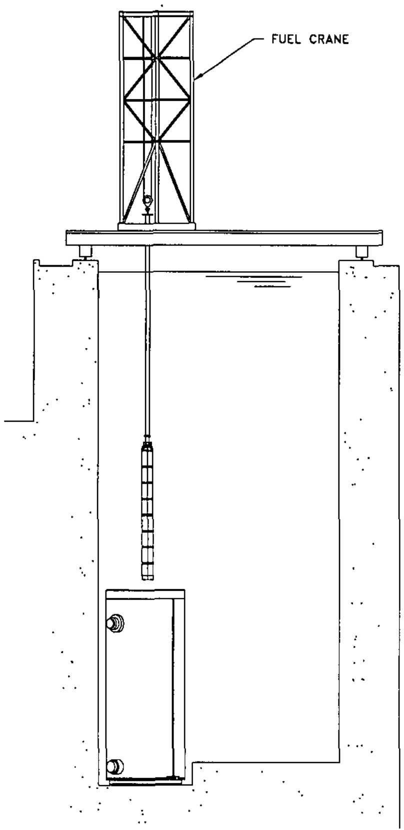
A general licensee shall meet the requirements of applicable Technical Specification of Amendment 11 prior to the use of OS197L TC for onsite transfer of an authorized payload.

Placement of the DSC into the OS197L TC and preparations for placement of the TC into the fuel pool are the same as for the OS197 TC. The DSC/TC annulus is filled with clean water and sealed with the annulus seal. The TC neutron shield is also filled with clean water. As there is no fuel in the DSC at this time, the 75 ton limit is not approached, and the DSC may be filled with fuel pool water prior to lowering into the pool. This may be done either prior to the lift to the fuel pool, or the OS197L TC lowered to within a few feet of submergence and the DSC filled at that time. The OS197L TC with DSC is then lowered to the fuel pool bottom and landed, and the yoke removed. Sequence 1 below shows the cask as it enters the pool.

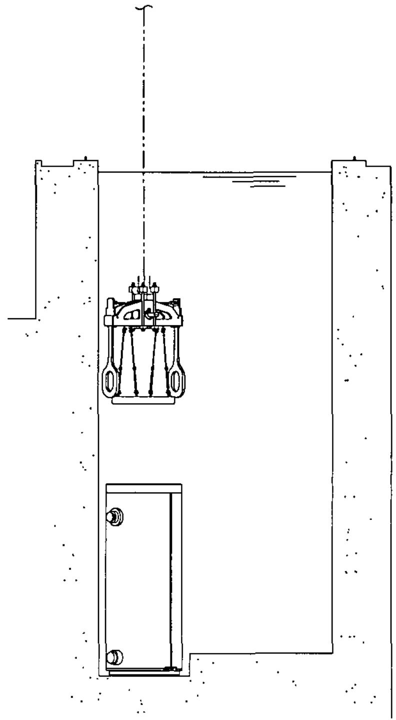


(1) OS197L IS BROUGHT TO SURFACE

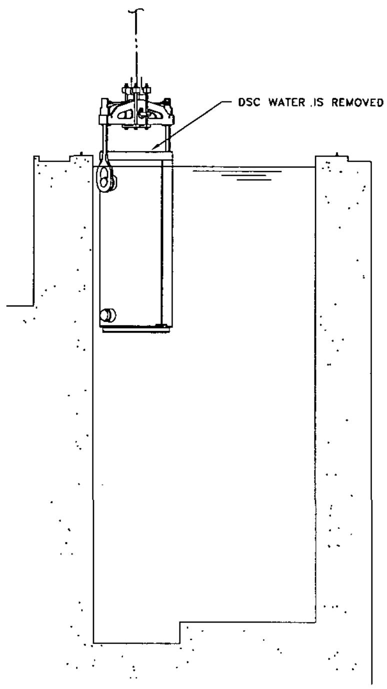
Selected Fuel Assemblies (FA's) are then placed into the DSC. Following fuel verification, the top shield plug is lowered into place and set. The yoke is then lowered and connected to the OS197L TC. The cask is then lifted until the cask top just breaks the surface of the fuel pool. At this time the water weight in the DSC and cask is offset by the buoyancy of the OS197L TC and allows for the hook weight to remain below 75 tons. However, further raising of the DSC and cask would exceed the 75 ton limit. This is shown as Sequences 2 through 4.



