CHAPTER A.6
Criticality Evaluation

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Chapter A.6
Criticality Evaluation

NOTE: References in this Chapter are shown as [1], [2], etc. and refer to the reference list in Section A.6.4.

The MP197HB transportation cask (TC), as transported, will provide criticality control to meet the criticality performance requirements specified in Sections 71.55 and 71.59 of 10 CFR Part 71 [2]. The criticality control design ensures that the effective multiplication factor (k_{eff}) of the contained fuel is no greater than an Upper Subcritical Limit (USL) for the most reactive configuration. The USL includes a confidence band with an administrative safety margin of 0.05. The design has a Criticality Safety Index (CSI, given in 10 CFR 71.59(b) as CSI = 50/"N") of 0 because "N" is infinity (∞). The number "N" is based on all of the following conditions being satisfied, assuming packages are stacked together in any arrangement and with close full reflection on all sides of the stack by water:

1. Five times "N" undamaged packages with nothing between the packages are subcritical;
2. Two times "N" damaged packages, if each package is subjected to the tests specified in 10 CFR Part 71.73 (HAC) is subcritical with optimum interspersed hydrogenous moderation; and
3. The value of "N" cannot be less than 0.5.

A.6.1 Description of Criticality Design

A.6.1.1 Design Features

The MP197HB cask is designed to transport a payload consisting of any one of the DSCs listed below, with a brief description of the design features provided in Appendix A.1.4:
NUHOMS®-24PT4 DSC (See Appendix A.1.4.1)
NUHOMS®-32PT DSC (See Appendix A.1.4.2)
NUHOMS®-24PTH DSC (See Appendix A.1.4.3)
NUHOMS®-32PTH and 32PTH Type 1 DSC (See Appendix A.1.4.4)
NUHOMS®-32PTH1 DSC (See Appendix A.1.4.5)
NUHOMS®-37PTH DSC (See Appendix A.1.4.6)
NUHOMS®-61BT DSC (See Appendix A.1.4.7)
NUHOMS®-61BTH DSC (See Appendix A.1.4.8)
NUHOMS®-69BTH DSC (See Appendix A.1.4.9)
Radioactive Waste Canister *(RWC) (See Appendix A.1.4.9A)*

A.6.1.2 Criticality Safety Index

Each of the above listed payloads when transported in MP197HB TC is shown to be subcritical for an infinite array of flooded undamaged casks and for an infinite array of damaged casks after being subjected to Hypothetical Accident Conditions (HAC) events. The design has a CSI of 0 as "N" is equal to ∞. A CSI of 0 (less than 50) ensures that, per 10 CFR Part 71.59(c)(1), the package may be shipped by a carrier in a nonexclusive conveyance, from a criticality requirements point of view.

A.6.1.3 Summary of Criticality Evaluations

A brief summary of the criticality analysis results for each of the payloads along with the source are presented in the following table:

Payload	K_{EFF}	USL	Reference Appendix
NUHOMS®-24PT4 DSC	0.9393	0.9411	A.6.5.3
NUHOMS®-32PT DSC	*0.9256*	*0.9380*	A.6.5.6
NUHOMS®-24PTH DSC NUHOMS®-24PTHF DSC	*0.9260*	*0.9380*	A.6.5.5
NUHOMS®-32PTH and 32PTH Type 1 DSC	*0.9260*	*0.9380*	A.6.5.4
NUHOMS®-32PTH1 DSC	*0.9260*	*0.9380*	A.6.5.4
NUHOMS®-37PTH DSC	*0.9265*	*0.9380*	A.6.5.7
NUHOMS®-61BT DSC	0.9364	0.9414	A.6.5.1
NUHOMS®-61BTH DSC NUHOMS®-61BTHF DSC	0.9400	0.9415	A.6.5.1
NUHOMS®-69BTH DSC	*0.9406*	*0.9415*	A.6.5.2

From a criticality analysis point of view, 32PTH and 32PTH Type 1 DSCs are identical. In this chapter, any reference to 32PTH is also applicable to 32PTH Type 1.

Due to the absence of any fissile material payload content in the *RWC*, no criticality calculations are required for this DSC. Therefore, no further discussion of the criticality of this canister is necessary.

A.6.2 Contents, Calculational Models and Criticality Calculations

The methodology employed to ensure the subcriticality of the 61BT, 61BTH, 24PT4 and 69BTH DSCs is based on a "fresh fuel" representation of the spent fuel assemblies. For these DSCs, the fuel assemblies are modeled with fresh (unirradiated) fuel.

The methodology employed to ensure the subcriticality of the 32PT, 24PTH, 32PTH, 32PTH1 and 37PTH DSCs is based on "burned fuel" representation of the spent fuel assemblies. Credit for the negative reactivity of the fuel assemblies as a result of irradiation, or "burnup credit" is employed in these calculations. The maximum burnup "credited" in these analyses does not exceed 50 GWD/MTU.

A.6.2.1 Fresh Fuel Methodology

For the NUHOMS®-61BT, 61BTH, 24PT4 and 69BTH DSCs, the system's criticality safety is ensured by both fixed neutron absorbers and favorable geometry. For each of these four DSCs, fresh fuel is assumed (no burnup credit is taken) in the evaluation. The fixed neutron absorber is present in the form of borated aluminum alloy or a boron-carbide/aluminum metal matrix

Proprietary information on pages A.6-4 to A.6-12 and A.6-12a to A.6-12e withheld pursuant to 10 CFR 2.390

Proprietary information on pages A.6-14 to A.6-20, A.6-20a, A.6-21 to A.6-29, A.6-29a and A.6-29b withheld pursuant to 10 CFR 2.390

A.6.4 References

1. Oak Ridge National Laboratory, RSIC Computer Code Collection, "SCALE: A Modular Code System for Performing Standardized Computer Analysis for Licensing Evaluations for Workstations and Personal Computers," NUREG/CR-0200, Revision 6, ORNL/NUREG/CSD-2/V2/R6.
2. 10 CFR 71, Packaging and Transportation of Radioactive Materials.
3. NUH-003, Updated Final Safety Analysis Report for the Standardized NUHOMS® Horizontal Modular Storage System for the Irradiated Nuclear Fuel (UFSAR), Revision *11*.
4. *Same as [3] above. The Certificate of Compliance (CoC) for* Amendment 10 *to part 72 CoC 1004 was issued on August 24, 2009.*
5. ANUH-01.0150, Updated Final Safety Analysis Report for the Standardized Advanced NUHOMS® Horizontal Modular Storage System for the Irradiated Nuclear Fuel (UFSAR), Revision 3.
6. Final Safety Analysis Report for the NUHOMS® HD Horizontal Modular Storage System for the Irradiated Nuclear Fuel, Revision *3*.
7. U.S. Nuclear Regulatory Commission, "Criticality Benchmark Guide for Light-Water-Reactor fuel in Transportation and Storage Packages," NUREG/CR-6361, Published March 1997, ORNL/TM-13211.
8. U.S. Nuclear Regulatory Commission, "Recommendations for Preparing the Criticality Safety Evaluation of Transportation Packages," NUREG/CR-5661, Published April 1997, ORNL/TM-11936.
9. "Topical Report on Actinide-Only Burnup Credit for PWR Spent Nuclear Fuel Packages," DOE/RW-0472, Revision 2.
10. U.S. Nuclear Regulatory Commission, "Parametric Study of the Effect of Burnable Poison Rods for PWR Burnup Credit," NUREG/CR-6761, Published March 2002, ORNL/TM-2000/373.
11. U.S. Nuclear Regulatory Commission, "Criticality Benchmark Guide for Light-Water-Reactor fuel in Transportation and Storage Packages," NUREG/CR-6361, Published March 1997, ORNL/TM-13211.
12. Oak Ridge National Laboratory, "An Extension of the Validation of SCALE (SAS2H) Isotopic Predictions for PWR Spent Fuel," ORNL/TM-13317, Published September 1996.
13. U.S. Nuclear Regulatory Commission, "Parametric Study of the Effect of Burnable Poison Rods for PWR Burnup Credit," NUREG/CR-6761, Published March 2002.
14. U.S. Nuclear Regulatory Commission, "Recommendations for Addressing Axial Burnup in PWR Burnup Credit Analyses," NUREG/CR-6801, Published March 2003, ORNL/TM-2001/273.
15. U.S. Nuclear Regulatory Commission, "Study of the Effect of Integral Burnable Absorbers for PWR Burnup Credit," NUREG/CR-6760, Published March 2002, ORNL/TM-2000-329.
16. U.S. Nuclear Regulatory Commission, "Parametric Study of the Effect of Control Rods for PWR Burnup Credit," NUREG/CR-6759, Published February 2002, ORNL/TM-2001/69.
17. NRC Spent Fuel Project Office, Interim Staff Guidance No 8, Revision 2.
18. "Validation of the SCALE System for PWR Spent Fuel Isotopic Composition Analyses," ORNL/TM-12667, OW Hermann, SM Bowman, MC Brady, CV Parks, March 1995.

19. "Isotopic Analysis of High-Burnup PWR Spent Fuel Samples From the Takahama-3 Reactor," ORNL/TM-2001/259 (NUREG/CR-6798), CE Sanders and IC Gauld, January 2003.
20. U. S. Nuclear Regulatory Commission, "Strategies for Application of Isotopic Uncertainties in Burnup-Credit," NUREG/CR-6811, Published June 2003, ORNL/TM-2001/257.
21. CAL-UDC-NU-000011 Rev A, "Three Mile Island Unit 1 Radiochemical Assay Comparisons to SAS2H Calculations," Office of Civilian Radioactive Waste Management, U.S. Department of Energy, April 2002.
22. M. D. DeHart "SCALE-4 Analysis of Pressurized Water Reactor Critical Configurations: Volume 1 – Summary," Oak Ridge National Laboratory, March 1995, ORNL/TM-12294/V1.
23. Radulescu G, Mueller D. E. and J. C. Wagner, "Sensitivity and Uncertainty Analysis of Commercial Reactor Criticals for Burnup Credit," Oak Ridge National Laboratory, January 2008, ORNL/TM-2006-87, NUREG/CR-6951.
24. S. M. Bowman, W.C. Jordan, J. F. Mincey, C.V. Parks, and L. M. Petrie, "Experience with the SCALE Criticality Safety Cross-Section Libraries," Oak Ridge National Laboratory, NUREG/CR-6686, Published October 2000, ORNL/TM-1999/322.
25. D. E. Mueller, K. R. Elam, and P. B. Fox, "Evaluation of the French Haut Taux de Combustion (HTC) Critical Experiment Data," Oak Ridge National Laboratory, September 2008, ORNL/TM-2007-083, NUREG/CR-6979.
26. Jean-Michel GOMIT et al., "CRISAL V1: Criticality Package for Burn up Credit Applications," Proceedings of the International Conference on Nuclear Criticality Safety, ICNC 2003, Tokai Mura, Japan, October 20-24, 2003.
27. Jacques ANNO et al., "French Fission Products Experiments Performed in Cadarache and Valduc. Results Comparison," Proceedings of the International Conference on Nuclear Criticality Safety, ICNC'2003, Tokai Mura, Japan, October 20-24, 2003.
28. B. ROQUE, A. Santamarina, "Experimental Validation of Actinide and Fission Products Inventory from Chemical Assays in French PWR Spent Fuels," Practices and Developments in Spent Fuel Burnup Credit Applications, Proceedings of Technical Committee Meeting, Madrid, 22-26 April 2002, IAEA-TECDOC-1378, published October 2003.
29. *NEA/NSC/DOC(95)03, "International Handbook of Evaluated Criticality Safety Benchmark Experiments," September 2009.*
30. *M. D. DeHart "Sensitivity and Parametric Evaluations of Significant Aspects of Burnup Credit for PWR Spent Fuel Packages," Oak Ridge National Laboratory, May 1996, ORNL/TM-12973.*
31. *B. ROQUE et al., "Experimental Validation of the Code System "DARWIN" for Spent Fuel Isotopic Predictions in Fuel Cycle Applications," Proceedings of the International Conference on the New Frontiers of Nuclear Technology, PHYSOR 2002, Seoul, Korea, October 2002.*
32. *B. ROQUE et al., "The French Post Irradiation Examination Database for the validation of depletion calculation tools," proceedings of the International Conference on Nuclear Criticality Safety, ICNC-2003, Tokai-mura, Japan, October 2003.*
33. *NRC Safety Evaluation Report, "Safety Evaluation of Topical Report BAW-10228P, SCIENCE," USNRC, October 26, 1999, TAC NO. MA4599.*
34. *DOE for Fuel Inventory, DE-AF28-04RW12278, "Pool Inventories in Compact Disk Attachment," May 21, 2004.*

Proprietary information on pages A.6-32 to A.6-38 withheld pursuant to 10 CFR 2.390

Proprietary information withheld pursuant to 10 CFR 2.390

Proprietary information on pages A.6-44 to A.6-61 withheld pursuant to 10 CFR 2.390

Table A.6-13
CSAS25 Benchmark Results
(continued)

Run ID	U Enrich. wt. %	Pu Enrich. Wt. %	Pitch (cm)	H_2O/fuel volume	Separation of assemblies (cm)	EALF (eV)	k_{eff}	1σ
W3269SL1	2.72		1.524	1.494		0.3247	0.9973	0.0010
W3269SL2	5.7		1.422	1.93		0.3152	1.0024	0.0010
W3269W1	2.72		1.524	1.494		0.3080	0.9972	0.0012
W3269W2	5.7		1.422	1.93		0.3056	1.0015	0.0010
W3385SL1	5.74		1.422	1.932		0.2970	1.0004	0.0009
W3385SL2	5.74		2.012	5.067		0.1031	1.0014	0.0010
BAW1484A	2.46		1.636	1.84	1.636	0.1874	0.9942	0.0008
E196U6N	2.35		1.562	1.2		0.2578	0.9959	0.0008
E196U87C	2.35		2.21	3.69		0.0823	1.0011	0.0009
P2438X24	2.35		2.032	2.92	8.67	0.0944	0.9969	0.0008
SAXU56	5.74		1.4224	1.93		0.2909	0.9966	0.0011
SAXU792	5.74		2.0112	5.07		0.1023	0.9985	0.0010
EPRI70UN	0.71	2	1.778	1.2		0.7611	0.9983	0.0010
EPRI70B	0.71	2	1.778	1.2		0.5676	0.9999	0.0010
EPRI87B	0.71	2	2.210	1.53		0.2771	1.0077	0.0009
EPRI99UN	0.71	2	2.515	3.64		0.1355	1.0066	0.0009
EPRI99B	0.71	2	2.515	3.64		0.1798	1.0099	0.0009
SAXTON52	0.71	6.6	1.321	1.68		0.8858	1.0011	0.0010
SAXTON56	0.71	6.6	1.422	2.16		0.5404	1.0004	0.0012
SAXTN56B	0.71	6.6	1.422	2.16		0.6397	0.9997	0.0009
SAXTN735	0.71	6.6	1.867	4.7		0.1858	1.0019	0.0011
SAXTN792	0.71	6.6	2.012	5.67		0.1552	1.0026	0.0010
SAXTN104	0.71	6.6	2.642	10.75		0.1002	1.0051	0.0009
MCT-007-C01	*0.71*	*2.0*	*2.362*	*2.488*		*0.1943*	*1.0027*	*0.0003*
MCT-007-C02	*0.71*	*2.0*	*2.667*	*3.515*		*0.1392*	*0.9999*	*0.0004*
MCT-007-C03	*0.71*	*2.0*	*2.903*	*4.397*		*0.1172*	*1.0026*	*0.0004*
MCT-007-C04	*0.71*	*2.0*	*3.353*	*6.282*		*0.0953*	*1.0034*	*0.0003*
MCT-007-C05	*0.71*	*2.0*	*3.520*	*7.054*		*0.0905*	*1.0011*	*0.0003*
MCT-007-C06-A1	*0.71*	*2.0*	*2.667*	*3.515*		*0.1384*	*0.9976*	*0.0004*
MCT-007-C07-B1	*0.71*	*2.0*	*2.667*	*3.515*		*0.1395*	*0.9945*	*0.0003*
MCT-007-C08-B2	*0.71*	*2.0*	*2.667*	*3.515*		*0.1391*	*0.9962*	*0.0004*
MCT-007-C09-B3	*0.71*	*2.0*	*2.667*	*3.515*		*0.1390*	*0.9972*	*0.0004*
MCT-007-C10-B4	*0.71*	*2.0*	*2.667*	*3.515*		*0.1387*	*0.9968*	*0.0004*
MCT-008-C01	*0.71*	*2.0*	*2.032*	*1.515*		*0.3946*	*0.9951*	*0.0003*
MCT-008-C02	*0.71*	*2.0*	*2.362*	*2.488*		*0.1964*	*0.9975*	*0.0003*
MCT-008-C03	*0.71*	*2.0*	*2.667*	*3.515*		*0.1399*	*0.9986*	*0.0003*
MCT-008-C04	*0.71*	*2.0*	*2.903*	*4.397*		*0.1180*	*1.0028*	*0.0003*
MCT-008-C05	*0.71*	*2.0*	*3.353*	*6.282*		*0.0956*	*1.0040*	*0.0002*
MCT-008-C06	*0.71*	*2.0*	*3.520*	*7.054*		*0.0904*	*1.0038*	*0.0002*
MCT-008-C07-A1	*0.71*	*2.0*	*2.667*	*3.515*		*0.1391*	*0.9991*	*0.0003*
MCT-008-C13-B4	*0.71*	*2.0*	*2.667*	*3.515*		*0.1395*	*0.9966*	*0.0003*
MCT-008-C14-B3	*0.71*	*2.0*	*2.667*	*3.515*		*0.1399*	*0.9963*	*0.0003*
MCT-008-C15-B2	*0.71*	*2.0*	*2.667*	*3.515*		*0.1400*	*0.9959*	*0.0003*
MCT-008-C16-B1	*0.71*	*2.0*	*2.667*	*3.515*		*0.1402*	*0.9951*	*0.0003*
Correlation	**0.31**	***0.19***	***0.26***	***0.23***	**0.63**	***0.041***	**N/A**	**N/A**

Table A.6-13
CSAS25 Benchmark Results
(continued)

The results of the CRC benchmarks are shown below.