(2) FUEL ASSEMBLIES ARE LOADED INTO OS197L



(3) TOP SHIELD PLUG IS LOWERED INTO DSC



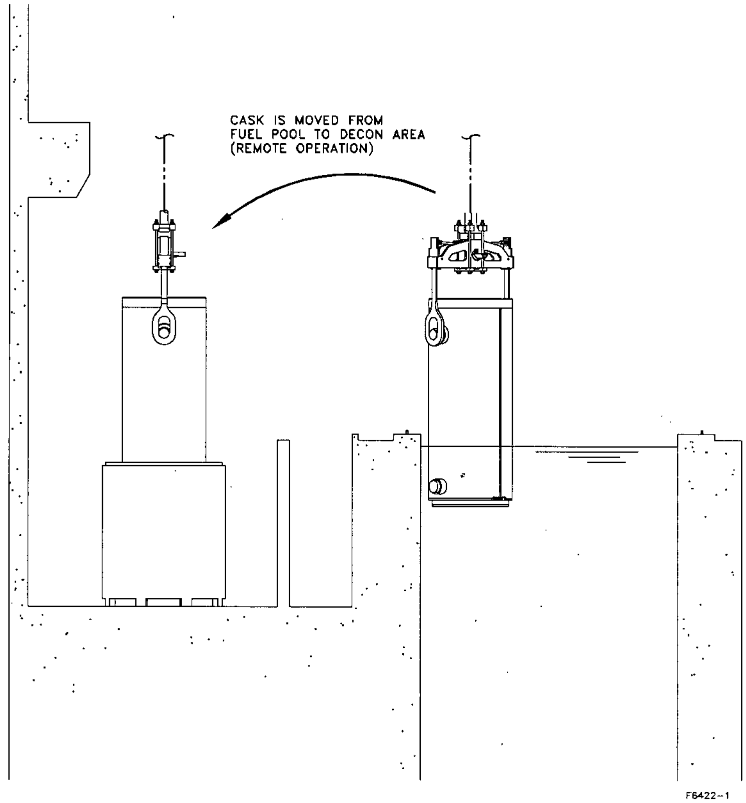
(4) OS197L IS BROUGHT TO SURFACE, AND WATER WITHIN THE DSC IS PUMPED OUT

Connections are then made to the DSC siphon and vent ports and (up to a maximum of 13,600 lbs) water within the DSC removed (pumped out). During this water removal, a helium gas blanket will be supplied through the vent port as the water is drained. The neutron shield will not be drained during this step and the DSC/TC annulus will be maintained full. To provide additional assurance, the necessary equipment to provide makeup to the DSC/TC annulus during the movement of the cask from the fuel pool to the decon area is to be installed/staged to ensure that the annulus level can be maintained during this operation. This is shown as Sequence 4.

CAUTION: Prior to performing the next step of lifting OS197L TC from the pool, the licensee shall meet the specific radiation protection program requirements of applicable Amendment 11 Technical Specification associated with the use of OS197L TC and remote monitoring devices. The licensee shall develop appropriate measures to keep the dose rates ALARA during recovery from a potential malfunction of these devices, if needed.

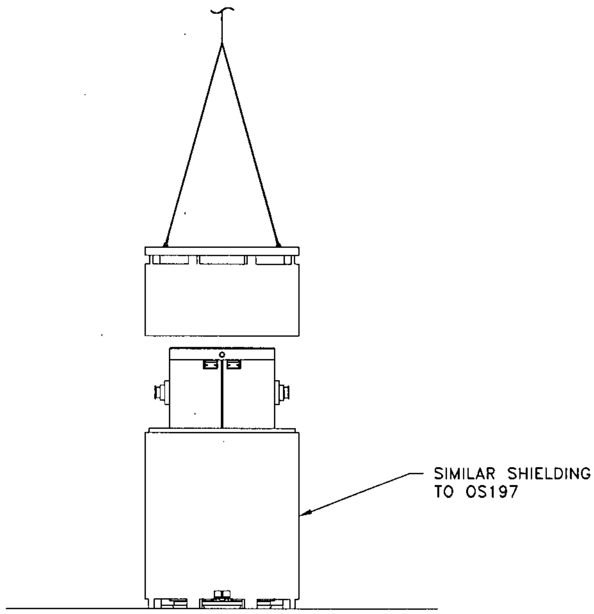
After water has been pumped out from the DSC (up to a maximum of approximately 13,600 lbs.), the OS197L TC will be lifted from the fuel pool to the decontamination area. The 75 ton cask itself has significantly reduced shielding and employs draining of the water in the DSC to achieve the 75 ton limit. However, the OS197L TC operations utilize additional shielding and measures to achieve shielding capacity similar to the OS197 TC. As described in the applicable Amendment 11 Technical Specification, the OS197L TC system consists of the bare cask and the upper and lower cask shielding utilized in the decontamination area and the additional shielding provided on the cask support skid. The bare cask is in this reduced shielding configuration ONLY during the movement of the cask from the fuel pool to the decontamination area and from the decontamination area to the transfer trailer. Both of these operations are of short time duration (i.e. minutes).

During bare cask movement from the fuel pool to the decontamination area and from the decontamination area to the trailer, remote crane operation and/or an optical targeting system with remote camera monitoring will be used to minimize personnel exposure to the reduced shielding configuration. This remote operation is shown in Sequence 5.



(5) FROM FUEL POOL TO DECONTAMINATION AREA,
OS197L IS PLACED IN SHIELDING SLEEVE
(PART OF OS197L CASK SYSTEM)

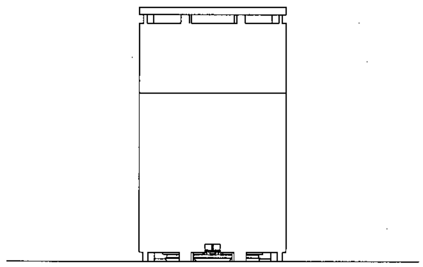
In the decontamination area, the bare cask is placed in a shielding sleeve (lower cask shield) which provides shielding below the trunnions. An upper cask shield (shielding bell) is then placed on top of the shielding sleeve to shield the upper section of the cask. The shielding sleeve and shield bell are nominally 6" thick carbon steel. Placement of the cask in the shielding sleeve and placement of the shielding bell on the cask is performed using remote crane operation and/or an optical targeting system with remote camera monitoring. The OS197L TC system configuration of the cask and shielding sleeve and bell is shown as Sequences 5 and 6.



(6) TOP SHIELDING BELL COMPONENT OF OS197L IS PLACED (REMOTE OPERATION)

The combination of the bare OS197L TC and these shielding structures provide a similar level of shielding as the OS197 TC in the radial direction and thus provide assurances that the TC dose rates during this operation are ALARA.

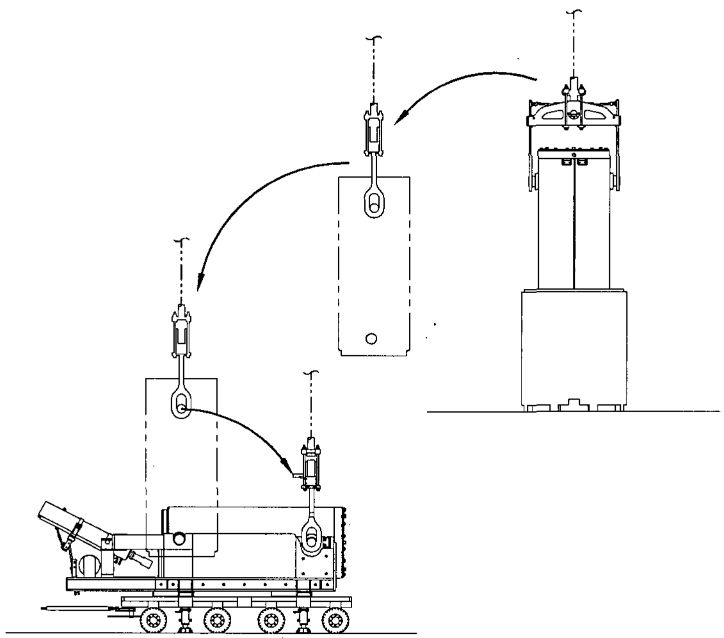
While in the shielding sleeve and bell, the canister is vacuum dried, helium backfilled, and all top covers welded in place. During these operations the DSC/TC annulus nearly remains full (approximately 12" drained from the top of the DSC) similar to OS197 TC operations. The OS197L TC neutron shield will remain filled and vented, similar to OS197 TC operations, during these steps. During these operations, the cask and the shielding sleeve and bell provide occupational radiation shielding for personnel necessary to perform the canister closure operations. These operations are essentially unchanged from those listed in the UFSAR, Chapter 5 and the canister specific Appendices, such as M.8 for the 32PT. The shielding sleeve and the bell are designed to not interfere with the NUHOMS® AWS system or other equipment of the canister sealing operations. This is shown in Sequence 7.