Run ID	U Enrich. wt. %	Pu Enrich. Wt. %	Pitch (cm)	H_2O/fuel volume	Average Burnup (GWD/MTU)	EALF (eV)	k_{eff}	1σ
CR3SP1	2.445		1.443	1.65	0	0.5571	0.99377	0.00036
CR3SP2	2.447		1.443	1.65	8.09	0.6307	0.99166	0.00035
CR3SP3	2.447		1.443	1.65	12.34	0.6113	0.99413	0.00041
CR3SP4	2.67		1.443	1.651	8.67	0.6455	0.99063	0.00041
CR3SP5	2.693		1.443	1.654	7.5	0.6524	0.99346	0.00044
CR3SP6	2.693		1.443	1.654	12.54	0.6454	0.99289	0.00039
CR3SP7	2.693		1.443	1.654	14.98	0.6421	0.98935	0.0004
CR3SP8	2.648		1.443	1.661	6.92	0.6604	0.99149	0.0004
CR3SP9	2.648		1.443	1.661	14	0.6755	0.98797	0.00043
CR3SP10	2.648		1.443	1.661	14.77	0.6638	0.99547	0.00037
CR3SP11	2.915		1.443	1.662	7.08	0.7233	0.99355	0.0004
CR3SP12	2.915		1.443	1.662	19.12	0.7114	0.9952	0.00039
CR3SP13	3.21		1.443	1.662	12.01	0.7901	0.99355	0.00046
CR3SP14	3.21		1.443	1.662	14.99	0.7911	0.99454	0.0003
CR3SP15	3.21		1.443	1.662	24.41	0.7351	0.98907	0.00033
CR3SP16	3.554		1.443	1.662	10.02	0.8763	0.99127	0.00042
CR3SP17	3.554		1.443	1.662	18.09	0.8443	0.99072	0.0003
CR3SP18	3.554		1.443	1.662	19.04	0.8497	0.98937	0.0003
CR3SP19	3.554		1.443	1.662	19.91	0.8271	0.98818	0.00043
CR3SP20	3.554		1.443	1.662	24.35	0.7789	0.99095	0.00044
CR3SP21	3.554		1.443	1.662	24.87	0.7819	0.99104	0.00037
CR3SP22	3.755		1.443	1.662	12.26	0.9341	0.99005	0.00036
CR3SP23	3.755		1.443	1.662	15.27	0.9461	0.99057	0.00042
CR3SP24	3.755		1.443	1.662	16.58	0.9290	0.99007	0.00043
CR3SP25	3.755		1.443	1.662	24.74	0.8512	0.99016	0.00039
CR3SP26	3.755		1.443	1.662	24.91	0.8462	0.99118	0.00044
CR3SP27	3.755		1.443	1.662	28.19	0.8236	0.9871	0.00039
CR3SP28	3.892		1.443	1.658	14.18	0.9560	0.98832	0.00045
CR3SP29	3.892		1.443	1.658	19.1	0.9313	0.99224	0.00038
CR3SP30	3.892		1.443	1.658	20.96	0.9233	0.98937	0.0004
CR3SP31	3.892		1.443	1.658	25.42	0.8879	0.9862	0.00044
CR3SP32	4.015		1.443	1.653	15.24	1.0410	0.98086	0.00043
CR3SP33	4.015		1.443	1.653	33	0.8586	0.97859	0.00039
NA1C5B	3.43		1.26	1.668	11.07	0.9151	1.00482	0.00038
SQ2C3BZ	3.43		1.26	1.668	11.15	0.9606	1.00607	0.00035
SQ2C3BF	3.43		1.26	1.668	11	0.8651	1.00593	0.00039
SQ2C3M	2.63		1.43	1.675	19.25	0.9445	1.00569	0.00036
SU1C2B	2.63		1.43	1.675	6.93	0.6174	1.00538	0.00039
SU1C2E	2.82		1.443	1.655	13.85	0.6703	1.01023	0.00042
TMI1C5B	3.54		1.26	1.668	11.44	0.7276	1.00151	0.00037
Correlation	***0.17***	***0.19***	***0.35***	**0.26**	**-0.*47***	**-0.39**	*N/A*	*N/A*

Notes:

The *Crystal* River benchmarks are labeled "CR3"and are based on 85 isotopes using the 238 Group Cross Section Library.

The Sequoyah benchmarks are labeled "SQ2," the Surry benchmarks are labeled "SU1," the Three Mile Island benchmarks are labeled "TMI1," the North Anna benchmarks are labeled "NA1" and are based on 48 isotopes.

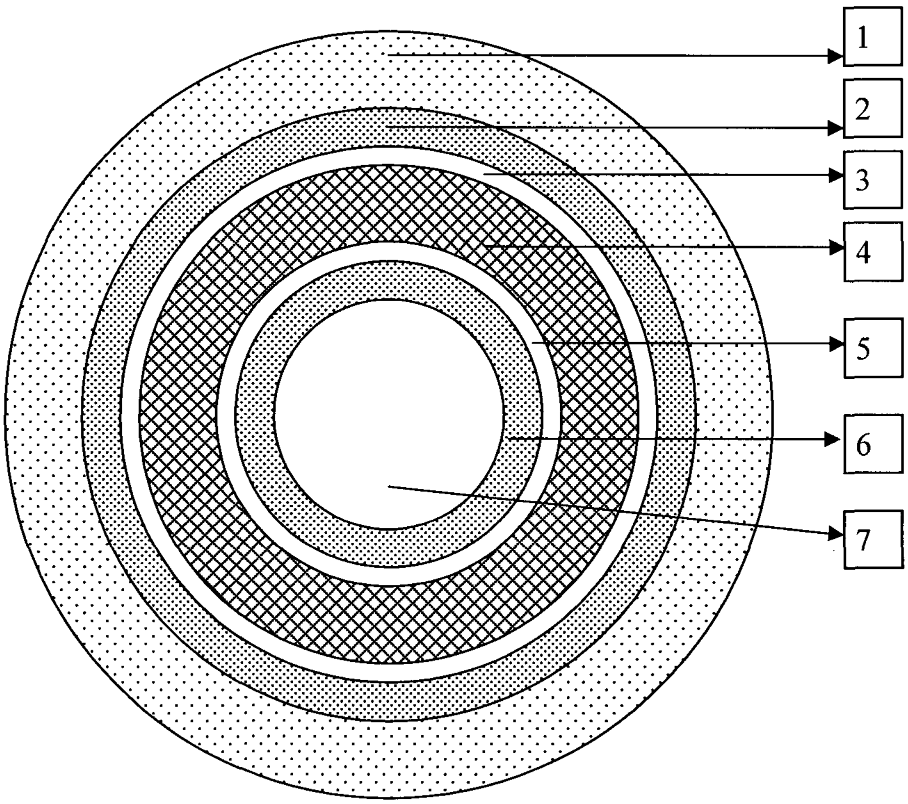
Proprietary information on pages A.6-67 and A.6-68 withheld pursuant to 10 CFR 2.390

Table A.6-16
Fuel Assembly Parameters

Parameters	Assembly *Class*		
	WE 14x14	**CE 14x14**[(1)]	**WE 17x17**
Initial Uranium Content (KgU)	410	441	475
Fuel Density (gm/cm^3)	10.47	10.54	10.59
Active Fuel Length (in)	144	144	144
Fuel Assembly Pitch (cm)	19.9	21	21.5
Fuel Rods per Assembly	179	176	264
Pitch (in)	0.556	0.580	0.496
Fuel Pellet OD (in)	0.3659	0.3815	0.3225
Clad Thickness (in)	0.0243	0.0280	0.0225
Clad OD (in)	0.422	0.440	0.374
Guide Tube OD (in) Instrument Tube OD (in)	16@0.539 1@0.422	5@1.115	24@0.474 1@0.480
Guide Tube ID (in) Instrument Tube ID (in)	16@0.505 1@0.3734	5@1.035	24@0.422 1@0.450

(1) The CE 14x14 assembly class calculations are employed only in the depletion benchmark and criticality sensitivity analyses.

Proprietary information on pages A.6-70 to A.6-94 withheld pursuant to 10 CFR 2.390



Legend	Description
1	Annular Gap between BP Rod and Guide Tube
2	BP Rod Outer Clad (Stainless Steel)
3	Gap between Outer Clad and BP Pellet (Air)
4	BP Pellet
5	Gap between Inner Clad and BP Pellet (Air)
6	BP Rod Inner Clad (Stainless Steel)
7	Air within the hollow Clad

Figure A.6-1
Example SAS2H Model

Proprietary information on pages A.6-96 to A.6-115 withheld pursuant to 10 CFR 2.390

Appendix A.6.5.1
NUHOMS®-61BT DSC and NUHOMS®-61BTH DSC Criticality Evaluation

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Appendix A.6.5.1
NUHOMS®-61BT DSC and NUHOMS®-61BTH DSC Criticality Evaluation

NOTE: References in this Appendix are shown as [1], [2], etc. and refer to the reference list in Section A.6.5.1.7.

This Appendix A.6.5.1 to Chapter A.6 demonstrates that the MP197HB package when transporting the NUHOMS®-61BT DSC or the NUHOMS®-61BTH DSC payload meets the criticality performance requirements specified in Sections 71.55 and 71.59 of 10 CFR Part 71 [2]. The criticality control design ensures that the effective multiplication factor (k_{eff}) of the contained fuel is not greater than an Upper Subcritical Limit (USL) for the most reactive configuration. The USL includes a confidence band with an administrative safety margin of 0.05. The design has a Criticality Safety Index (CSI, given in 10 CFR 71.59(b) as CSI = 50/"N") of 0 because "N" is infinity (∞). The number "N" is based on all of the following conditions being satisfied, assuming packages are stacked together in any arrangement and with close full reflection on all sides of the stack by water:

1. Five times "N" undamaged packages with nothing between the packages are subcritical;
2. Two times "N" damaged packages, if each package is subjected to the tests specified in 10 CFR Part 71.73 (HAC) is subcritical with optimum interspersed hydrogenous moderation; and
3. The value of "N" cannot be less than 0.5.

A.6.5.1.1 Discussion and Results

Chapter K.6 of the NUHOMS® UFSAR [5] presents the criticality analysis of the specific BWR assemblies authorized for storage in the NUHOMS®-61BT DSC. Chapter T.6 *(Currently incorporated in the NUHOMS® UFSAR [5])* associated with Amendment 10 to Part 72 CoC 1004 for the Standardized NUHOMS® System [6] added some additional BWR fuel assembly types to those authorized in [5] for storage in a modified version of the 61BT DSC, designated as the NUHOMS®-61BTH DSC. The contents of NUHOMS®-61BTH DSC are qualified for higher enrichment levels, higher burnup, and higher decay heat loads. Chapter A.1, Appendices A.1.4.7 and A.1.4.8 provide a detailed description of the contents of the NUHOMS®-61BT and NUHOMS®-61BTH DSCs, respectively.

The criticality analysis documented for the 61BT/61BTH DSC utilizes a cask (TC) that is similar to the MP197HB Cask. The TC has a liquid neutron shield and has a slightly (1/2") thicker lead gamma shield. However, the calculations documented herein assume complete loss of neutron shielding and employ close reflection around the TC structural shell. This is conservative since the MP197HB has a solid neutron shield. Therefore, no additional modeling with the MP197HB cask is necessary for the 61BT/61BTH DSC.

The criticality analysis for the NUHOMS®-61BT and 61BTH is based on fresh fuel assumption.

A. 61BT DSC Results

- For the case of a double ended shear, an extra row of fuel is assumed to be present in each damaged fuel cell (compartment) to simulate a portion of the severed rods breaking off and moving adjacent to the rest of the assembly in the fuel cell. This is a very conservative assumption because the total fuel loading in the fuel assembly (kg U) is increased.
- The damaged fuel reactivity comparisons are then carried out for the other classes of fuel assemblies to determine the most reactive fuel assembly for the double ended shear damaged configuration.
- A lattice average enrichment of 4.0 wt. % U-235 is used for all of the initial sensitivity calculations with damaged assemblies. For these sensitivity calculations, the damaged row of fuel is modeled with a peak enrichment of 4.4 wt. % U-235.
- The fuel assembly pitch is varied from a minimum to a maximum constrained only by the size of the fuel compartment to determine the optimum rod pitch for each fuel assembly class. Subsequently, fuel rods are removed to determine the optimum number of fuel rods for any given lattice design and the most reactive damaged rod configuration is determined.
- As with the case with intact fuel, the GE 10x10 fuel assembly is once again determined to be the most reactive damaged/failed fuel assembly. The damaged assembly is modeled with an optimum rod pitch configuration containing 95 fuel rods and 5 water pin locations.
- The design basis damaged/failed assembly model is then synthesized from the design basis intact assembly model.

Figure A.6.5.1-2 is a sketch of each KENO V.a unit showing all materials and dimensions for each unit and an annotated cross section map showing the assembled geometry units in the radial direction of the model.

The criticality calculational models are similar to the 61BT DSC model described in Table A.6.5.1-4. The only differences in the basket geometry is the modeling of the fixed poison as a paired combination of poison/aluminum and modeling the basket periphery (rails and water holes) to include conservative considerations for 61BTH Type 1 and Type 2 DSC designs.

Table A.6.5.1-54 is a comprehensive summary of the various criticality analyses carried out for the NUHOMS®-61BTH DSC. It includes a brief description of the analyses carried out for this evaluation. Since some of the evaluations utilized are obtained for the 61BT DSC, such a summary is useful to maintain continuity.

A.6.5.1.3.3 Package Regional Densities

The Oak Ridge National Laboratory (ORNL) SCALE code package [1] contains a standard material data library for common elements, compounds, and mixtures. All the materials used for the cask and DSC analysis are available in this data library. The neutron shield material in the cask is modeled as water, and a cask neutron shield skin is not modeled.

Table A.6.5.1-5 and A.6.5.1-55 provide a complete list of all the relevant materials used for the criticality evaluation of 61BT DSC and 61BTH DSC, respectively. The cask neutron shield material is conservatively modeled as water. The actual neutron shield hydrogen atom density is

A.6.5.1.7 References

1. Oak Ridge National Laboratory, RSIC Computer Code Collection, "SCALE: A Modular Code System for Performing Standardized Computer Analysis for Licensing Evaluations for Workstations and Personal Computers," NUREG/CR-0200, Revision 6, ORNL/NUREG/CSD-2/V2/R6.
2. 10 CFR 71, Packaging and Transportation of Radioactive Materials.
3. U.S. Nuclear Regulatory Commission, "Criticality Benchmark Guide for Light-Water-Reactor fuel in Transportation and Storage Packages," NUREG/CR-6361, Published March 1997, ORNL/TM-13211.
4. U.S. Nuclear Regulatory Commission, "Recommendations for Preparing the Criticality Safety Evaluation of Transportation Packages," NUREG/CR-5661, Published April 1997, ORNL/TM-11936.
5. NUH-003, Updated Final Safety Analysis Report for the Standardized NUHOMS® Horizontal Modular Storage System for the Irradiated Nuclear Fuel (UFSAR), Revision *11*.
6. *Same as [5] above.* The Certificate of Compliance (CoC) for Amendment 10 to Part 72 CoC 1004 issued on *August 24th*, 2009.

Proprietary information on pages A.6.5.1-30 to A.6.5.1-57 withheld pursuant to 10 CFR 2.390

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Table A.6.5.2-2 lists the fuel parameters for the BWR fuel assemblies. Equivalent reload fuel from other manufacturers, for the same fuel assembly class, with the same parameters is also allowed. The design basis fuel chosen for the NUHOMS® -69BTH DSC as transported in the NUHOMS®-MP197HB Cask is the GE 10x10 fuel assembly. As demonstrated in Appendix A.6.5.1, the GE 10x10 assembly is the most reactive assembly of those authorized to be shipped in the NUHOMS® -61BTH DSC as transported in the NUHOMS®-MP197HB Cask. Hence, it is assumed to be the most reactive assembly of those authorized to be shipped in the similar NUHOMS® -69BTH DSC as transported in the NUHOMS®-MP197HB Cask as well. Calculations are performed with the ABB SVEA fuel design consisting of the 64-, 92-, 96-, and 100-pin versions, and three additional Framatome ANP 9x9 designs, with 72, 79, 80 and 81 pins. This analysis demonstrates that the GE 10x10 fuel type remains the most reactive fuel type for the NUHOMS® -69BTH DSC.

A.6.5.2.3 Model Specification

The following subsections describe the physical models and materials of the NUHOMS®-69BTH system used for input to the CSAS25 module of SCALE-4.4 [1] to perform the criticality evaluation.

A.6.5.2.3.1 Description of the Calculational Models

The cask and canister were explicitly modeled using the appropriate geometry options in KENO V.a of the CSAS25 module in SCALE-4.4.

Intact Fuel Assemblies Model

The model utilized is a full-active fuel height model and full radial cross section of the cask and canister with reflective boundary conditions on all sides. This model includes the worst case gaps between the poison plates and the basket internals modeled *in the most reactive configuration.* This model includes the GE 10x10-fuel assembly only because this assembly type is determined to be the most reactive fuel assembly type of the authorized contents. The GE 10x10-fuel assembly is modeled as a 10x10 array *comprised of* 92 fuel rods, including fuel, gap and cladding and two large water holes. The fuel cladding OD is also reduced by 0.004 inches in the models to conservatively bound fuel manufacturing tolerances. The cask neutron shield (solid material) and outer steel skin *are* modeled as water. This is conservative because the neutron shield includes boron to capture the neutrons for shielding purposes. The external moderator variation cases cover the hydrogen content range of the actual neutron shield. This model is shown in Figure A.6.5.2-3.

A design change required the fuel compartment minimum internal dimensions to be reduced. To compensate for the increased reactivity of this configuration, the areal density of the boron was increased slightly for each Poison ID. This design change is reflected in Table A.6.5.2-1.

The model is flexible enough such that the fixed neutron poison in the basket can be modeled as a single sheet or can be paired with aluminum. Radial cross-section of the model is shown in Figure A.6.5.2-4.