(7) CANISTER IS PREPARED FOR CLOSURE OPERATIONS

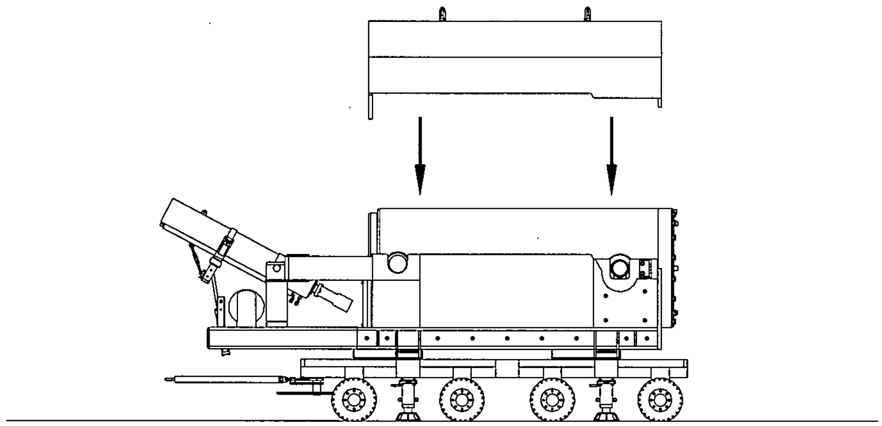
Once the DSC is sealed, the DSC/TC annulus will be drained and the cask top cover installed prior to downending onto the transfer trailer. In the event that the neutron shield is to be drained (required for 32PT DSC only) to reduce weight during the transfer from the decon area to the trailer, the DSC/TC annulus will essentially remain filled and the interim cover will be installed using a gasket to prevent annulus water from leaking during downending operations. The annulus will remain vented to the atmosphere through the annulus fill port in the cask side and/or through fittings in the interim cask cover. During the downending process, the bare OS197L TC movement is of short time duration and is performed using remote crane operation and/or an optical targeting system with remote camera monitoring. This remote operation is shown in Sequence 8. To provide additional assurance, the necessary equipment to provide makeup to the DSC/TC annulus during the movement of the cask from the decon area to the trailer will be installed/staged to ensure that the annulus level can be maintained during this operation.

Note: See UFSAR Section W.8.1.5 regarding the use of a reduced weight interim cask cover.



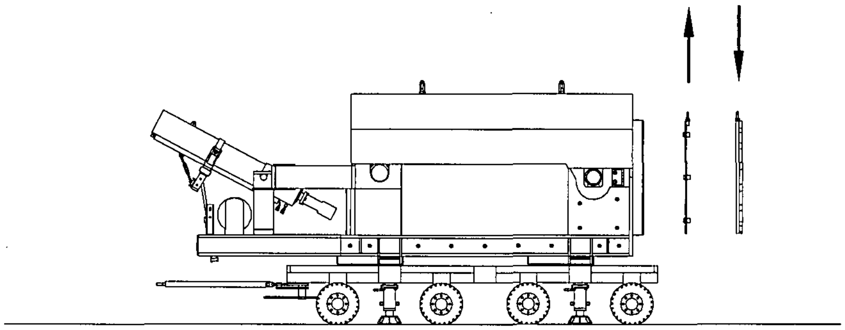
(8) CASK IS MOVED FROM DECON AREA TO TRANSFER TRAILER (REMOTE OPERATION)

Once on the transfer trailer, the skid provides 5.5" of carbon steel shielding to the sides of the cask up to the trunnions. A 2.5" thick carbon steel shield will be placed over the cask/skid inside the fuel building, after which a 3" thick carbon steel shield will be placed over the 2.5" thick shield providing a total of 5.5" of shielding on the skid. These shields may be placed on the skid inside the fuel handling building, or if load limits exist within the building, the 3" outer shield may be placed on the skid once the trailer exits the building. If the neutron shield was drained (for 32PT DSC only) during transfer from the decon area to the trailer (with the annulus filled), the neutron shield will be refilled and the annulus drained. This operation may be performed before the placement of the 3" outer shield. Placement of the inner shields and outer shields (if selected) on the skid inside the fuel handling building will be performed in accordance with the plants heavy loads procedures, and is evaluated within the plant 72.212 (50.59) for the dry fuel loading process. Sequence 9 shows this remote operation.



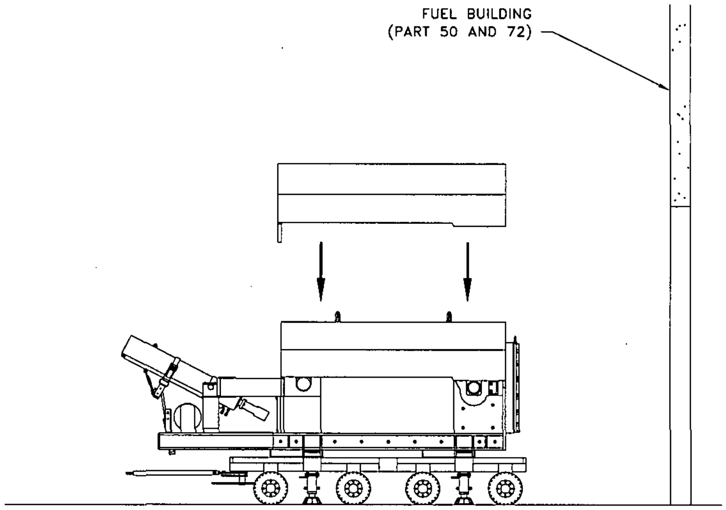
(9) INSTALLATION OF SUPPORT SKID INNER TOP SHIELDING

If fuel assembly weights are of a magnitude that would exceed the 75 ton limit, the standard cask top cover may be replaced with a reduced weight interim cover (see Sequence 8) during transfer from the decontamination area to the trailer. Following placement of the cask on the trailer, and placement of the inner top shield on the transfer trailer, the interim cask top cover would be removed and the standard top cask cover installed prior to exiting the spent fuel/reactor building. This is shown in Sequence 10.



(10) INTERIM CASK TOP COVER IS REPLACED WITH STANDARD TOP COVER

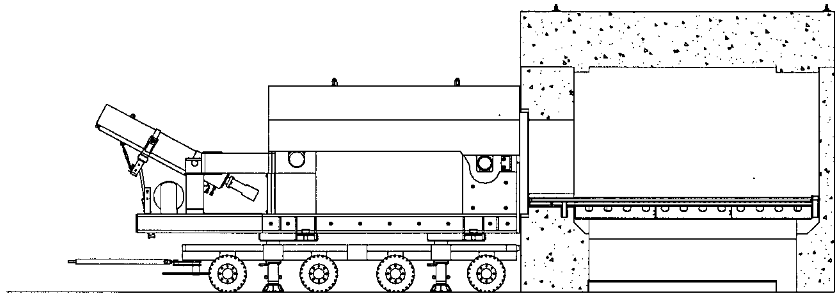
Following placement of the standard cask top cover, the trailer with the OS197L TC may be moved out of the fuel building and the outer top trailer shielding installed outside, if the fuel building weight limits preclude placement of the outer top trailer shielding inside the fuel building. This is shown in Sequence 11. The OS197L TC system shielding (6" of shielding) provided in the decontamination area and the 5.5" provided on the trailer, along with the shielding provided by the bare OS197L TC, provides a level of shielding equivalent to that provided by the standard OS197 TC (with lead shielding) and is the bounding condition of the two from a dose perspective (decon area and transfer trailer).



(11) INSTALLATION OF PART 72 SUPPORT SKID OUTER TOP SHIELDING

CAUTION: Visually monitor the outer top trailer shield vents and the openings around the cask ends for any sign of steaming which may indicate leakage of water from the cask neutron shield. If steaming is determined to be due to leakage of neutron shield water and not due to any rain or snow or other ambient conditions, then Licensee must take appropriate corrective actions including terminating the transfer operation and returning the loaded cask to the fuel handling building for further assessment.

The transfer trailer, with loaded OS197L TC including the supplemental shielding, is then moved to the ISFSI and the Cask docked with the HSM. The DSC is then inserted into the HSM using the same methods as the OS197 TC. This is shown in Sequence 12.



(12) TRANSFER TRAILER IS DOCKED TO HSM AND CANISTER IS TRANSFERRED

W.8.1 Operational Differences between OS197L and OS197 TCs

Listed below are each of the UFSAR sections for preparation and loading of fuel assemblies into the HSM using the NUHOMS® OS197L TC system. In each section, which mirrors that of Chapter 5 of the UFSAR and Chapter 8 of the canister-specific appendices (e.g., M.8 for the 32PT DSC) the differences specific to the OS197L TC are listed.

W.8.1.1 UFSAR Section 5.1.1.1 – Preparation of the Transfer Cask and DSC

- The transfer cask may be filled in the fuel pool or prior to placement in the fuel pool.

W.8.1.2 UFSAR Section 5.1.1.2 – DSC Fuel Loading

- A preliminary measurement of the OS197L TC dose rates at 3 feet from the top of the cask with the shield plug installed and water in the DSC cavity is performed.
- Water (up to a maximum of 13,600 lbs) is pumped out of the DSC when the cask breaks the surface of the fuel pool to reduce cask weight.
- A helium back fill will be provided during initial draining to eliminate exposure of the fuel to air. The shield plug restraints will be installed to prevent shield plug movement.
- Personnel are evacuated from the area, as specified by plant's ALARA practices, due to the high cask dose rates. Crane operations will be performed remotely and/or an optical targeting system with remote camera monitoring will be used to minimize personnel exposure.
- The cask is placed into the decontamination area shielding sleeve once removed from the fuel pool. A decontamination area shielding bell is then placed over the side of the cask above the upper trunnions. The shielding sleeve and bell provide the additional shielding to produce similar shielding as the OS197 TC.

W.8.1.3 UFSAR Section 5.1.1.3 – DSC Drying and Backfilling

- OS197L TC dose rates at 3 feet from the top of the cask with the Automated Welding System (AWS) installed on the inner top cover plate are to be verified after the cask is placed in the decontamination area shields. This configuration offers shielding similar to that of the OS197 TC. Verification of TC dose rates is performed to assure that they are ALARA and consistent with the analysis provided in the UFSAR.