The axial layout is modeled as a sequence of units 58, 59, and 79 (each 0.25 inches thick) defined by array 21. For the axial regions where the poison plates are present unit 58 (Figure A.6.5.2-4) is used, for the regions with poison plate gaps between the arrays unit 59 (Figure A.6.5.2-5) is used, and for the regions with no poison unit 79 (Figure A.6.5.2-6) is used. The total length of the fuel column is 151 inches. *T*herefore*,* the number of units in array 21 is 604, except when additional layers are used at the axial ends of the basket, canister, or cask. Figure A.6.5.2-3 is a sketch of each KENO V.a unit showing all materials and some dimensions for each unit and an annotated cross section map showing the assembled geometry units in the radial direction of the model. The assembly-to-assembly pitch is a variable in the model with the fuel assemblies modeled in the center of the fuel cells and pushed towards the center and away from the center of the cask. In Figure A.6.5.2-3 through Figure A.6.5.2-*4* the configuration is shown with minimum assembly-to-assembly pitch. All potential gaps between poison plates are modeled. The maximum axial gap between the plates is modeled in the *most reactive configuration*. The axial gaps between the poison plates are due to the need to provide space for thermal expansion of the poison plates relative to the stainless steel parts of the basket and to allow for fabrication tolerances in the basket. In addition, the drawings allow the poison plates to be fabricated in sections, rather than one continuous piece. The only differences in the basket geometry *are* the modeling of the fixed poison as a paired combination of poison/aluminum and modeling the basket periphery (rails) to include conservative considerations.

Table A.6.5.2-3 is a comprehensive summary of the various criticality analyses carried out for the NUHOMS®-69BTH DSC. It includes a brief description of the criticality evaluation, the various activities (or analyses) carried out for that evaluation and the relevant reference. Since some of the evaluations utilized herein are obtained from reference [5] and reference [6], such summary is useful to show how this calculation is linked to these references.

Damaged Fuel Assemblies Model

The model that includes the "damaged" fuel assemblies conservatively models 4, 8, or 24 "damaged" fuel assemblies in the four partial 3x3 arrays in the corners of the basket, the remainder of basket compartments being filled with intact fuel assemblies. This model is very similar to the intact model with the following changes:

- One row of fuel rods is assumed to shear off from the rest of the assembly.
- The single row of "damaged" rods is assumed to slide 15.0 in. above the poison plates (Single-Break).
- For the case of double ended shear, an extra row of fuel is assumed to be present in each damaged fuel cell to simulate a portion of the severed rods breaking off and moving adjacent to the rest of the assembly in the fuel cell. This is a very conservative assumption because the total fuel loading in the fuel assembly (kg U) is increased.
- The damaged fuel reactivity comparisons are then carried out for the other classes of fuel assemblies to determine the most reactive fuel assembly for the double ended shear damaged configuration.

- A lattice average enrichment of 4.1 wt. % U-235 is used for all of the initial damaged fuel sensitivity calculations. For these calculations, the "damaged" row of fuel is modeled with a peak enrichment of 4.7 wt. % U-235 for the sensitivity studies only.

- Varied the fuel assembly pitch from a minimum to a maximum constrained only by the size of the fuel compartment to determine the optimum rod pitch for each fuel assembly class. Subsequently, fuel rods were removed to determine the optimum number of fuel rods for any given lattice design and the most reactive damaged rod configuration is determined.

- As with the case with intact fuel, the GE 10x10 fuel assembly is once again determined to be the most reactive damaged fuel assembly. The damaged assembly is modeled with an optimum rod pitch configuration containing *99* fuel rods and *1* water pin location.

The design basis damaged assembly model is then synthesized from the design basis intact and damaged assembly configurations.

A.6.5.2.3.2 Package Regional Densities

The Oak Ridge National Laboratory (ORNL) SCALE code package [1] contains a standard material data library for common elements, compounds, and mixtures. All the materials used for the cask and canister analysis are available in this data library. The neutron shield material in the cask is modeled as water and the cask skin is not modeled.

The cask neutron shield material is conservatively modeled as water. The hydrogen atom density of the solid neutron shield (for the transportation cask) is lower than that of water *and the shield contains boron*; therefore, replacing the neutron shield with water is slightly conservative. The material data for the fuel assemblies were obtained from reference [6] and are included in Table A.6.5.2-4.

A.6.5.2.4 Criticality Calculations

This section describes the models used for the criticality analysis. The analyses were performed with the CSAS25 module of the SCALE system. A series of calculations were performed to determine the most reactive fuel and configuration. The most reactive fuel, as demonstrated by the analyses is the GE 12/14 10x10 assembly for the intact lattices. The most reactive credible configuration is an infinite array of flooded casks with centered assemblies in their compartments and no axial poison plate gaps. This configuration is employed to model the intact fuel assemblies within the 69BTH DSC.

The NUHOMS® -69BTH DSC is analyzed for additional considerations arising from mechanical uncertainties of damaged fuel assemblies after a hypothetical accident. In case of a severe transportation accident, rod breakage may be postulated to occur in rods with known pre-existing gross cladding failure. These models were constructed to evaluate the effects of radial movement of fuel rod pieces (the result of "single-ended" breaks), and axial movement (the result of "double-ended" breaks). Loose fuel pellets or shards may become dislodged if a rod becomes severed, but this will not result in a more reactive state than the cases described below because the fuel assembly is under-moderated by design. The models used to study these limiting breaks are described below. Three damaged fuel assembly loading configurations are evaluated corresponding to a maximum to 4, 8 or 24 damaged fuel assemblies and the remaining intact fuel assemblies as shown in Figure A.6.5.2-7.

Single breaks–"Free ends" caused by break*s* were assumed to move away from the rest of the assembly. Increasing the rod spacing of the broken rods was found to increase k_{eff}. Conversely, k_{eff} is expected to decrease for local decreases in rod pitch. Rods on the exterior of the fuel assembly were displaced in the models and the assembly was assumed to be pressed in the corner of the fuel cell, thus maximizing the potential rod displacement. Since internal rods can not move as far as rods on the outside of the assembly, they are not limiting. For modeling simplicity, an entire face of 10 rods for the 10x10 array were assumed to evenly move away from the remainder of an assembly, as shown in Figure A.6.5.2-8. This overpredicts the effect of single rod breaks since the grid spacers of the fuel will limit radial rod displacement over most of the length of the rod.

Double breaks–The effect of pieces of fuel rod migrating axially was investigated by conservatively adding an entire row of fuel rods in the models. Again, the fuel assembly was assumed to be in the worst case position: pressed in the corner of the fuel cell as shown in Figure A.6.5.2-9. In addition, total cladding loss was assumed for the damaged rows of rods to simulate the bare fuel rod case. The limiting case was the double-ended break with the damaged rods being modeled without the cladding. This is not unexpected because the extra row of rods added to the model represents an increase in the fuel loading of the canister.

Rod Pitch Variation–The effect of bending and bowing of rods together with the total loss of grid spacers was investigated by varying the fuel rod pitch for all the fuel assembly classes from a minimum (where the rods are close to each other) to a maximum (bounded by the internal dimension of the rod compartment). This was done to determine the optimum rod pitch where the reactivity of the fuel lattice is maximized. In addition, rods were removed (non-mechanistically) from within the lattice to determine the optimum rod positions (and the number of rods) to determine the bounding (expected) lattice configurations. This hypothetical accident case is modeled to maximize the reactivity of the damaged fuel assembly and also to qualify fuel assemblies with damaged grids and missing rods to be loaded in the damaged assembly locations.

Similar to the intact assembly results, calculations are also performed to determine the most reactive configuration for damaged assemblies. The most reactive damaged assembly configuration is based on a 10x10 lattice with optimum pitch and *99* fueled rods.

A.6.5.2.4.1 Calculational Method

A. Computer Codes

The CSAS25 control module of SCALE-4.4 [1] was used to calculate the effective multiplication factor (k_{eff}) of the fuel in the cask. The CSAS25 control module allows simplified data input to the functional modules BONAMI-S, NITAWL-II, and KENO V.a. These modules process the required cross sections and calculate the k_{eff} of the system. BONAMI-S performs resonance self-shielding calculations for nuclides that have Bondarenko data associated with their cross sections. NITAWL-II applies a Nordheim resonance self-shielding correction to nuclides having resonance parameters. Finally, KENO V.a calculates the k_{eff} of a three-dimensional system. A sufficiently large number of neutron histories are run so that the standard deviation is below 0.0015 for all calculations.

B. Physical and Nuclear Data

The physical and nuclear data required for the criticality analysis include the fuel assembly data and cross-section data as described below.

Table A.6.5.2-2 lists the pertinent data for criticality analysis for all the authorized fuel assembly types in the NUHOMS® -69BTH DSC as transported in the NUHOMS® -MP197HB Cask.

The criticality analysis used the 44-group cross-section library built into the SCALE system. ORNL used ENDF/B-V data to develop this broad-group library specifically for criticality analysis of a wide variety of thermal systems.

C. Bases and Assumptions

The analytical results reported in Chapter A.2, Section A.2.13.1 demonstrate that the cask containment boundary and canister basket structure do not experience any significant distortion under hypothetical accident conditions. The fuel assembly drop analyses documented in Chapter A.2, Section A.2.13.8 also demonstrate that the fuel rods do not experience any deformation significant to cause a change in the fuel geometry. Therefore, for both normal and hypothetical accident conditions the cask geometry is identical except for the neutron shield and skin. As discussed above, the neutron shield and skin are conservatively modeled as water.

The cask was modeled with KENO V.a using the permissible geometry options. These options allow a model to be constructed with regular geometric shapes and define the material boundaries. No cases have been made to model the fuel assemblies with fission products, burnable absorbers, or radial and axial variations in the initial fuel enrichment. Instead, fuel assemblies have been modeled as unirradiated fuel with a uniform enrichment. This results in a very large margin of conservatism in the calculated k_{eff}.

The following conservative assumptions were also incorporated into the criticality calculations:

1. Omission of grid plates, spacers, and hardware in the fuel assembly.

2. Unirradiated fuel - no credit taken for fissile depletion or fission product poisoning.

3. No credit is taken for burnable absorbers.

4. For intact fuel, the pins are modeled assuming a lattice average uniform enrichment everywhere in the lattice. Natural Uranium blankets, Gadolinia, Integral Fuel Burnable Absorber (IFBA), Erbia or any other burnable absorber rods and axial or radial enrichment zones are modeled as enriched Uranium, uniform everywhere.

5. All fuel rods are assumed to be filled with 100% pure water in the fuel/cladding gap to account for the possibility of water being entrained in the fuel pin and because it has a slight positive effect on reactivity.

6. The fuel pellet stack was conservatively modeled at 96.5% of theoretical density with no allowance for dishing or chamfer.

7. Water density at optimum internal and external moderator density.

8. Only the active fuel length of each assembly type is explicitly modeled. The presence of the plenum, end fittings, channels above and below the active fuel reduce the k_{eff} of the system, therefore; these regions are modeled as water or the reflective boundary conditions. For the cases with reflective boundary condition, the model is effectively infinitely long. For intact fuel the active fuel region is conservatively assumed to start level with the bottom of the poison plates even though the fixed poison spans the entire length of the basket.

9. For all of the transportation Hypothetical Accident Conditions (HAC) cases the neutron shield and stainless steel skin of the cask assumed to be replaced with external moderator (water).

10. The *most reactive configuration* is assumed for the fuel compartment, poison plates and wrappers.

11. The *most reactive* gap *width* between the poison plates in the worst case position is explicitly modeled to maximize k_{eff}.

small changes in the dimensions of these assemblies were not expected to alter the reactivity ranking significantly.

Calculations were also carried out for the GE 4 fuel assembly design loaded in the NUHOMS® -61BTH DSC in reference [6] to qualify fuel with non-standard (lesser) number of fuel rods, particularly, the GE 4 lattice with 59 fueled rods. The normal GE 4 fuel assembly has 63 fueled rods. The most reactive input file for GE 4 fuel, was modified to determine the relative reactivity for various rod configurations.

These results are included in Table A.6.5.2-5 and show that the GE 4 fuel assembly can be loaded with a minimum of 58 fueled rods in the NUHOMS® -61BTH DSC. The arrangement of the fuel rods within the lattice in these evaluations was based on expected maximum reactivity. All possible fuel rod arrangements were not analyzed due to their very large number. However, a few representative, reactive variations were analyzed in order to draw conclusions about relative reactivity. Finally, a limit of 58 fueled rods was found and the k_{eff} of this configuration was at least 3σ below the most reactive fuel lattice. The GE 4 fuel assembly design is included in the authorized loading of NUHOMS® -69BTH DSC.

A typical input file with GE12 fuel assembly design loaded in the NUHOMS® -69BTH DSC is included in Section A.6.5.2.7.1. The results of the search for the most reactive fuel design loaded in the NUHOMS® -61BTH DSC from calculations performed in reference [6] and Appendix A.6.5.1 are also listed in Table A.6.5.2-5 to present the design type ranking with respect to reactivity, which is expected to be unchanged for the NUHOMS® -69BTH DSC. In the last part of the same table are included the k_{eff} results for additional calculations for some of the most reactive fuel assembly designs loaded in the NUHOMS® -69BTH DSC. The most reactive fuel lattice evaluated for the NUHOMS® -69BTH DSC design is the GE 12/14 lattice, (10x10 array), with a 0.120" thick Zircaloy fuel channel.

Four of the most reactive fuel types from Table A.6.5.2-5 were analyzed using the revised minimum fuel compartment width of 5.88" to show that the GE 12/14 lattice (10x10 array) with a 0.08" thick zircaloy-2 fuel channel remains the most reactive fuel type. These results are shown in Table A.6.5.2-5a. However, further analysis shows that for the final analysis, 0.12" thick fuel channels are more reactive, as shown in Table A.6.5.2-6.

B. Determination of the Most Reactive Intact Fuel Configuration

The fuel-loading configuration of the canister/cask affects the reactivity of the package. Several series of analyses determined the most reactive configuration for the canister/cask.

The first analysis investigated the effect of using fuel assemblies with their actual variable enrichment or with homogenized enrichment. The system with homogeneous enrichment fuel assemblies had a higher reactivity, therefore on the basis of conservatism this type of configuration will be used for the rest of this calculation.

The sensitivity of the similar NUHOMS® -61BTH DSC system reactivity with fuel cladding OD was analyzed in reference [6]. The reactivity of the system decreases as the cladding OD decreases, therefore the minimum cladding OD must be used. Based on the results of the analysis in reference [6], the GE12 10x10 assembly cladding is conservatively modeled utilizing an OD 0.004 inches less than that reported in Table A.6.5.2-2 for this evaluation. All the results of this evaluation are shown in Table A.6.5.2-*6*.

For this analysis, the canister and cask are modeled over the active fuel height of the fuel with reflective boundary conditions on the positive and negative x and y sides and water boundary condition on the positive and negative z sides of the model; this represents an infinite array in the x-y direction of canister/casks that have water reflected ends in the z direction. The fuel assemblies are placed in the center of their compartments and the nominal geometric dimensions are used unless specified otherwise. The canister/cask model for this evaluation differs from the actual design in the following ways:

- the B-10 absorber loading in the poison plates is lower than specified,
- gaps between poison plates are modeled for most reactive configuration,
- the rail structure for the basket is modeled using solid aluminum, and
- the neutron shield and the skin of the cask are conservatively modeled as water.

The models are fully described in Section A.6.5.2.3 except for the additional considerations for paired aluminum/poison plates. These additional modeling considerations are described in this section. The purpose of these models is to determine the most reactive configuration for intact fuel assemblies.

The second series of analyses investigated the effect of fuel compartment internal dimension (cell width) on the system reactivity. The model uses fuel cell widths equal to 5.92 inches (minimum), 5.96 inches (nominal), and 6.00 inches (maximum), and includes the configurations with assembly channels (all three thicknesses, 0.065, 0.080, and 0.120 inches). The results show that the most reactive configuration is with the minimum fuel compartment width. The balance of this evaluation uses the minimum cell width because it represents the most reactive configuration.

The third set of analyses evaluated the effect of fuel assembly compartment wall thickness on the system reactivity. The wall thicknesses used are 0.158 inches (minimum), 0.165 inches (nominal), and 0.172 inches (maximum). The results show a slightly higher $k_{eff} + 2\sigma$ for the inches (maximum). The results show a slightly higher $k_{eff} + 2\sigma$ with the model that has the nominal shell thickness; therefore it is used throughout the rest of the analysis.

The tenth set of analyses evaluates the effect of transversal (e.g., along x and y axes) gaps. They were varied from 0.01 in. to the maximum of 0.125 in. Higher gap size values up to 0.200 in. were also included to analyze this parameter effect on the system's reactivity for an extended range. The highest $k_{eff} + 2\sigma$ value is obtained for the minimum gap analyzed, 0.01 in. (0.025 cm), therefore it is used throughout the rest of the analysis. This analysis also demonstrates that the effect of gaps (as much as 0.20") along the radial extents of the poison plates do not significantly affect the reactivity of the system – rather the model using *minimal* gaps is shown to be bounding.

The eleventh set of analyses evaluates the effect of axial gaps. All cases analyzed had no gaps at the axial ends. The total number of poison plates used was eleven as the height of each plate is between 13 and 16 inches, and their lengths were no more than 0.25 inches different. Two types of gaps were included: gaps outside arrays only (modeled by Unit 59) and gaps inside and outside arrays (modeled by unit 79). The cases analyzed were as follows: with no gaps (only Unit 58 used), with eleven gaps (modeled by Unit 59), with one 0.25 inches Unit 79 middle axial gap and ten Unit 59 gaps, with one 0.5 inches Unit 79 middle axial gap and ten Unit 59 gaps, with one 0.75 inches Unit 79 middle axial gap and ten Unit 59 gaps. The results show a slightly higher $k_{eff} + 2\sigma$ with the model that has no axial gaps, therefore is used throughout the rest of the analysis. This analysis also demonstrates that the effect of gaps (as much as 0.75") along the axial extents of the poison plates do not significantly affect the reactivity of the system – rather the model using no gaps is shown to be bounding.

The twel*f*th set of analyses evaluates the effect of rail material. The cases analyzed had the following rail materials: solid aluminum, full density water, water at 10% density, water at 1% density, and water at 0.1% density. The results show a higher $k_{eff} + 2\sigma$ with the model that has aluminum as rail material, therefore it is used throughout the rest of the analysis.

The thirteenth set of analyses evaluates the effect of internal moderator density (IMD). The cases evaluated had the internal moderator density varied from 100% to 0.1%. The results show that the highest $k_{eff} + 2\sigma$ is obtained for the model that has 100% IMD, therefore it is used throughout the rest of the analysis.

C. Enrichment of Intact Fuel as a Function of Poison Loading

Finally, the maximum lattice average enrichment of the intact fuel assemblies as a function of the fixed poison loading in the poison plate is evaluated. These models represent the most reactive intact fuel assembly (GE12, 10x10) with homogeneous fuel enrichment, minimum fuel clad OD and fuel compartment inner width, maximum fuel compartment wall thickness, nominal array wrap thickness, 0.075 inches poison plate and maximum total poison plate thicknesses, centered fuel assemblies in compartments, water axial boundaries, nominal canister shell thickness, 0.01 inches transversal gaps, no axial gaps, solid aluminum rails, and with full IMD.

The boron-10 areal density (corresponding to the six different Poison IDs shown in Table A.6.5.2-1) in the poison plate is varied to determine the maximum lattice average fuel assembly enrichment. Thus, these cases can be used to specify the maximum lattice average assembly enrichment as a function of Poison ID (fixed poison loading) for the 69BTH DSC. The results are reported in Table A.6.5.2-7. *The updated results in Table A.6.5.2-7 reflect the design change which reduced the minimum fuel compartment width from 5.92" to 5.88" and the corresponding required increase in boron areal density.*

The optimum external moderator density (EMD) *is evaluated by varying the EMD from 100 to 1 percent full density to determine the maximum reactivity.* The results in Table A.6.5.2-7 show that the system reactivity is not affected by external moderator density. The variation in the results is due entirely to the statistical uncertainties in KENO V.a. However, the optimum external moderator density is utilized to determine the maximum k_{eff}.

The highest k_{eff} in Table A.6.5.2-7 is equal to 0.*9399* for the case with 4.*8* wt.% U-235 enrichment, 0.*0477* g B-10/cm^2 poison areal loading, and 1*00*% relative external moderator density. Using this case as *a* basis, additional cases *were* run *with* the DSC inside the MP-197 HB transportation cask. To investigate the system reactivity changes in case of a HAC resulting in the loss of water in the neutron shield, the additional cases run (in Table A.6.5.2-8) include this configuration. These results demonstrate that the calculated k_{eff} values based on the most *reactive* configuration are appropriate and bounding.

D. Determination of the Most Reactive Damaged Fuel Configuration

This section determines the most reactive configuration for the damaged fuel. Calculations with intact and damaged BWR fuel lattices with the 61BTH DSC documented in reference [*6*] indicate that the GE 10x10 fuel assembly *is* the most reactive intact and damaged fuel assembly. The most reactive intact 10x10 assembly design for the 69BTH DSC, as demonstrated by the results in Table A.6.5.2-*5,* is the GE12 (GE14) 10x10 assembly. Therefore, it is expected that the GE 10x10 fuel assembly will also result in the most reactive damaged assembly configuration.

For the "single-ended" and "double-ended" shear *scenarios,* five damaged GE 10x10 fuel configurations are evaluated to determine the design basis damaged assembly configuration for fuel with gross cladding damage, a peak pellet enrichment of 4.7 wt. % U-235, and a lattice average of 4.1 wt. % U-235. These models evaluate the effects of radial movement of fuel rod pieces (the result of "single-ended" breaks), and axial movement (the result of "double-ended" breaks). All models include water in the fuel pellet cladding annulus. Figures A.6.5.2-8 and A.6.5.2-9 show the single and double-ended break models, respectively. Figures A.6.5.2-10 and A.6.5.2-11 show the single and double-ended break models with axial movements, respectively.

The results of the first set of calculations shown in Table A.6.5.2-9 indicate that the most reactive configuration is based on the double-ended shear with a conservative addition of an extra row or rods for the entire fuel length. The implementation of the "UP" configuration in the KENO model is done by adding the 15″ row of rods at the top of the fuel assembly. There is no difference between adding the 15″ of fuel above or below the remainder of the fuel assembly. The results indicate that the most reactive damaged rod configuration is the double-shear with no cladding. The remaining *analyses are* not evaluated for these configurations; however, they are considered in the rod pitch studies.

An additional modeling consideration in the damaged assembly KENO model is the treatment of the additional lattice. The "Dancoff" factor, an input parameter, is required to describe all additional fuel lattices in the input model. In the intact assembly calculations, only one fuel lattice is described in the model; therefore, KENO calculates all the required parameters for this lattice. In the damaged assembly model, two lattices are described, the intact fuel lattice and the damaged fuel lattice. The Dancoff factor for *one of* the fuel lattice*s* is a required input to the KENO model. This factor is a strong function of the internal moderator density. Since, most of the calculations are performed with full internal moderator density, only one value of this factor is used for *all* of the *intact assemblies*. This value, 2.7588812E-01, is obtained from the output files of the intact fuel calculations.

The next series of damaged fuel analyses involved a study on the effect of the fuel rod pitch on the system reactivity. The rod pitch study is carried out for the four lattice designs - 7x7, 8x8, 9x9 and 10x10. KENO models with rod pitches ranging from a minimum (based on the rod OD) and a maximum *(*bounded by the fuel compartment inner width*)* are created and analyzed. All models assume 100% internal and external moderator density, 100% moderator flooded fuel-cladding gap and specular radial and water axial boundary conditions. *T*hese calculations were carried out assuming that all of the lattice positions were occupied by fuel rods.

Once the most reactive pitch was determined, a series of calculations *was* performed that subtracted fuel rods from the base assembly to ensure that the limiting fuel assembly geometry was determined. The removal of fuel rods was restricted to those in the interior locations of the the four lattice*s*. The selection of the rod loading patterns is aimed at maximizing the reactivity, and those that are investigated are representative. All combinations of fuel rod positions are not investigated here because of the sheer enormity of the task. It is expected that the reactivities of other cases (not investigated) with the same number of rods but with different loading patterns are within statistical uncertainty. Sufficient rods were removed from these lattices to ensure that the optimum rod configuration is determined and also to ensure that further removal of rods would only result in a lower k_{eff}.

All the fuel rod pitch and rod removal cases are analyzed utilizing the models shown in Table A.6.5.2-10 of this calculation. A lattice average enrichment of 4.1 wt. % was utilized in these models. The results of these evaluations are intended to be used to determine the most reactive damaged rod configuration with optimum pitch and are not to be compared to USL since such a configuration (69 damaged assemblies) will not be authorized. Moreover, most of these results show a k_{eff} value that is much greater than the USL indicating that these results shall only be utilized to perform a *relative reactivity* comparison. The results of these calculations are shown in Table A.6.5.2-11 and demonstrate that the most reactive configuration is based on the GE 12 10x10 lattice at maximum pitch (*0.6089*") containing *99* fuel rods. These results are consistent with those for the 61BTH DSC in Appendix A.6.5-1 demonstrating that for approximately the same compartment size, the GE12 10x10 assembly results in the most reactive intact and damaged assembly configuration. These calculations are done to qualify fuel assemblies with missing rods as damaged without any limits on the number of missing rods.

Figure A.6.5.2-7 indicates that there are two variations for loading 4 damaged fuel assemblies. Calculations were performed to determine the bounding configuration for loading the four damaged assemblies. From the results shown in Table A.6.5.2-11, *both configurations are equally reactive, so the* first with 4 damaged assemblies in off-center corner outer locations *is utilized.* This configuration is used to determine the maximum lattice average initial enrichment *of the damaged assemblies* as a function of *the* boron loading in the poison plates for the 69BTH DSC loaded with 65 intact and 4 damaged assemblies.

E. Enrichment of Damaged Fuel as a Function of Poison Loading

Finally, the maximum lattice average enrichment of the damaged fuel assemblies as a function of the fixed poison loading in the poison plate is evaluated. These models represent the DSC with the most reactive damaged fuel assemblies (GE 10x10, optimum pitch, *99* rods) for the 4-, 8-, and *24-damaged* assembly loading configurations with the most reactive configuration determined in the analysis documented in Section A.6.5.2.4.2D. The remaining locations are loaded with the most reactive intact fuel assembly (GE 10x10) with the most reactive configuration determined in Section A.6.5.2.4.2B for intact fuel. All the damaged assembly calculations are carried out with the borated aluminum poison. The KENO models for the 4-, 8-, and *24*-damaged *assembly* loading configuration*s* are shown in Figure A.6.5.2-12, Figure A.6.5.2-13, and Figure A.6.5.2-14, respectively.

The minimum fixed poison loading and the maximum lattice average initial enrichment employed in the intact assembly calculations documented in Section A.6.5.2.4.2C remain unchanged. The calculations are performed to determine the maximum lattice average enrichment of the damaged fuel assemblies for the three damaged fuel loading configurations. The results are reported in Table A.6.5.2-12 for the 4-damaged assembly loading configuration, Table A.6.5.2-13 for the 8-damaged assembly loading configuration, and Table A.6.5.2-14 for the 24-damaged assembly loading configuration. An active fuel length of 151 inches was utilized in *all* assembly calculations.

The KENO input files for the most reactive damaged assembly cases are *given* in Section A.6.5.2.7.2.

A.6.5.2.4.3 Criticality Results

Table A.6.5.2-15 lists the results for the two cases given in the transportation regulations: (1) single undamaged package optimally flooded and reflected per 10 CFR Part 71.55(b), (2) infinite array of undamaged packages with no in-leakage of water per 10 CFR Part 71.59(a)(1), and (3) an infinite array of damaged packages under hypothetical accident conditions (∞ x "N" = ∞) per 10 CFR Part 71.59(a)(2) or per 10 CFR Part 71.55(b). 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®-MP197 HB Cask containing the NUHOMS® - 69BTH DSC can transport up to 24 damaged and 41 (or more) undamaged BWR fuel assemblies.

The maximum lattice average initial enrichment for intact and damaged fuel assemblies as a function of poison plate boron-10 loading is shown in Table A.6.5.2-1.

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 A.6.5.2.5, the minimum USL over the parameter range (in this case, pitch) is 0.*9415*. From Table A.6.5.2-15, for the most reactive case,

$$k_{KENO} + 2\sigma_{KENO} = 0.9386 + 2\ (0.0010) = 0.9406 < 0.9416.$$

A.6.5.2.5 Critical Benchmark Experiments

The criticality safety analysis of the NUHOMS®-69BTH system used the CSAS25 module of the SCALE system of codes. The CSAS25 control module allows simplified data input to the functional modules BONAMI-S, NITAWL-II, and KENO V.a. These modules process the required cross-section data and calculate the k_{eff} of the system. BONAMI-S performs resonance self-shielding calculations for nuclides that have Bondarenko data associated with their cross sections. NITAWL-II applies a Nordheim resonance self-shielding correction to nuclides having resonance parameters. Finally, KENO V.a calculates the effective neutron multiplication (k_{eff}) of a 3-D system.

The analysis presented herein uses the fresh fuel assumption for criticality analysis. The analysis employed the 44-group ENDF/B-V cross-section library because it has a small bias, as determined by 125 benchmark calculations. The upper safety limit (USL-1) was determined using the results of these 125 benchmark calculations.

The benchmark problems used to perform this verification are representative of benchmark arrays of commercial light water reactor (LWR) fuels with the following characteristics:

1. water moderation
2. boron neutron absorbers
3. unirradiated light water reactor type fuel (no fission products or "burnup credit") near room temperature (vs. reactor operating temperature)
4. close reflection
5. uranium oxide.

The 125 uranium oxide experiments were chosen to model a wide range of uranium enrichments, fuel pin pitches, assembly separation, *and* fixed neutron absorbers in order to test the ability of the code to accurately calculate k_{eff}.

A.6.5.2.5.1 Benchmark Experiments and Applicability

A summary of all of the pertinent parameters for each experiment is included in Table A.6.5.2-16 along with the results of each run. The best correlation is observed for fuel assembly separation distance with a correlation of 0.65. All other parameters show much lower correlation ratios indicating no real correlation. All parameters were evaluated for trends and to determine the most conservative USL.

The Upper Subcritical Limit (USL) is calculated in accordance with NUREG/CR-6361 [3]. USL Method 1 (USL-1) applies a statistical calculation of the bias and its uncertainty plus an administrative margin (0.05) to the linear fit of results of the experimental benchmark data. The basis for the administrative margin is from Reference [4]. Results from the USL evaluation are presented in Table A.6.5.2-17.

The criticality evaluation used the same cross section set, fuel materials and similar material/geometry options that were used in the 125 benchmark calculations as shown in Table A.6.5.2-16. The modeling techniques and the applicable parameters listed in Table A.6.5.2-18 for the actual criticality evaluations fall within the range of those addressed by the benchmarks in Table A.6.5.2-16.

The results from the comparisons of physical parameters of each of the fuel assembly types to the applicable USL value are presented in Table A.6.5.2-18. The minimum value of the USL was determined to be 0.*9415* based on comparisons to the limiting assembly parameters shown in Table A.6.5.2-18.

A.6.5.2.6 References

1. Oak Ridge National Laboratory, RSIC Computer Code Collection, "SCALE: A Modular Code System for Performing Standardized Computer Analysis for Licensing Evaluations for Workstations and Personal Computers," NUREG/CR-0200, Revision 6, ORNL/NUREG/CSD-2/V2/R6.
2. 10 CFR 71, Packaging and Transportation of Radioactive Materials.
3. U.S. Nuclear Regulatory Commission, "Criticality Benchmark Guide for Light-Water-Reactor fuel in Transportation and Storage Packages," NUREG/CR-6361, Published March 1997, ORNL/TM-13211.
4. U.S. Nuclear Regulatory Commission, "Recommendations for Preparing the Criticality Safety Evaluation of Transportation Packages," NUREG/CR-5661, Published April 1997, ORNL/TM-11936.
5. NUH-003, Updated Final Safety Analysis Report for the Standardized NUHOMS® Horizontal Modular Storage System for the Irradiated Nuclear Fuel (UFSAR), Revision *11*.
6. *Same as [5] above. The Certificate of Compliance (CoC) for Amendment 10 to Part 72 CoC 1004 was issued on August 24th, 2009.*

Proprietary information on pages A.6.5.2-22 to A.6.5.2-63 withheld pursuant to 10 CFR 2.390

Table A.6.5.2-1
Maximum Lattice Average Initial Enrichment for 69BTH

	Maximum Lattice Average Initial Enrichment (1) (wt.% U-235)				Minimum B-10 Content (g/cm^2)		
Poison ID	Intact Assemblies	Up to 4 Damaged Assemblies(2)	5 to 8 Damaged Assemblies(2)	9 to 24 Damaged Assemblies(2)	Utilized in this Analysis	Specified for 90% Credit	Specified for 75% Credit
A	3.70	3.70	3.30	2.80	0.0189	0.021	0.025
B	4.10	4.10	3.60	3.00	0.0279	0.031	0.037
C	4.40	4.20	3.60	3.10	0.0351	0.039	0.047
D	4.60	4.40	3.70	3.20	0.0414	0.046	0.055
E	4.80	4.40	3.70	3.20	0.0477	0.053	0.064
F	5.00	4.80	3.90	3.40	0.0549	0.061	0.073

(1) For LaCrosse fuel assemblies, the enrichment shall be reduced by 0.1 wt% U-235.
(2) Only in corner locations; see Figure A.6.5.2-7 for the exact locations of these assemblies in the DSC.

Table A.6.5.2-5
Most Reactive Fuel Type
(continued)

Manufacturer	Array	Version	k_{KENO}	1σ	k_{eff}
GE	8x8 w/ variable enrichment	GE5	0.8951	0.0011	0.8973
GE	8x8 w/ variable enrichment	GE9	0.9008	0.0013	0.9034
GE	9x9	GE11, GE13	0.9042	0.0014	0.9070
GE	9x9 0.120 channel	GE11, GE13	0.9025	0.0014	0.9053
GE	9x9 0.080 channel	GE11, GE13	0.9066	0.0012	0.9090
GE	9x9 0.065 channel	GE11, GE13	0.9040	0.0013	0.9066
GE	**10x10**	**GE12, 14**	**0.9095**	**0.0013**	**0.9121**
GE	10x10 0.120 channel	GE12, 14	0.9094	0.0010	0.9114
GE	10x10 0.080 channel	GE12, 14	0.9092	0.0013	0.9118
GE	10x10 0.065 channel	GE12, 14	0.9076	0.0011	0.9098
Results from Appendix T, Table T.6-6 of reference [6] for NUHOMS 61BTH DSC					
Framatome-ANP	8x8(4)	8x8-62/2	0.8991	0.0013	0.9017
Framatome-ANP	8x8 0.120 channel	8x8-62/2	0.8966	0.0012	0.8990
Framatome-ANP	8x8 0.080 channel	8x8-62/2	0.9005	0.0014	0.9033
Framatome-ANP	8x8 0.065 channel	8x8-62/2	0.8973	0.0013	0.8999
Framatome-ANP	9x9	9x9-79/2	0.9072	0.0015	0.9102
Framatome-ANP	9x9 0.120 channel	9x9-79/2	0.9065	0.0013	0.9091
Framatome-ANP	9x9 0.080 channel	9x9-79/2	0.9075	0.0013	0.9101
Framatome-ANP	9x9 0.065 channel	9x9-79/2	0.9054	0.0012	0.9078
Siemens	9x9	QFA	0.9078	0.0013	0.9104
Siemens	9x9 0.120 channel	QFA	0.9084	0.0012	0.9108
Siemens	9x9 0.080 channel	QFA	0.9085	0.0012	0.9109
Siemens	9x9 0.065 channel	QFA	0.9077	0.0012	0.9101
Framatome-ANP	10x10	Atrium-10	0.9070	0.0013	0.9096
Framatome-ANP	10x10 0.120 channel	Atrium-10	0.9070	0.0014	0.9098
Framatome-ANP	10x10 0.080 channel	Atrium-10	0.9081	0.0012	0.9105
Framatome-ANP	10x10 0.065 channel	Atrium-10	0.9072	0.0012	0.9096
GE	8x8(5)	GE4	0.8951	0.0013	0.8977
GE	8x8, 62 fueled rods	GE4	0.8966	0.0012	0.8990
GE	8x8, 61 fueled rods	GE4	0.8973	0.0013	0.8999
GE	8x8, 60 fueled rods	GE4	0.8971	0.0012	0.8995
GE	8x8, 59 fueled rods, alternate	GE4	0.8964	0.0013	0.8990
GE	8x8, 59 fueled rods, alternate	GE4	0.8955	0.0013	0.8981
GE	8x8, 59 fueled rods, alternate	GE4	0.9043	0.0014	0.9071
GE	8x8, 59 fueled rods	GE4	0.9007	0.0011	0.9029
GE	8x8, 58 fueled rods, alternate	GE4	0.9048	0.0013	0.9074
GE	8x8, 58 fueled rods	GE4	0.8965	0.0013	0.8991
GE	10x10	GE 12/14	0.9095	0.0013	0.9121
Results for NUHOMS 61BTH DSC in Appendix A.6.5.1, Table A.6.5.1-56					
GE	10x10, 0.400" clad OD	GE12, 14	0.9158	0.0012	0.9182
ABB	10x10	ABB-10-3	0.9117	0.0010	0.9137
Allis Chalmers	10x10	LaCrosse	0.9119	0.0011	0.9141
EXXON	10x10	LaCrosse	0.8752	0.0011	0.8774