  NOTE: DSC blowdown is not required in this sequence since the DSC cavity has been drained with helium prior to lifting the canister out of the pool (air or nitrogen is not allowed).

  CAUTION: During the DSC closure operations, the opening at the top and bottom of the decontamination area shielding shall be monitored (visual inspection) to assure no significant blockage of openings. Although blockage is improbable as all 16 openings would require sealing, personnel shall perform visual inspection of shielding sleeve and bell openings during the operations when DSC is in the sleeve.

W.8.1.4 UFSAR Section 5.1.1.4 – DSC Sealing Operations

- No change

W.8.1.5 UFSAR Section 5.1.1.5 – Transfer Cask Downending and Transport to ISFSI

- Crane operations for removal of the decontamination area shielding bell, engagement of the yoke to the cask trunnions, movement of the cask to the trailer, lowering of the cask onto the trailer and placement of the trailer shielding on the cask will be performed remotely using cameras and laser/target positioning, due to bare cask dose rates. The additional trailer shielding may be placed on the trailer at this time or the outer top shield may be placed on the trailer once the trailer exits the auxiliary building, as applicable based on site specific weight restrictions. Placement of the inner shields and outer shields (if selected) on the skid inside the fuel handling building will be performed in accordance with the plant's heavy load procedures, and is evaluated within the plant 72-212 (50.59) for the dry fuel loading procedures.

- If fuel assembly weights are of a magnitude that would exceed the 75 ton limit, the standard cask top cover may be replaced with a reduced weight interim cover during transfer from the decontamination area to the trailer. The interim top cover will be placed on the cask with a gasket. If water from the neutron shield was drained for transfer from the decon area to the trailer, (required for 32PT DSC only) the neutron shield will be refilled after the cask is placed on the trailer and after placement of the inner shield cover on the trailer. The DSC/TC annulus will then be drained. Following placement of the cask on the trailer, and placement of the inner top shield on the transfer trailer, the interim cask top cover would be removed and the standard top cask cover installed prior to exiting the spent fuel/reactor building. The interim cask top cover shall not be used outside the fuel building.

- The OS197L TC system shielding (6" of shielding) provided in the decontamination area and the 5.5" provided on the trailer, along with the shielding provided by the bare OS197L TC, provides a level of shielding similar to that provided by the standard OS197 TC (with lead shielding) and is the bounding condition of the two (decon area and transfer trailer). The TC dose rates are verified to ensure that they are consistent with the analysis provided in the UFSAR and are ALARA.

W.8.1.6 UFSAR Section 5.1.1.6 – DSC Transfer to the HSM

- Following placement of the standard cask top cover, the trailer with the OS197L TC may be moved out of the fuel building and the outer top trailer shielding installed outside, if the fuel building weight limits preclude placement of the outer top trailer shielding inside the fuel building.
- Install the cask top centerline alignment target, through the trailer shielding.
- CAUTION: During the actual movement of the Transfer Cask on the transfer trailer to the ISFSI, the gap between the transfer deck and bottom of the skid shall be monitored (visual inspection) to assure no significant blockage of airflow. Although blockage is improbable as over 60 feet of gap would require sealing, personnel shall maintain a visual scan of the trailer.

CAUTION: Visually monitor the outer top trailer shield vents and the openings around the cask ends for any sign of steaming which may indicate leakage of water from the cask neutron shield. If steaming is determined to be due to leakage of neutron shield water and not due to any rain or snow or other ambient conditions, then Licensee must take appropriate corrective actions including terminating the transfer operation and returning the loaded cask to the fuel handling building for further assessment.

The operational differences specified above for loading operations will also apply for unloading operations.

W.9 Acceptance Criteria and Maintenance Program

All acceptance criteria and maintenance requirements for the OS197L TC are identical to those of the OS197 and OS197H TCs described throughout the body of this UFSAR.

W.10 Radiation Protection

The shaded portion of Chapter W.10 provided in this FCN is for completeness and information only. It is part of Amendment 11 to be submitted to the NRC for review and approval. Therefore, the OS197L TC shall not be used until Amendment 11 to CoC 1004 is approved by the NRC.

As discussed in Section W.5, use of the OS197L TC does not significantly affect personnel dose rates (during closure operations, handling, or storage) or site boundary dose rates. The OS197L TC is used only for loading/unloading and transfer operations, and the storage conditions are unchanged. Therefore, the personnel doses, occupational exposures and site bounding dose rates documented for each DSC/HSM storage configuration in Section 7.4 and Appendix K, Chapter K.10, Appendix L, Chapter L.10, Appendix M, Chapter M.10 and Appendix N, Chapter N.10 remain unchanged and are applicable to operations using the OS197L TC.