Table A.6.5.2-5
Most Reactive Fuel Type
(concluded)

Manufacturer	Array[5]	Version	k_{KENO}	1σ	k_{eff}
ABB	4x(5x5-1) 5.6 mm x-width[6]	ABB-10-3 SVEA-96	0.9412	0.0012	0.9436
ABB	4x(5x5-1) 5.6 mm x-width[6]	ABB-10-4 SVEA-96	0.9308	0.0011	0.9330
ABB	4x(5x5) 5.6 mm x-width[6]	ABB-10-5 SVEA-100	0.9077	0.0011	0.9099
ABB	4x(5x5-2) 4.0 mm x-width[6]	OPTIMA 92 rods	0.9152	0.0013	0.9178
ABB	4x(5x5-1) 4.0 mm x-width[6]	OPTIMA 96 rods	0.9309	0.0012	0.9333
ABB	4x(5x5) 4.0 mm x-width[6]	OPTIMA 100 rods	0.9214	0.0013	0.9240
ABB	4x(5x5-2) 4.0 mm x-width[6]	OPTIMA 2 92 rods	0.9248	0.0011	0.9270
ABB	4x(5x5-1) 4.0 mm x-width[6]	OPTIMA 2 96 rods	0.9374	0.0011	0.9396
ABB	4x(5x5) 4.0 mm x-width[6]	OPTIMA 2 100 rods	0.9324	0.0011	0.9346
Allis Chalmers[7]	No Channel	LaCrosse	0.9403	0.0010	0.9423

(1) Small Fuel Pellet OD (Note Large Pellet OD identical to GE1 analysis)
(2) Small Fuel Pellet OD
(3) Large Fuel Pellet OD
(4) Used maximum pellet OD
(5) For certain fueled rod configurations, alternate arrangements have also been analyzed
(6) X-width represents the arms width of the cruciform internal water channel featured by SVEA fuels; 4.0 mm and 5.6 mm are representative of these widths.
(7) The enrichment of the Allis Chalmers LaCrosse fuel assembly is reduced by 0.1 wt. % U-235 to ensure that the GE 10x10 fuel assembly is bounding. All the results of the GE 10x10 fuel assembly can directly be applied to the Allis Chalmers fuel assembly provided the enrichment is reduced by 0.1 wt.% U-235.

Table A.6.5.2-5a
Most Reactive Fuel Type for 5.88" Cell Width

Manufacturer	*Array*	*Version*	k_{KENO}	*1σ*	k_{eff}
Siemens	*9x9 0.120 channel*	*QFA*	*0.9443*	*0.0011*	*0.9465*
GE	***10x10 0.080 channel***	***GE12***	***0.9459***	***0.0012***	***0.9483***
GE	*10x10 0.120 channel*	*GE12*	*0.9451*	*0.0012*	*0.9475*
ABB	*4x(5x5-1) 5.6 mm x-width[1]*	*ABB-10-3 SVEA-96*	*0.9453*	*0.0011*	*0.9475*
ABB	*4x(5x5-1) 4.0 mm x-width[1]*	*OPTIMA 2 96 rods*	*0.9433*	*0.0012*	*0.9457*

(1) X-width represents the arms width of the cruciform internal water channel featured by SVEA fuels; 4.0 mm and 5.6 mm are representative of these widths.

Table A.6.5.2-7
Criticality Analysis Results *for 5.88" Cell Width*

Model Description	k_{KENO}	1σ	*keff*
3.70 wt.% U-235, 0.0189 g B-10/cm²			
EMD=1%	*0.9356*	*0.0009*	*0.9374*
EMD=10%	***0.9353***	***0.0011***	***0.9375***
EMD=20%	*0.9340*	*0.0012*	*0.9364*
EMD=40%	*0.9325*	*0.0012*	*0.9349*
EMD=60%	*0.9335*	*0.0010*	*0.9355*
EMD=80%	*0.9339*	*0.0010*	*0.9359*
EMD=100%	*0.9321*	*0.0011*	*0.9343*
4.10 wt.% U-235, 0.0279 g B-10/cm²			
EMD=1%	*0.9344*	*0.0011*	*0.9366*
EMD=10%	*0.9346*	*0.0012*	*0.9370*
EMD=20%	*0.9345*	*0.0011*	*0.9367*
EMD=40%	*0.9330*	*0.0012*	*0.9354*
EMD=60%	*0.9324*	*0.0011*	*0.9346*
EMD=80%	***0.9359***	***0.0011***	***0.9381***
EMD=100%	*0.9323*	*0.0011*	*0.9345*
4.40 wt.% U-235, 0.0351 g B-10/cm²			
EMD=1%	***0.9367***	***0.0013***	***0.9393***
EMD=10%	*0.9333*	*0.0011*	*0.9355*
EMD=20%	*0.9342*	*0.0011*	*0.9364*
EMD=40%	*0.9322*	*0.0012*	*0.9346*
EMD=60%	*0.9351*	*0.0011*	*0.9373*
EMD=80%	*0.9356*	*0.0011*	*0.9378*
EMD=100%	*0.9367*	*0.0011*	*0.9389*
4.60 wt.% U-235, 0.0414 g B-10/cm²			
EMD=1%	***0.9365***	***0.0011***	***0.9387***
EMD=10%	*0.9350*	*0.0012*	*0.9374*
EMD=20%	*0.9345*	*0.0012*	*0.9369*
EMD=40%	*0.9342*	*0.0012*	*0.9366*
EMD=60%	*0.9326*	*0.0011*	*0.9348*
EMD=80%	*0.9360*	*0.0012*	*0.9384*
EMD=100%	*0.9350*	*0.0011*	*0.9372*
4.80 wt.% U-235, 0.0477 g B-10/cm²			
EMD=1%	*0.9345*	*0.0011*	*0.9367*
EMD=10%	*0.9342*	*0.0012*	*0.9366*
EMD=20%	*0.9350*	*0.0012*	*0.9374*
EMD=40%	*0.9343*	*0.0012*	*0.9367*
EMD=60%	*0.9348*	*0.0010*	*0.9368*
EMD=80%	*0.9350*	*0.0012*	*0.9374*
EMD=100%	***0.9377***	***0.0011***	***0.9399***
5.00 wt.% U-235, 0.0549 g B-10/cm²			
EMD=1%	*0.9350*	*0.0013*	*0.9376*
EMD=10%	*0.9341*	*0.0012*	*0.9365*
EMD=20%	*0.9336*	*0.0013*	*0.9362*
EMD=40%	*0.9334*	*0.0012*	*0.9358*
EMD=60%	***0.9354***	***0.0012***	***0.9378***
EMD=80%	*0.9346*	*0.0013*	*0.9372*
EMD=100%	*0.9345*	*0.0011*	*0.9367*

Table A.6.5.2-8
Results for Additional Cases

Model Description	k_{KENO}	1σ	k_{eff}
DSC Inside MP197HB Transport Cask	0.9368	0.0010	0.9388
MP197HB with Vyal B Instead of Water	0.9343	0.0011	0.9365
MP197HB Neutron Shield Water Removed	0.9359	0.0012	0.9383
DSC Inside a Transfer Cask	0.9304	0.0011	0.9326

Table A.6.5.2-9
Most Reactive Configuration–Single and Double Shear

Model Description	$\mathbf{k_{KENO}}$	**1σ**	$\mathbf{k_{eff}}$
10x10 Lattice with Double Shear	*0.9468*	*0.0011*	*0.9490*
Same as above with 15.0 inches rod shift	*0.9489*	*0.0011*	*0.9511*
10x10 Lattice with Double Shear and no Clad	*0.9504*	*0.0012*	*0.9528*
10x10 Lattice with Single Shear	*0.9435*	*0.0012*	*0.9459*
Same as above with 15.0 inches rod shift	*0.9432*	*0.0011*	*0.9454*

Table A.6.5.2-10
Most Reactive Configuration–Optimum Rod Pitch
(Part 1 of 2)

Model Description	k_{KENO}	1σ	k_{eff}
Optimum Rod Pitch Calculations for the 7x7 Lattice: GE 2 Lattice			
7x7 Lattice, Pitch = 0.563"	*0.6947*	*0.0010*	*0.6967*
7x7 Lattice, Pitch = 0.600"	*0.7450*	*0.0010*	*0.7470*
7x7 Lattice, Pitch = 0.640"	*0.8041*	*0.0011*	*0.8063*
7x7 Lattice, Pitch = 0.680"	*0.8570*	*0.0011*	*0.8592*
7x7 Lattice, Pitch = 0.720"	*0.9067*	*0.0011*	*0.9089*
7x7 Lattice, Pitch = 0.738"	*0.9298*	*0.0012*	*0.9322*
7x7 Lattice, Pitch = 0.760"	*0.9539*	*0.0011*	*0.9561*
7x7 Lattice, Pitch = 0.800"	*0.9899*	*0.0011*	*0.9921*
7x7 Lattice, Pitch = 0.840"	*1.0181*	*0.0011*	*1.0203*
7x7 Base, Pitch = 0.8862"	***1.0338***	***0.0010***	***1.0358***
7x7 Base, 1 rod removed	*1.0308*	*0.0010*	*1.0328*
7x7 Base, 2 rods removed	*1.0279*	*0.0010*	*1.0299*
7x7 Base, 3 rods removed	*1.0254*	*0.0011*	*1.0276*
7x7 Base, 4 rods removed	*1.0217*	*0.0010*	*1.0237*
7x7 Base, 5 rods removed	*1.0128*	*0.0012*	*1.0152*
7x7 Base, 8 rods removed	*0.9917*	*0.0010*	*0.9937*
7x7 Base, 12 rods removed	*0.9544*	*0.0011*	*0.9566*
7x7 Base, 16 rods removed	*0.9252*	*0.0011*	*0.9274*
Optimum Rod Pitch Calculations for the 8x8 Lattice: GE 9 Lattice			
8x8 Lattice, Pitch = 0.483"	*0.6790*	*0.0012*	*0.6814*
8x8 Lattice, Pitch = 0.520"	*0.7425*	*0.0011*	*0.7447*
8x8 Lattice, Pitch = 0.560"	*0.8068*	*0.0011*	*0.8090*
8x8 Lattice, Pitch = 0.600"	*0.8688*	*0.0011*	*0.8710*
8x8 Lattice, Pitch = 0.640"	*0.9228*	*0.0011*	*0.9250*
8x8 Lattice, Pitch = 0.680"	*0.9681*	*0.0012*	*0.9705*
8x8 Lattice, Pitch = 0.710"	*0.9944*	*0.0011*	*0.9966*
8x8 Lattice, Pitch = 0.735"	*1.0143*	*0.0011*	*1.0165*
8x8 Base, Pitch = 0.771"	***1.0255***	***0.0011***	***1.0277***
8x8 Base, 1 rod removed	*1.0249*	*0.0011*	*1.0271*
8x8 Base, 2 rods removed	*1.0216*	*0.0011*	*1.0238*
8x8 Base, 3 rods removed	*1.0180*	*0.0010*	*1.0200*
8x8 Base, 4 rods removed	*1.0181*	*0.0011*	*1.0203*
8x8 Base, 5 rods removed	*1.0118*	*0.0012*	*1.0142*
8x8 Base, 6 rods removed	*1.0094*	*0.0010*	*1.0114*
8x8 Base, 7 rods removed	*1.0027*	*0.0010*	*1.0047*
8x8 Base, 10 rods removed	*0.9878*	*0.0010*	*0.9898*
8x8 Base, 12 rods removed	*0.9746*	*0.0011*	*0.9768*

Table A.6.5.2-10
Most Reactive Configuration–Optimum Rod Pitch
(Part 2 of 2)

Model Description	k_{KENO}	1σ	k_{eff}
Optimum Rod Pitch Calculations for the 9x9 Lattice : Siemens QFA Lattice			
9x9 Lattice, Pitch = 0.433"	*0.6872*	*0.0010*	*0.6892*
9x9 Lattice, Pitch = 0.470"	*0.7567*	*0.0013*	*0.7593*
9x9 Lattice, Pitch = 0.510"	*0.8293*	*0.0011*	*0.8315*
9x9 Lattice, Pitch = 0.540"	*0.8813*	*0.0010*	*0.8833*
9x9 Lattice, Pitch = 0.569"	*0.9295*	*0.0011*	*0.9317*
9x9 Lattice, Pitch = 0.600"	*0.9696*	*0.0010*	*0.9716*
9x9 Lattice, Pitch = 0.630"	*1.0037*	*0.0011*	*1.0059*
9x9 Lattice, Pitch = 0.6533"	*1.0228*	*0.0014*	*1.0256*
9x9 Base, Pitch = 0.6809"	*1.0343*	*0.0010*	*1.0363*
9x9 Base, 1 rod removed	*1.0344*	*0.0010*	*1.0364*
9x9 Base, 2 rods removed	***1.0347***	***0.0011***	***1.0369***
9x9 Base, 3 rods removed	*1.0310*	*0.0012*	*1.0334*
9x9 Base, 4 rods removed	*1.0346*	*0.0010*	*1.0366*
9x9 Base, 5 rods removed	*1.0298*	*0.0013*	*1.0324*
9x9 Base, 6 rods removed	*1.0279*	*0.0009*	*1.0297*
9x9 Base, 7 rods removed	*1.0283*	*0.0010*	*1.0303*
9x9 Base, 8 rods removed	*1.0248*	*0.0009*	*1.0266*
9x9 Base, 9 rods removed	*1.0180*	*0.0011*	*1.0202*
9x9 Base, 12 rods removed	*1.0150*	*0.0012*	*1.0174*
Optimum Rod Pitch Calculations for the 10x10 Lattice : GE 12/14 Lattice			
10x10 Lattice, Pitch = 0.400"	*0.6974*	*0.0010*	*0.6994*
10x10 Lattice, Pitch = 0.440"	*0.7789*	*0.0011*	*0.7811*
10x10 Lattice, Pitch = 0.480"	*0.8614*	*0.0010*	*0.8634*
10x10 Lattice, Pitch = 0.510"	*0.9168*	*0.0012*	*0.9192*
10x10 Lattice, Pitch = 0.540"	*0.9649*	*0.0011*	*0.9671*
10x10 Lattice, Pitch = 0.570"	*1.0049*	*0.0012*	*1.0073*
10x10 Lattice, Pitch = 0.588"	*1.0236*	*0.0012*	*1.0260*
10x10 Lattice, Pitch = 0.6089"	*1.0367*	*0.0011*	*1.0389*
10x10 Base, 1 rod removed	***1.0401***	***0.0011***	***1.0423***
10x10 Base, 2 rods removed	*1.0380*	*0.0011*	*1.0402*
10x10 Base, 3 rods removed	*1.0374*	*0.0012*	*1.0398*
10x10 Base, 4 rods removed	*1.0389*	*0.0012*	*1.0413*
10x10 Base, 5 rods removed	*1.0382*	*0.0013*	*1.0408*
10x10 Base, 7 rods removed	*1.0388*	*0.0011*	*1.0410*
10x10 Base, 8 rods removed	*1.0366*	*0.0011*	*1.0388*
10x10 Base, 9 rods removed	*1.0340*	*0.0010*	*1.0360*
10x10 Base, 10 rods removed	*1.0332*	*0.0011*	*1.0354*
10x10 Base, 12 rods removed	*1.0342*	*0.0010*	*1.0362*

Table A.6.5.2-11
Most Reactive Configuration with 4 Damaged Assemblies

Model Description	**k_{KENO}**	**1σ**	**k_{eff}**
4 damaged assemblies in off-center corner outer locations	0.9401	0.0011	0.9423
4 damaged assemblies in corner center outer locations	0.9401	0.0013	0.9427

Table A.6.5.2-12
Criticality Analysis Results for DSC with 4 Damaged Fuel Assemblies

Model Description	k_{KENO}	1σ	k_{eff}
Intact Fuel 3.7 wt. %, Damaged Fuel 3.7 wt. % 18.9 mg B-10/cm²			
EMD=1.0%	*0.9361*	*0.0008*	*0.9377*
EMD=10%	***0.9382***	***0.0008***	***0.9398***
EMD=20%	*0.9357*	*0.0009*	*0.9375*
EMD=40%	*0.9364*	*0.0009*	*0.9382*
EMD=60%	*0.9365*	*0.0009*	*0.9383*
EMD=80%	*0.9345*	*0.0009*	*0.9363*
EMD=100%	*0.9363*	*0.0008*	*0.9379*
Intact Fuel 4.1 wt. %, Damaged Fuel 4.1 wt. % 27.9 mg B-10/cm²			
EMD=1.0%	*0.9373*	*0.0008*	*0.9389*
EMD=10%	*0.9344*	*0.0010*	*0.9364*
EMD=20%	*0.9381*	*0.0009*	*0.9399*
EMD=40%	*0.9355*	*0.0009*	*0.9373*
EMD=60%	*0.9350*	*0.0010*	*0.9370*
EMD=80%	***0.9387***	***0.0009***	***0.9405***
EMD=100%	*0.9380*	*0.0009*	*0.9398*
Intact Fuel 4.4 wt. %, Damaged Fuel 4.2 wt. % 35.1 mg B-10/cm²			
EMD=1.0%	*0.9382*	*0.0008*	*0.9398*
EMD=10%	*0.9365*	*0.0009*	*0.9383*
EMD=20%	*0.9376*	*0.0009*	*0.9394*
EMD=40%	*0.9367*	*0.0009*	*0.9385*
EMD=60%	***0.9382***	***0.0009***	***0.9400***
EMD=80%	*0.9375*	*0.0010*	*0.9395*
EMD=100%	*0.9376*	*0.0010*	*0.9396*
Intact Fuel 4.6 wt. %, Damaged Fuel 4.4 wt. % 41.4 mg B-10/cm²			
EMD=1.0%	***0.9379***	***0.0008***	***0.9395***
EMD=10%	*0.9364*	*0.0009*	*0.9382*
EMD=20%	*0.9372*	*0.0009*	*0.9390*
EMD=40%	*0.9366*	*0.0008*	*0.9382*
EMD=60%	*0.9375*	*0.0010*	*0.9395*
EMD=80%	*0.9375*	*0.0008*	*0.9391*
EMD=100%	*0.9361*	*0.0011*	*0.9383*
Intact Fuel 4.8 wt. %, Damaged Fuel 4.4 wt. % 47.7 mg B-10/cm²			
EMD=1.0%	*0.9363*	*0.0008*	*0.9379*
EMD=10%	***0.9388***	***0.0009***	***0.9406***
EMD=20%	*0.9366*	*0.0008*	*0.9382*
EMD=40%	*0.9372*	*0.0009*	*0.9390*
EMD=60%	*0.9368*	*0.0009*	*0.9386*
EMD=80%	*0.9385*	*0.0009*	*0.9403*
EMD=100%	*0.9377*	*0.0009*	*0.9395*
Intact Fuel 5.0 wt. %, Damaged Fuel 4.8 wt. % 54.9 mg B-10/cm²			
EMD=1.0%	***0.9386***	***0.0010***	***0.9406***
EMD=10%	*0.9387*	*0.0008*	*0.9403*
EMD=20%	*0.9380*	*0.0009*	*0.9398*
EMD=40%	*0.9363*	*0.0009*	*0.9381*
EMD=60%	*0.9355*	*0.0009*	*0.9373*
EMD=80%	*0.9363*	*0.0009*	*0.9381*
EMD=100%	*0.9379*	*0.0010*	*0.9399*

Table A.6.5.2-13
Criticality Analysis Results for DSC with 8 Damaged Fuel Assemblies

Model Description	k_{KENO}	1σ	k_{eff}
Intact Fuel 3.7 wt. %, Damaged Fuel 3.3 wt. % 18.9 mg B-10/cm²			
EMD=1.0%	*0.9375*	*0.0009*	*0.9393*
EMD=10%	***0.9376***	***0.0009***	***0.9394***
EMD=20%	*0.9365*	*0.0008*	*0.9381*
EMD=40%	*0.9366*	*0.0009*	*0.9384*
EMD=60%	*0.9346*	*0.001*	*0.9366*
EMD=80%	*0.9374*	*0.0009*	*0.9392*
EMD=100%	*0.9358*	*0.0008*	*0.9374*
Intact Fuel 4.1 wt. %, Damaged Fuel 3.6 wt. % 27.9 mg B-10/cm²			
EMD=1.0%	*0.9372*	*0.0008*	*0.9388*
EMD=10%	*0.9372*	*0.0009*	*0.9390*
EMD=20%	***0.9385***	***0.0008***	***0.9401***
EMD=40%	*0.9379*	*0.0009*	*0.9397*
EMD=60%	*0.9365*	*0.0008*	*0.9381*
EMD=80%	*0.9377*	*0.0009*	*0.9395*
EMD=100%	*0.9363*	*0.0009*	*0.9381*
Intact Fuel 4.4 wt. %, Damaged Fuel 3.6 wt. % 35.1 mg B-10/cm²			
EMD=1.0%	***0.9380***	***0.0009***	***0.9398***
EMD=10%	*0.9364*	*0.0009*	*0.9382*
EMD=20%	*0.9369*	*0.0010*	*0.9389*
EMD=40%	*0.9361*	*0.0009*	*0.9379*
EMD=60%	*0.9376*	*0.0008*	*0.9392*
EMD=80%	*0.9377*	*0.0010*	*0.9397*
EMD=100%	*0.9375*	*0.0009*	*0.9393*
Intact Fuel 4.6 wt. %, Damaged Fuel 3.7 wt. % 41.4 mg B-10/cm²			
EMD=1.0%	*0.9368*	*0.0009*	*0.9386*
EMD=10%	*0.9366*	*0.0008*	*0.9382*
EMD=20%	*0.9360*	*0.0010*	*0.9380*
EMD=40%	*0.9363*	*0.0008*	*0.9379*
EMD=60%	*0.9380*	*0.0008*	*0.9396*
EMD=80%	***0.9379***	***0.0009***	***0.9397***
EMD=100%	*0.9368*	*0.0008*	*0.9384*
Intact Fuel 4.8 wt. %, Damaged Fuel 3.7 wt. % 47.7 mg B-10/cm²			
EMD=1.0%	***0.9390***	***0.0008***	***0.9406***
EMD=10%	*0.9362*	*0.0008*	*0.9378*
EMD=20%	*0.9366*	*0.0009*	*0.9384*
EMD=40%	*0.9379*	*0.0010*	*0.9399*
EMD=60%	*0.9371*	*0.0008*	*0.9387*
EMD=80%	*0.9363*	*0.0008*	*0.9379*
EMD=100%	*0.9376*	*0.0009*	*0.9394*
Intact Fuel 5.0 wt. %, Damaged Fuel 3.9 wt. % 54.9 mg B-10/cm²			
EMD=1.0%	*0.9370*	*0.0010*	*0.9390*
EMD=10%	***0.9375***	***0.0008***	***0.9391***
EMD=20%	*0.9356*	*0.0009*	*0.9374*
EMD=40%	*0.9367*	*0.0011*	*0.9389*
EMD=60%	*0.9360*	*0.0009*	*0.9378*
EMD=80%	*0.9364*	*0.0008*	*0.9380*
EMD=100%	*0.9365*	*0.0011*	*0.9387*

Table A.6.5.2-14
Criticality Analysis Results for DSC with 24 Damaged Fuel Assemblies

Model Description	kKENO	1σ	k_{eff}
Intact Fuel 3.7 wt. %, Damaged Fuel 2.8 wt. % 18.9 mg B-10/cm²			
EMD=1.0%	*0.9365*	*0.0009*	*0.9383*
EMD=10%	*0.9370*	*0.0008*	*0.9386*
EMD=20%	*0.9366*	*0.0008*	*0.9382*
EMD=40%	*0.9376*	*0.0008*	*0.9392*
EMD=60%	*0.9376*	*0.0008*	*0.9392*
EMD=80%	*0.9354*	*0.0008*	*0.9370*
EMD=100%	***0.9387***	***0.0009***	***0.9405***
Intact Fuel 4.1 wt. %, Damaged Fuel 3.0 wt. % 27.9 mg B-10/cm²			
EMD=1.0%	*0.9368*	*0.0008*	*0.9384*
EMD=10%	*0.9363*	*0.0009*	*0.9381*
EMD=20%	***0.9381***	***0.0010***	***0.9401***
EMD=40%	*0.9380*	*0.0009*	*0.9398*
EMD=60%	*0.9369*	*0.0009*	*0.9387*
EMD=80%	*0.9372*	*0.0009*	*0.9390*
EMD=100%	*0.9364*	*0.0008*	*0.9380*
Intact Fuel 4.4 wt. %, Damaged Fuel 3.1 wt. % 35.1 mg B-10/cm²			
EMD=1.0%	***0.9383***	***0.0009***	***0.9401***
EMD=10%	*0.9371*	*0.0008*	*0.9387*
EMD=20%	*0.9380*	*0.0009*	*0.9398*
EMD=40%	*0.9370*	*0.0008*	*0.9386*
EMD=60%	*0.9369*	*0.0009*	*0.9387*
EMD=80%	*0.9372*	*0.0008*	*0.9388*
EMD=100%	*0.9365*	*0.0009*	*0.9383*
Intact Fuel 4.6 wt. %, Damaged Fuel 3.2 wt. % 41.4 mg B-10/cm²			
EMD=1.0%	***0.9371***	***0.0010***	***0.9391***
EMD=10%	*0.9364*	*0.0009*	*0.9382*
EMD=20%	*0.9364*	*0.0009*	*0.9382*
EMD=40%	*0.9362*	*0.0009*	*0.9380*
EMD=60%	*0.9371*	*0.0008*	*0.9387*
EMD=80%	*0.9362*	*0.0009*	*0.9380*
EMD=100%	*0.9349*	*0.0009*	*0.9367*
Intact Fuel 4.8 wt. %, Damaged Fuel 3.2 wt. % 47.7 mg B-10/cm²			
EMD=1.0%	*0.9351*	*0.0009*	*0.9369*
EMD=10%	*0.9363*	*0.0008*	*0.9379*
EMD=20%	*0.9356*	*0.0009*	*0.9374*
EMD=40%	*0.9335*	*0.0009*	*0.9353*
EMD=60%	*0.9345*	*0.0009*	*0.9363*
EMD=80%	*0.9353*	*0.0009*	*0.9371*
EMD=100%	***0.9360***	***0.0011***	***0.9382***
Intact Fuel 5.0 wt. %, Damaged Fuel 3.4 wt. % 54.9 mg B-10/cm²			
EMD=1.0%	*0.9360*	*0.0008*	*0.9376*
EMD=10%	*0.9368*	*0.0009*	*0.9386*
EMD=20%	*0.9350*	*0.0008*	*0.9366*
EMD=40%	*0.9359*	*0.0008*	*0.9375*
EMD=60%	*0.9374*	*0.0008*	*0.9390*
EMD=80%	***0.9385***	***0.0009***	***0.9403***
EMD=100%	*0.9361*	*0.0009*	*0.9379*

Table A.6.5.2-15
Criticality Results

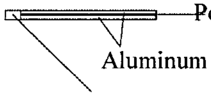
Model Description	k_{KENO}	1σ	k_{eff}
Regulatory Requirements for Transportation			
10CFR Part 71.55(b) (Bounded by infinite array of damaged transport packages)	*0.9388*	*0.0009*	*0.9406*
10CFR Part 71.59(a) (1) NCT Array	*0.4408*	*0.0004*	*0.4416*
10CFR Part 71.59 (a) (2) HAC Array	*0.9388*	*0.0009*	*0.9406*
Regulatory Requirements for Storage			
Dry Storage (Bounded by infinite array of undamaged storage casks)	*0.4408*	*0.0004*	*0.4416*
Normal Conditions (Wet Loading)	*0.9377*	*0.0011*	*0.9399*
Off-Normal Conditions (damaged transfer cask while fuel still wet)	*0.9388*	*0.0009*	*0.9406*
Design Basis Cases for Intact Fuel			
4.8 wt% U-235; 47.7 mgB-10/cm²; 100 % Internal Moderator Density (IMD), Optimum EMD	*0.9377*	*0.0011*	*0.9399*
Design Basis Cases for Damaged Fuel			
Intact @ 4.8 wt% U-235; 4 Damaged @ 4.4 wt% U-235; 47.7 mgB-10/cm², 100 % IMD, Optimum EMD	*0.9388*	*0.0009*	*0.9406*
Intact @ 4.8 wt% U-235; 8 Damaged @ 3.7 wt% U-235 47.7 mgB-10/cm², 100 % IMD, Optimum EMD	*0.939*	*0.0008*	*0.9406*
Intact @ 3.7 wt% U-235; 24 Damaged @ 2.8 wt% U-235 18.9 mgB-10/cm², 100 % IMD, Optimum EMD	*0.9387*	*0.0009*	*0.9405*

Table A.6.5.2-18
USL-1 Results

Parameter	Value from Limiting GE 10x10 Analysis	Bounding USL
Pin Pitch (cm)	1.2954	0.9416
Water to Fuel Volume Ratio	1.411[(1)]	0.9421
Average Energy Group Causing Fission (AEG)	< 34[(2)]	0.9433
Assembly Separation (cm)	*2.59*[(3)]	0.*9415*
Enrichment (wt. % U-235)	2.7 (minimum)	0.9424

(1) The ratio is calculated using the nominal clad OD, which is 0.404".
(2) Examination of the results shows that the value is between 32 and 34, hence a conservative value that produces the minimum USL was chosen.
(3) *From the 24-damaged assemblies case, average separation distance across the third row is calculated as the distance between the inner edges of the outermost assemblies minus the width of the four damaged and three undamaged assemblies in between divided by one less than the number of assemblies: (2 * 59.24053 – 4 * 14.93504 – 3 * 12.6476) / 8 = 2.59cm.*

Unit 15 Poison Plate with Gap for a 3x3 Compartment



Poison Plate; 15.6591 x 0.3175 cm (6.165 x 0.125 inches); Material 9, Borated Aluminum

Aluminum Plates; 15.6591 x 0.15875 cm (6.165 x 0.0625 inches); Material 8, Aluminum

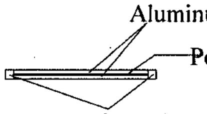
Gap; 0.3175 x 0.635 cm (0.125 x 0.25 inches); Material 3, Water

Unit 16 Gap for a 3x3 Compartment

Gap; 15.9766 x 0.635 cm (6.29 x 0.25 inches); Material 3, Water

Unit 17 Poison Plate with Gap for a 3x3 Compartment

Aluminum Plates; 156591 x 0.15875 cm (6.2275 x 0.0625 inches); Material 8, Aluminum

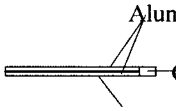


Poison Plate; 15.6591 x 0.3175 cm (6.2275x 0.125 inches); Material 9, Borated Aluminum

Gaps; 0.15875 x 0.635 cm (0.0625 x 0.25 inches); Material 3, Water

Unit 18 Poison Plate with Gap for a 3x3 Compartment

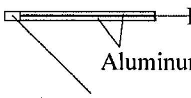
Aluminum Plates; 15.6591 x 0.15875 cm (6. 165x 0.0625 inches); Material 8, Aluminum



Gap; 0.3175 x 0.635 cm (0.125 x 0.25 inches); Material 3, Water

Poison Plate; 15.6591 x 0.3175 cm (6.165 x 0.125 inches); Material 9, Borated Aluminum

Unit 19 Poison Plate with Gap for a 2x2 Compartment



Poison Plate; 15.6591 x 0.3175 cm (6. 165 x 0.125 inches); Material 9, Borated Aluminum

Aluminum Plates; 15.6591 x 0.15875 cm (6. 165 x 0.0625 inches); Material 8, Aluminum

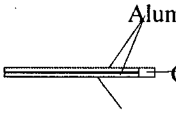
Gap; 0.3175 x 0.635 cm (0.125 x 0.25 inches); Material 3, Water

Unit 20 Gap for a 2x2 Compartment

Gap; 15.9766 x 0.635 cm (6.29 x 0.25 inches); Material 3, Water

Unit 21 Poison Plate with Gap for a 2x2 Compartment

Aluminum Plates; 15.6591 x 0.15875 cm (6.165 x 0.0625 inches); Material 8, Aluminum

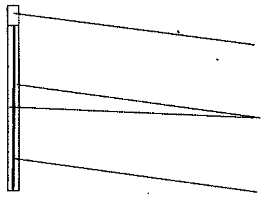


Gap; 0.3175 x 0.635 cm (0.125 x 0.25 inches); Material 3, Water

Poison Plate; 15.6591 x 0.3175 cm (6.165 x 0.125 inches); Material 9, Borated Aluminum

Figure A.6.5.2-3
KENO V.a units and radial cross sections of the model
Part 4 of 23 - (All units 0.635 cm (0.25 inches) high)

Unit 22 Poison Plate with Gap for a 3x3 Compartment



Gap; 0.635 x 0.3175 cm (0.25 x 0.125 inches);
Material 3, Water

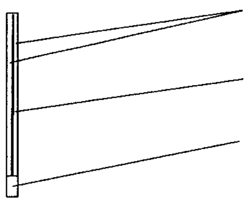
Aluminum plates; 0.15875x 15.6591 cm (0.0625x 6.165 inches);
Material 8, Aluminum

Poison Plate between Al plates; 0.3175 x 15.6591 cm (0.125 x 6.165 inches);
Material 9, Borated Aluminum

Unit 23 Gap for a 3x3 Compartment

Gap; 0.635x 15.9766 cm (0.25x 6.29 inches);
Material 3, Water

Unit 24 Poison Plate with Gap for a 3x3 Compartment

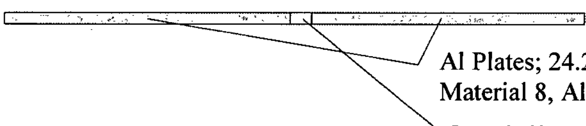


Al plates; 0.15875 x 15.9766cm (0.0625 x 6.165inches);
Material 8, Aluminum

Poison Plate between Al plates; 0.3175x 15.9766 cm (0.1256x.29 inches);
Material 9, Borated Aluminum

Gap; 0.635x 0.3175 cm (0.25x 0.125 inches);
Material 3, Water

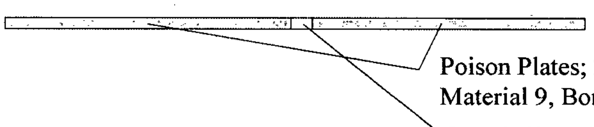
Unit 125 Al Plate with Gap for a 3x3 Compartment



Al Plates; 24.2824 x 0.3175 cm (9.56 x 0.125 inches);
Material 8, Aluminum

Gap; 0.635 x 0.3175 cm (0.25 x 0.125 inches);
Material 3, Water

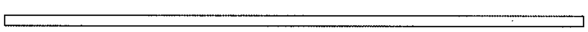
Unit 225 Poison Plate with Gap for a 3x3 Compartment



Poison Plates; 24.2824 x 0.3175 cm (9.56 x 0.125 inches);
Material 9, Borated Aluminum