The use of the OS197L TC is not expected to have any significant impact on personnel dose rates during normal operation since the operations for placement and removal of bare OS197L TC from the fuel pool into the decontamination area shielding sleeve, placement and removal of the decontamination area shielding bell, engagement of the yoke to the cask trunnions, movement of the cask to the trailer, lowering of the cask onto the trailer and placement of the trailer shielding on the cask will be performed remotely using cameras and laser/target positioning.

The OS197L uses remote handling devices for movement of the TC during loading and transfer operations. In the event of a failure of the remote handling device an evaluation has been performed to assess the additional occupational exposure during recovery operations. This evaluation was performed using the dose rates from the OS197L TC when loaded with a NUHOMS® 32PT DSC. In this event the crane is postulated to fail as the OS197L TC is being lowered onto the transfer trailer. This scenario bounds a failure of the crane at other times (e.g., movement of the TC from the pool to cask handling area).

To recover from this event, the exposure to two workers is evaluated. The exposure is estimated when the repair personnel enter from a low dose area to access the crane for repair or recovery operations and during manual operations to lower the cask onto the transfer trailer. Once the cask is safely lowered onto the transfer trailer normal operations can resume. Conservative assumptions are applied to the duration for repair/recovery operations and distance from the cask for these operations. The additional occupational exposure associated with a recovery from a remote handling device failure is estimated to be 1,600 man-mrem.

W.11 Accident Analyses

This section describes the postulated accident events that could occur during fuel loading, draining, drying, welding and transfer of the DSC using a NUHOMS® OS197L TC. Sections which do not affect the evaluation presented in Chapter 8 or Appendices K.11, L.11, M.11 and N.11 for various DSC designs are identified as "No change." Detailed analysis of the events are provided in other sections and are referenced herein.

W.11.1 Postulated Accidents

Only those accidents affecting the OS197L TC are addressed in this section. There is no change to accident evaluations affecting other NUHOMS® components.

W.11.1.1 OS197L TC Missile Impact Analysis

This event is described in Section 8.2.2.4. The OS197L TC uses a 2.68" steel shell in lieu of a 1.5" steel shell with a nominal 3.5" lead annulus and a 0.5" inner liner for OS197 TC. The missile impact analyses for the OS197 TC are therefore bounding for the OS197L TC.

W.11.1.2 Earthquake

This event is described in Section 8.2.3.D. The OS197L TC configuration (cg location, cask length, trunnion location and bottom forging configuration) does not significantly differ from that of the OS197 TC. The OS197L TC remains stable when subjected to the design basis earthquake.

W.11.1.2.1 OS197L TC in a Vertical Configuration during Vacuum Drying and Welding Operations

The bottom forging on which the cask is resting during vertical cask operations is the same size and configuration as the OS197 TC. The OS197L TC cg location is not significantly altered by the change in the cask shell configuration. The addition of the decontamination area shield will provide a larger diameter, more stable shell, outside the cask envelope, thereby potentially enhancing the OS197L TC seismic capacity.

W.11.1.2.2 OS197L TC in a Horizontal Configuration during Transfer Operations

The cask seismic stresses for the OS197L TC are bounded by the OS197 TC stresses due to the similar configurations of the cask ends (top and bottom forgings and covers) and larger thickness structural shell.

The trailer with the OS197L TC, with the additional shielding, remains stable for the design basis seismic accelerations.

W.11.1.3 OS197L TC Accidental Cask Drop

This event is described in Sections 8.2.5.2.B, D and E.

See Section W.3.1.3 for a discussion of the OS197L TC drop accident. This drop accident is bounded by the results for the OS197 TC drop accident discussed in Section 8.2.

W.11.1.4 <u>Loss of Neutron Shield</u>

This event is described in Section 8.2.5.3.

For the accident condition (the unlikely cask drop scenario) a complete loss of the OS197L TC neutron shield is postulated similar to the OS197 TC evaluation described in Section 8.2.5.3. In addition, the analysis conservatively assumes that all the trailer shielding is lost. However, the trailer shield is fabricated using two sets of plate shields (the inside shield is 2.5" thick, the outside shield is 3" thick) which may be damaged in a drop but are unlikely to separate completely from the skid and cask.

Assuming the non-mechanistic drop scenario occurs and the trailer shields and the cask are dislodged completely from the trailer and skid, recovery actions are required to manipulate the shields or providing supplemental shielding to reduce dose rates to a reasonable value until a long term recovery plan is in place.