Gap; 0.635 x 0.3175 cm (0.25 x 0.125 inches);
Material 3, Water

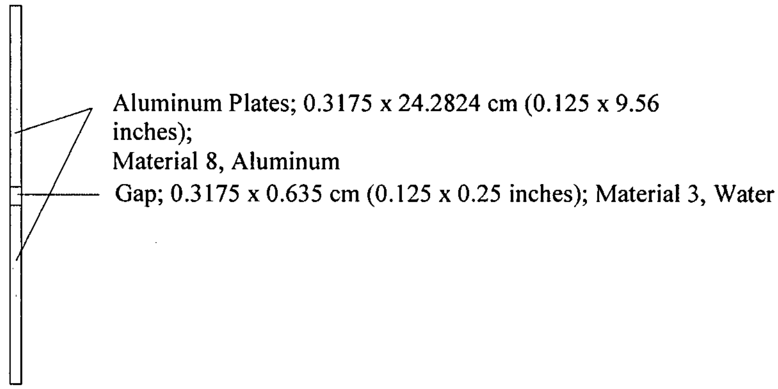
Unit 26 Long Gap for a 3x3 Compartment



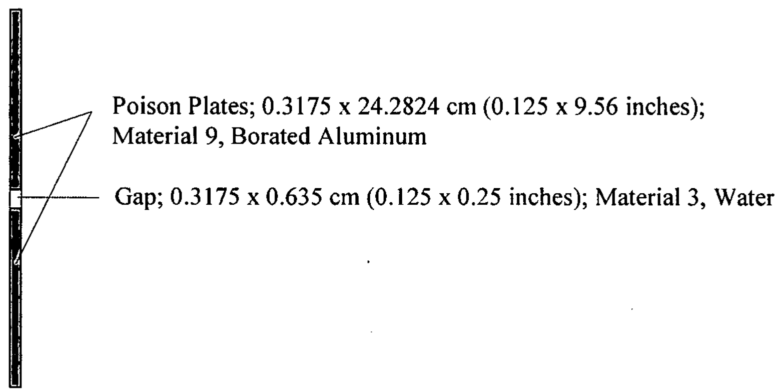
Gap; 49.19980 x 0.3175 cm (19.37 x 0.125 inches);
Material 3, Water

Figure A.6.5.2-3
KENO V.a units and radial cross sections of the model
Part 5 of 23 - (All units 0.635 cm (0.25 inches) high)

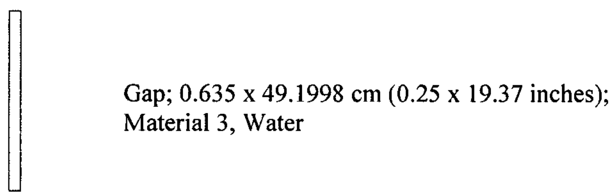
Unit 127 Aluminum Plates with Gap for a 3x3 Compartment



Unit 227 Poison Plates with Gap for a 3x3 Compartment



Unit 28 Gap for a 3x3 Compartment



Unit 129 Aluminum Plates with Gap for a 2x2 Compartment

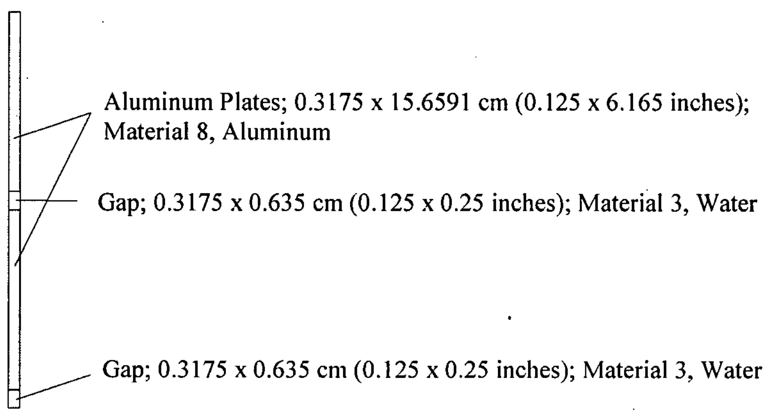
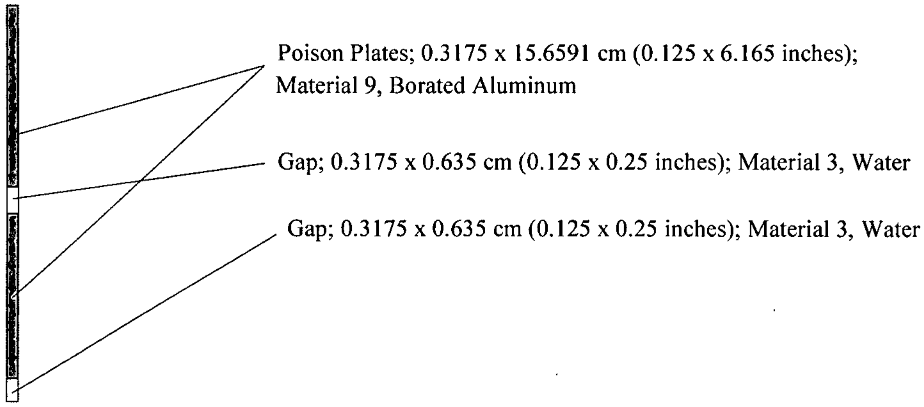
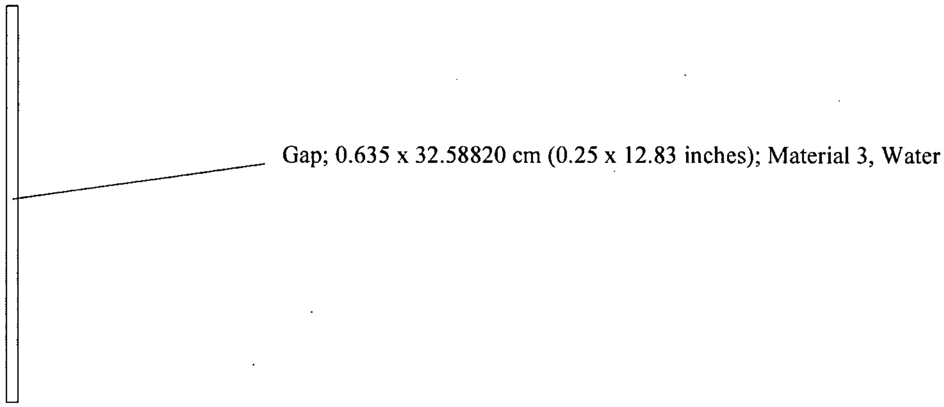


Figure A.6.5.2-3
KENO V.a units and radial cross sections of the model
Part 6 of 23 - (All units 0.635 cm (0.25 inches) high)

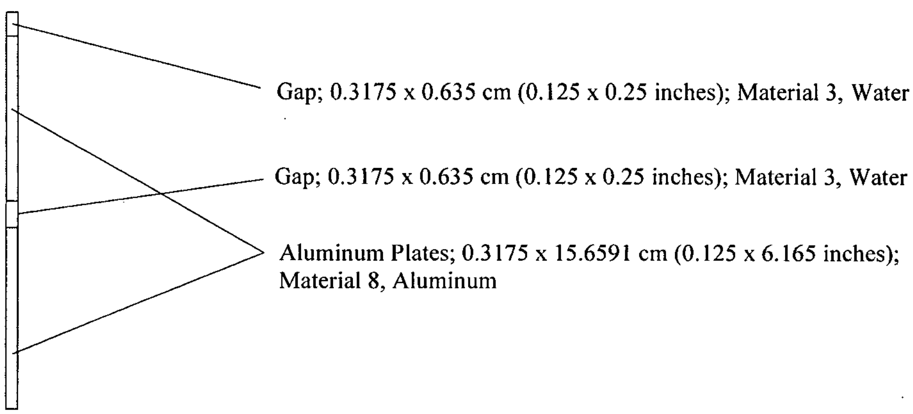
Unit 229 Poison Plates with Gap for a 2x2 Compartment



Unit 30 Gap for a 2x2 Compartment



Unit 131 Aluminum Plates with Gap for a 2x2 Compartment



Unit 231 Poison Plates with Gap for a 2x2 Compartment is identical to Unit 131 except material 8 is replaced by material 9, Borated Aluminum

Figure A.6.5.2-3
KENO V.a units and radial cross sections of the model
Part 7 of 23 - (All units 0.635 cm (0.25 inches) high)

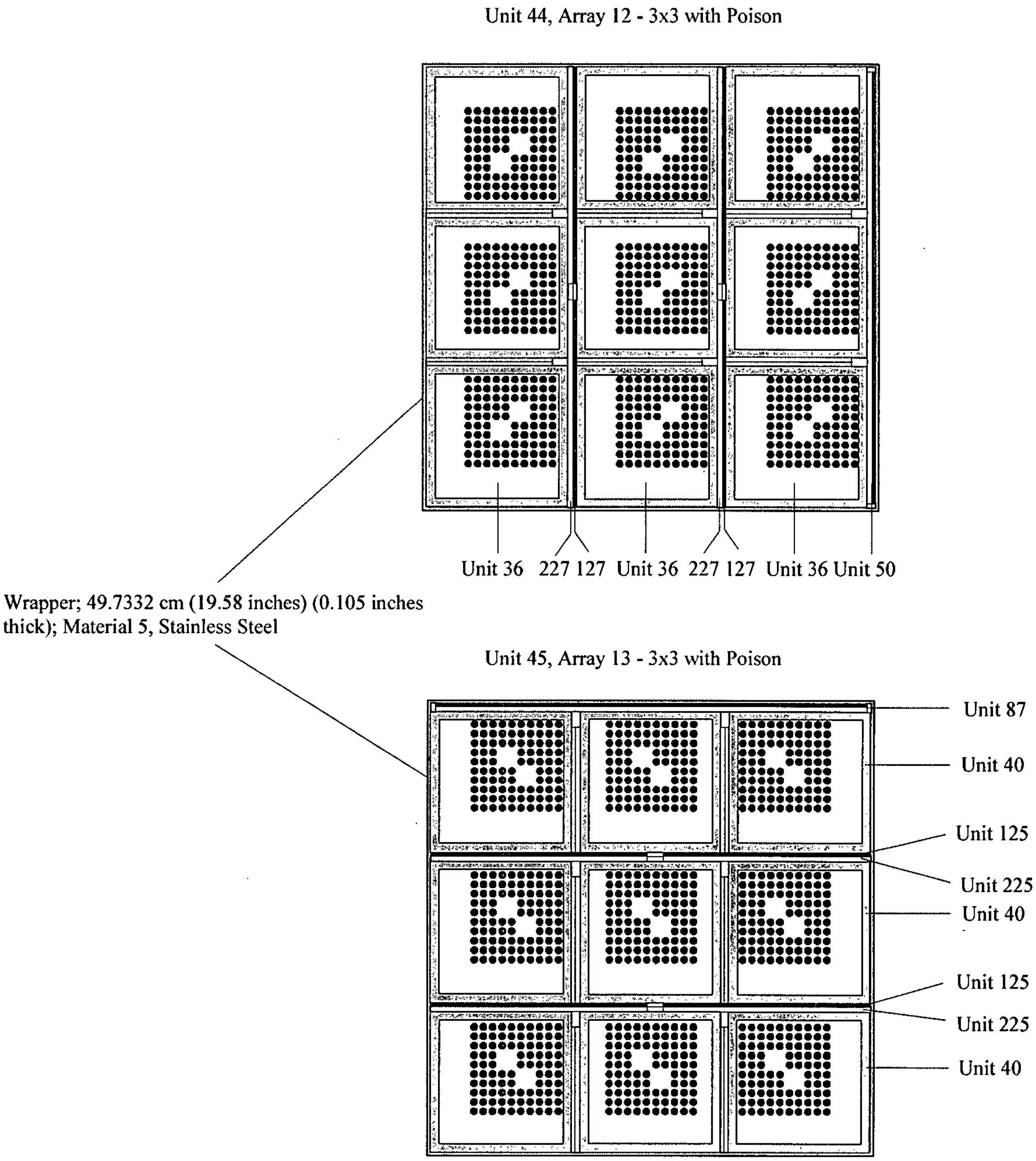
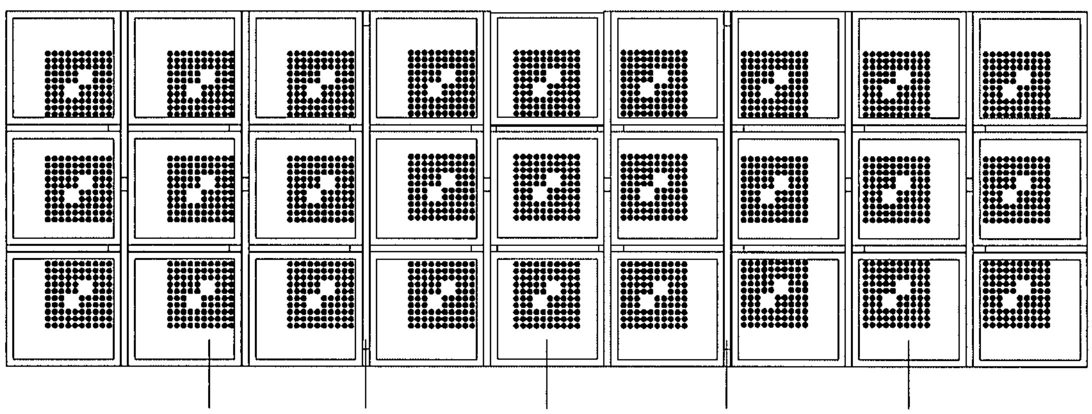


Figure A.6.5.2-3
KENO V.a units and radial cross sections of the model
Part 11 of 23 - (All units 0.635 cm (0.25 inches) high)

Unit 50 Poison Plates between center 3x3 Compartments with Gaps – Outside

Unit 51 Short Gap for 3x3 Compartments – Outside, is identical with Unit 28

Unit 52, Array 20 - Row of 3x3 Compartments with Poison



Unit 53 Long Horizontal Aluminum Plates

Aluminum Plate; 151.1046 x 0.3175 cm (59.49 x 0.125 inches); Material 8, Aluminum

Figure A.6.5.2-3
KENO V.a units and radial cross sections of the model
Part 13 of 23 - (All units 0.635 cm (0.25 inches) high)

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Figure A.6.5.2-3
KENO V.a units and radial cross sections of the model
Part 16 of 23 - (All units 0.635 cm (0.25 inches) high)

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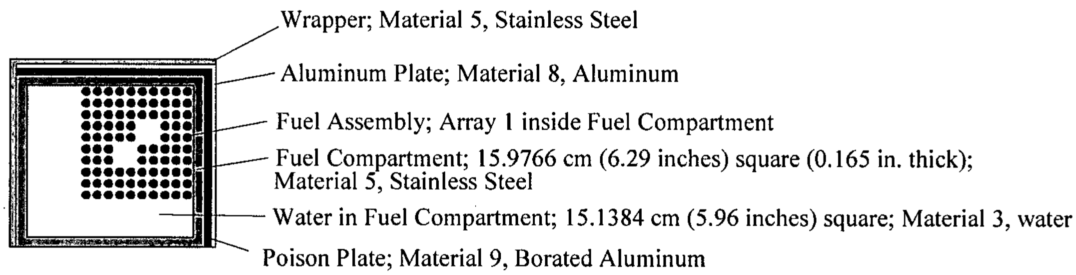
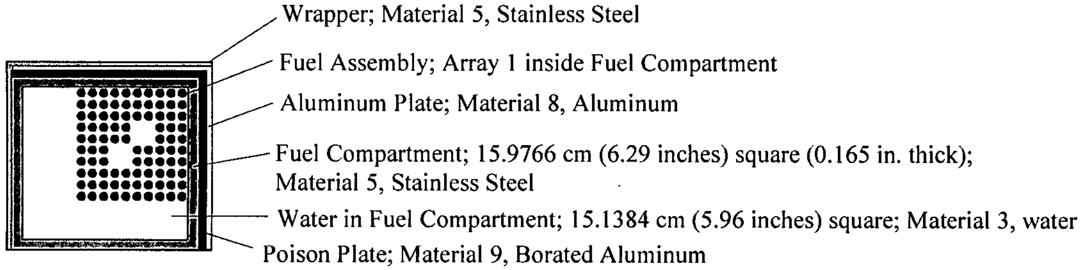
Figure A.6.5.2-3
KENO V.a units and radial cross sections of the model
Part 17 of 23 - (All units 0.635 cm (0.25 inches) high)

Unit 96 Upper Compartment in SW Quadrant



Unit 97 Lower Compartment in SE Quadrant



Unit 98 Upper Compartment in SE Quadrant

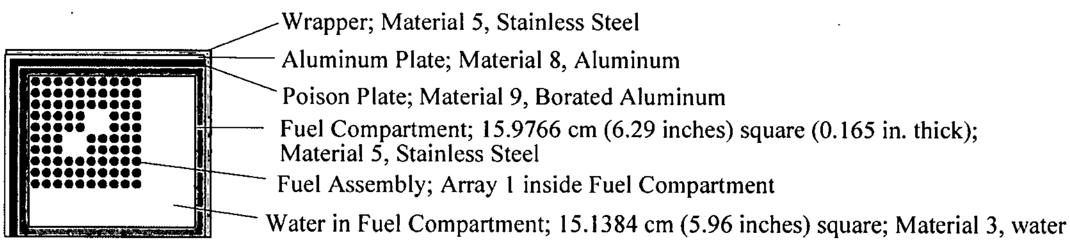


Figure A.6.5.2-3
KENO V.a units and radial cross sections of the model
Part 21 of 23 - (All units 0.635 cm (0.25 inches) high)

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Figure A.6.5.2-3
KENO V.a units and radial cross sections of the model
Part 22 of 23 - (All units 0.635 cm (0.25 inches) high)

DELETED

Figure A.6.5.2-3
KENO V.a units and radial cross sections of the model
Part 23 of 23 - (All units 0.635 cm (0.25 inches) high)