OS197L TC Accident Condition Dose Rates

Transfer Cask Configuration	Dose Rate Component	Dose Rates at Different Distances from Side Surface – Accident Condition No Neutron Shield			
		On Side Surface	4.57 meters (15')	100 meters	609.9 meters (2000')
		Dose Rate, mrem/hr	Dose Rate, mrem/hr	Dose Rate, mrem/hr	Dose Rate, mrem/hr
UFSAR (Table M.11-2)	Neutron	3,780	Not Calc.	Not Calc.	Not Calc.
	Gamma	1,070	Not Calc.	Not Calc.	Not Calc
	Total	4,640	Not Calc	Not Calc	0.01
OS197 TC	Neutron	1,282	66	0.067	1.87e-5
	Gamma	291	30	0.04	5.14e-5
	Total	1573	84	0.10	6.48e-5
OS197L TC (Bare Cask)	Neutron	3,691	187	0.20	1.06e-4
	Gamma	134,328	11,576	12.7	3.19e-2
	Total	138,019	11,763	12.9	3.20e-2

The dose rates provided for the UFSAR configuration above are based on a 32PT DSC with design basis source terms inside an OS197 TC. The shielding analysis for the OS197L TC configuration presented in W.5 credits some additional shielding such as the 32PT DSC basket aluminum rails and other basket structures that were not included in the OS197 TC evaluation (see Appendix M.5.4) due to limitation of the previous analysis methods. The above data for the OS197L TC bare cask is for a 32PT DSC payload but is provided for evaluation of relative doses. The relative effect of the OS197L TC configuration and the decontamination area/trailer shielding configurations with respect to the OS197 TC configurations shown above is representative of the relative effect for all CoC 1004 licensed DSC payloads for the OS197L TC.

The dose rates on the ends of the OS197L TC will be the same as the OS197 TC since the top and bottom forging and cover plate configurations have not been modified.

As shown in the table below, the dose rates at the site boundary, assuming a 100 meter site boundary, would be approximately 13 mrem/hr during the timeframe that the cask trailer shield is dislodged from the cask and until the trailer shield is repositioned.

The 8 hours of recovery period assumed is appropriate because the repositioning of the trailer shields will be performed using lifting hardware pre-positioned prior to transfer operations. This will facilitate quick positioning using a crane to minimize the need for personnel to approach the cask.

A comparison of the OS197 TC and OS197L TC accident dose analyses using the 32PT DSC as a representative payload is provided below:

Cask	Contact Dose (mrem/hr)	Dose at 15 feet (mrem/hr)	Dose at 100 meters (mrem/hr)	Dose at 2000 feet (mrem/hr)	Recovery Period Assumed (hours)	Total Person-Dose at 100 meters (mrem)	Total Person-Dose at 2000 feet (mrem)
UFSAR (Appendix M, Section M.11.2.5.3)	4,640	700	5.25	.011	8	N/A	0.09
OS197 TC	1,573	84	0.10	6.48e-5	8	0.8	5.184e-4
OS197L TC	138,019	11,763	12.9	0.032	8	103.2	0.25

The increase in dose rates at the site boundary (100 meters) is significant (approximately 130 times) between the OS197 TC and OS197L TC values. However, the total dose at the 100 meter site boundary still remains very low (103 mrem) and below the regulatory limit of 5,000 mrem.

A review of the UFSAR shows that the TC payload that produces the highest 100 meter dose rate is the 24PHB DSC (Appendix N.11). This is a 7 mrem/hr dose rate (Appendix N, Section N.11.2.5.3). Using the ratio of UFSAR dose rate and OS197L TC dose rate from the table above results in a factor of 12.9/5.25=2.45. Applying this factor to the 7 mrem/hr dose rate for the 24PHB DSC results in a 100 meter dose rate for a 24PHB DSC within the OS197L TC of 2.45x7=18 mrem/hr. This dose rate, applied over the 8 hour period, results in a total person-dose of 18x18=144 mrem. The 144 mrem is approximately 3% of the 5000 mrem limit for offsite exposure.

The thermal evaluation for this accident condition is included in Chapter W.4.

W.12 Operating Controls and Limits

The addition of OS197L TC to the standardized NUHOMS® system does result in a change to the Technical Specifications, Functional and Operating Limits described in NUHOMS® CoC 1004 Amendment 8. The proposed Technical Specifications will be submitted as part of Amendment 11 to NRC for review and approval.

W.13 Quality Assurance

Chapter 11 provides a description of the Quality Assurance Program to be applied to the safety-related and important-to-safety activities associated with the standardized NUHOMS® system. The addition of OS197L TC to the NUHOMS® system does not require any changes to the quality assurance requirements stipulated in Chapter 11.

W.14 Decommissioning

No change to the decommissioning evaluation presented in Section 9.6 due to the addition of the OS197L TC to the NUHOMS® system.