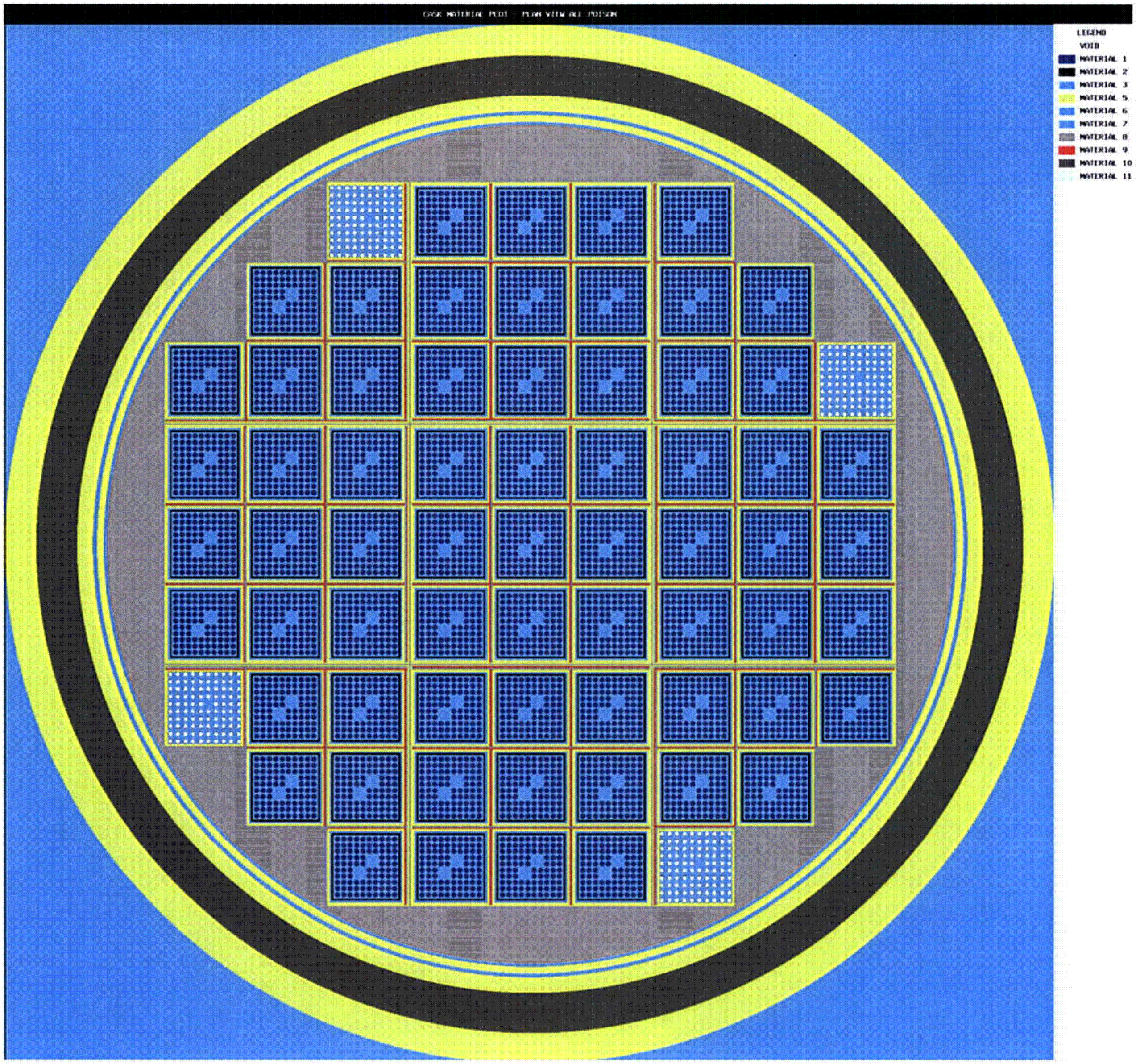

Figure A.6.5.2-12
69BTH DSC Damaged Assembly Loading–4 Assemblies

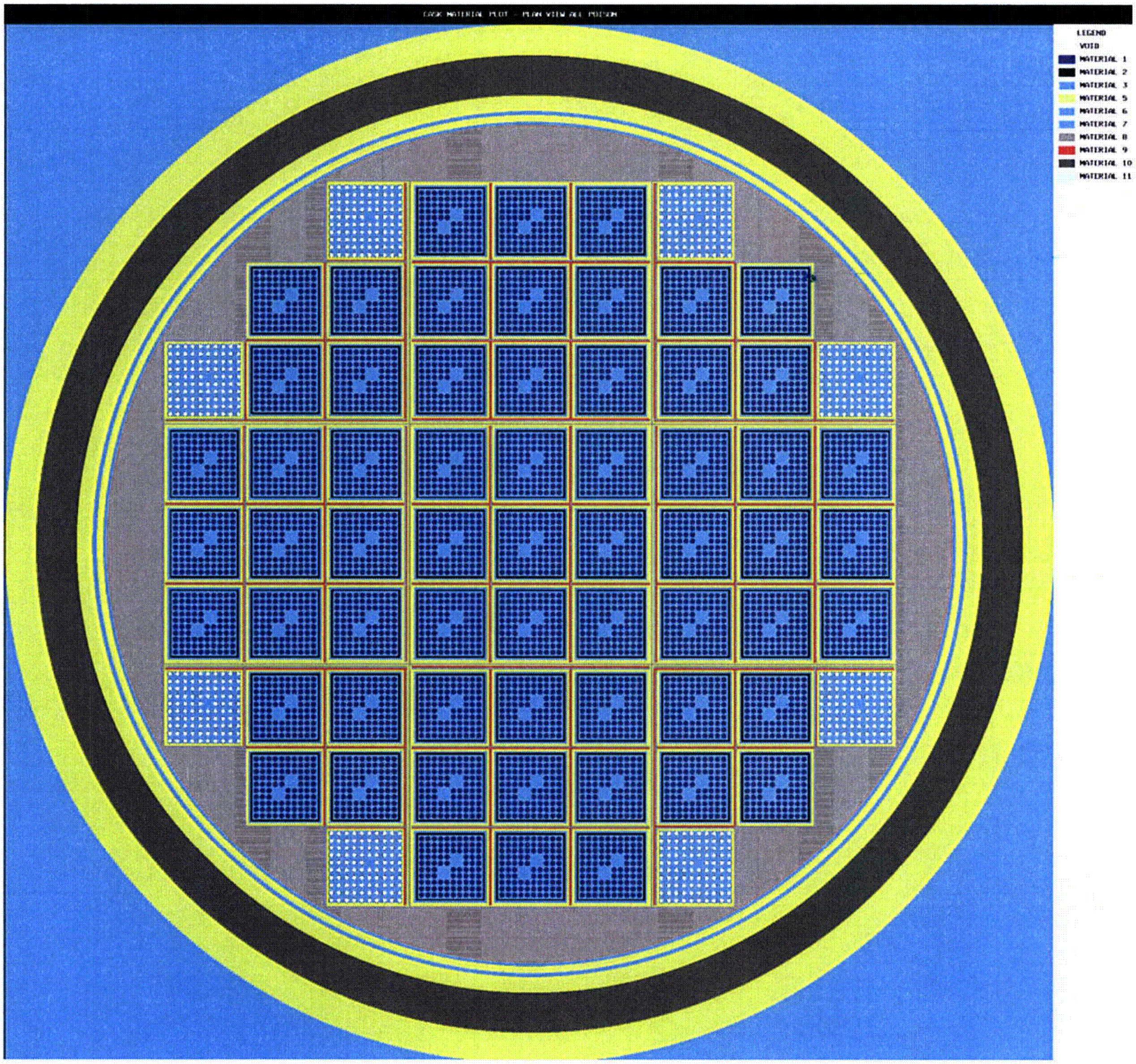

Figure A.6.5.2-13
69BTH DSC Damaged Assembly Loading–8 Assemblies

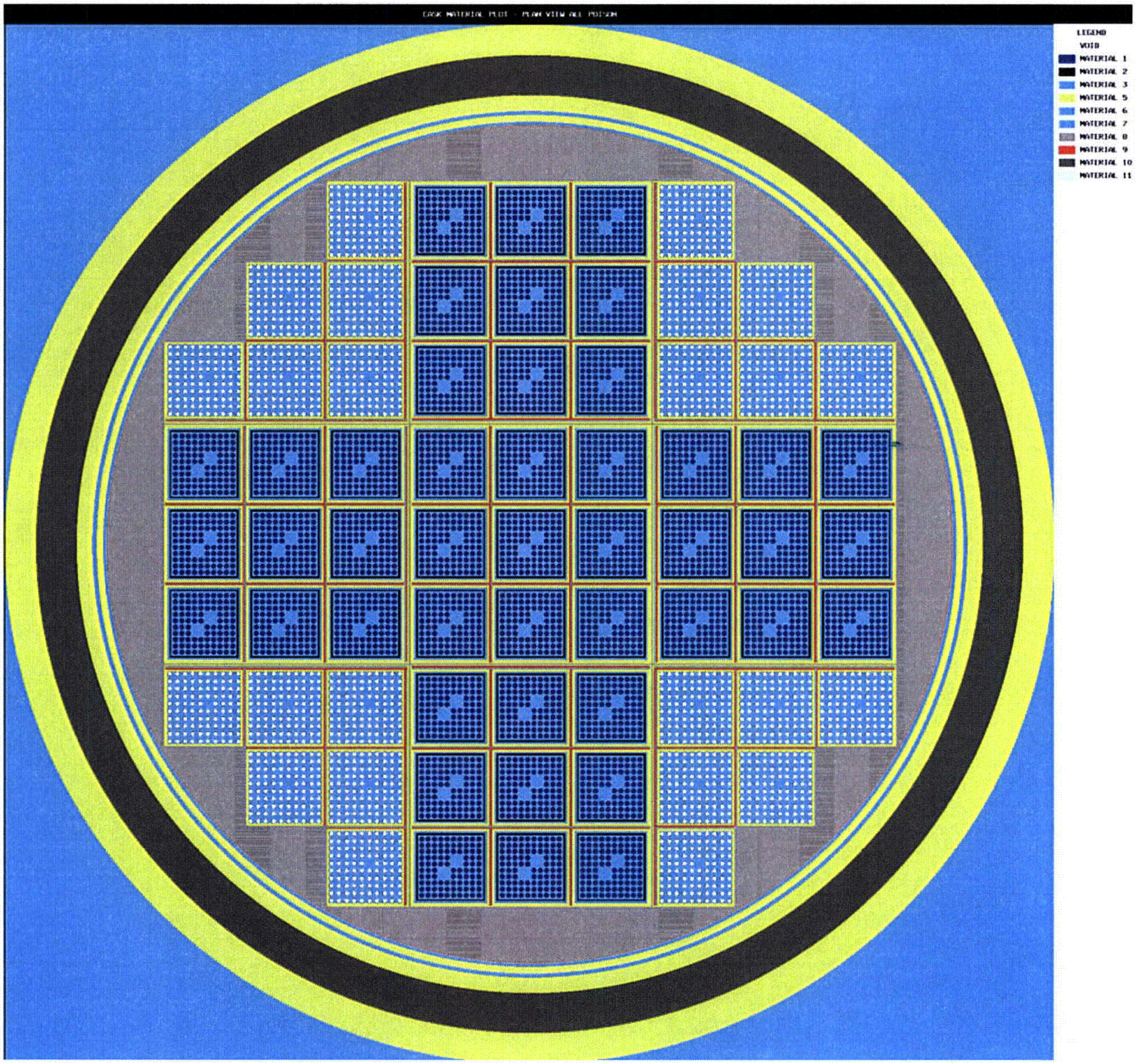

Figure A.6.5.2-14
69BTH DSC Damaged Assembly Loading–24 Assemblies

Appendix A.6.5.3
NUHOMS®-24PT4 DSC Criticality Evaluation

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A.6.5.3.4 Criticality Calculations

This section contains descriptions of the calculational methods used to determine the nuclear reactivity for the maximum fuel loading intended to be stored in the 24PT4-DSC.

A.6.5.3.4.1 Calculational Method

The effective neutron multiplication factor (k_{eff}) was calculated using the CSAS25 module of the SCALE 4.4 Code with the 44-group ENDF/B-V cross-section library [3]. The control module CSAS25 includes the three dimensional criticality code KENO V.a and the preprocessing codes BONAMI-S, NITAWL-II and XSDRNPM-S.

All the input decks were run with 500 generations with 1000 neutrons per generation. Five neutron generations were omitted before collecting the results. These values provided for a well converged solution.

Section A.6.*5.3.8* contains a listing of select KENO V.a input files.

A.6.5.3.4.2 Fuel Loading Optimization

A Determination of the Most Reactive Intact Fuel Configuration

The following parametric studies were performed for a Boral® sheet with 0.025 g/cm^2 ^{10}B areal density at a maximum fuel enrichment of 4.2 wt. % ^{235}U (except as noted) to determine the worst case geometry. This fuel to poison plate combination is designed to be similar in reactivity to the combination of 0.068 g/cm^2 ^{10}B areal density at a maximum fuel enrichment of 4.85 wt. % ^{235}U and therefore, the results from the parametric studies are applicable to all the fuel to poison plate combinations discussed in this chapter.

1. Most Reactive Fuel Pellet OD assuming 236 fuel rods in the fuel assembly.
2. Most Reactive Fuel Clad Thickness using the worst case model from Step 1.
3. Most Reactive Fuel Rod OD using the worst case model from Step 2.
4. Most Reactive Fuel Assembly using the worst case model from Step 3 and varying the absorber rod configurations for an enrichment of 4.1 wt. % ^{235}U.
5. Boral® Sheet Thickness using the worst case model from Step 4.

The following studies were performed for both a Boral® sheet with 0.025 g/cm^2 ^{10}B areal density at a maximum fuel enrichment of 4.1 wt. % ^{235}U and 0.068 g/cm^2 ^{10}B areal density at a maximum fuel enrichment of 4.85 wt. % ^{235}U using the worst case geometry as determined in Step 6:

6. Most Reactive Fuel Assembly Position using the worst case model from Step 5 (both the fuel/poison design are investigated).
7. Internal Moderator Density Varying.
8. External Moderator Density Varying.

Proprietary information on pages A.6.5.3-24 to A.6.5.3-24ll withheld pursuant to 10 CFR 2.390

Appendix A.6.5.4
NUHOMS®-32PTH/32PTH1 DSC Criticality Evaluation

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close full reflection between packages and no inleakage of water as required by 10 CFR Part 71.59(a)(1). In addition, as required by 10 CFR Part 71.59(a)(2), two times "N" or an infinite array of packages is shown to be subcritical with the fissile material in its most reactive configuration, optimum water moderation and close full water reflection consistent with its damaged condition. A CSI of 0 (less than 50) ensures that, per 10 CFR Part 71.59 (c)(1), the package may be shipped by a carrier in a nonexclusive conveyance.

Table A.6.5.4-1 lists the fuel assemblies considered as authorized contents of the NUHOMS® 32PTH1 DSC. A detailed criticality analysis of the NUHOMS® 32PTH1 DSC that meets the applicable requirements of Part 72 for storage is documented in Appendix U, Chapter U.6 associated with Amendment 10 to Part 72 CoC 1004 for the Standardized NUHOMS® System [5]. The results of the sensitivity calculations to determine the most reactive configuration of the fuel assemblies / basket materials is directly utilized herein. The design basis models from the storage calculations are utilized as starting models for the criticality analysis documented herein.

Table A.6.5.4-1 lists the fuel assemblies considered as authorized contents of the NUHOMS® 32PTH DSC. *A detailed* criticality analysis of the NUHOMS® 32PTH DSC that meets the applicable requirements of Part 72 for storage is documented in Chapter 6 of the NUHOMS® HD System (CoC 1030) UFSAR [6]. The results of the sensitivity calculations to determine the most reactive configuration of the fuel assemblies / basket materials is directly utilized herein. The design basis models from the storage calculations are utilized as starting models for the criticality analysis documented herein.

The criticality analysis begins by determining the most reactive DSC model from among the 32PTH1 and the 32PTH DSCs. Based on the results and modeling considerations of the Part 72 criticality analyses, the 32PTH1 DSC model is conservatively employed in the criticality calculations. The most reactive configuration for the basket (including transition rail configuration) and fuel assembly position utilized in the design basis storage models is then employed to determine the starting models for the criticality analysis documented herein.

The criticality analysis is performed using *two* bounding fuel assembly classes identified in Table A.6.5.4-1. These are the Westinghouse (WE) 17x17 and the WE 14x14 classes. The results of the WE 17x17 class bound those of the WE 15x15, the Babcock and Wilcox (B&W) 15x15, the *Combustion Engineering (*CE*)* 14x14, the CE 16x16 and CE 15x15 classes as *determined* in *Section A.6.2.6 of the SAR.*

Next, criticality calculations are performed to determine the minimum assembly average burnup as a function of initial enrichment and cooling time for the *two* fuel assembly classes as a function of basket poison type which are listed in Table A.6.5.4-14. The calculations determine k_{eff} with the CSAS25 control module of SCALE-4.4 [1] for each assembly *class* and initial enrichment, including all uncertainties to assure criticality safety under all credible conditions. Note that burnup credit is employed in the criticality analysis of the NUHOMS® -32PTH1 DSC.

The Control Components (CCs) are also authorized for storage in the 32PTH1 DSCs. The authorized CCs are Burnable Poison Rod Assemblies (BPRAs), Control Rod Assemblies (CRAs), Thimble Plug Assemblies (TPAs), Axial Power Shaping Rod Assemblies (APSRAs),

Proprietary information on pages A.6.5.4-4 to A.6.5.4-16 withheld pursuant to 10 CFR 2.390

A.6.5.4.6 References

1. Oak Ridge National Laboratory, RSIC Computer Code Collection, "SCALE: A Modular Code System for Performing Standardized Computer Analysis for Licensing Evaluations for Workstations and Personal Computers," NUREG/CR-0200, Revision 6, ORNL/NUREG/CSD-2/V2/R6.
2. 10 CFR 71, Packaging and Transportation of Radioactive Materials.
3. U.S. Nuclear Regulatory Commission, "Criticality Benchmark Guide for Light-Water-Reactor fuel in Transportation and Storage Packages," NUREG/CR-6361, Published March 1997, ORNL/TM-13211.
4. U.S. Nuclear Regulatory Commission, "Recommendations for Preparing the Criticality Safety Evaluation of Transportation Packages," NUREG/CR-5661, Published April 1997, ORNL/TM-11936.
5. *NUH-003, Updated Final Safety Analysis Report for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel (UFSAR), Revision 11. The Certificate of Compliance (CoC) for Amendment 10 to Part 72 CoC 1004 was issued on August 24, 2009.*
6. NUHOMS® HD Updated Final Safety Analysis Report, Revision *2*.

Proprietary information on pages A.6.5.4-18 to A.6.5.4-32 and pages A.6.5.4-32a to A.6.5.4-32u withheld pursuant to 10 CFR 2.390

Proprietary information on pages A.6.5.4-39 and A.6.5.4-40 withheld pursuant to 10 CFR 2.390

Proprietary information on pages A.6.5.4-42 to A.6.5.4-65, and pages A.6.5.4-65a to A.6.5.4-65c withheld pursuant to 10 CFR 2.390

Figure A.6.5.4-3
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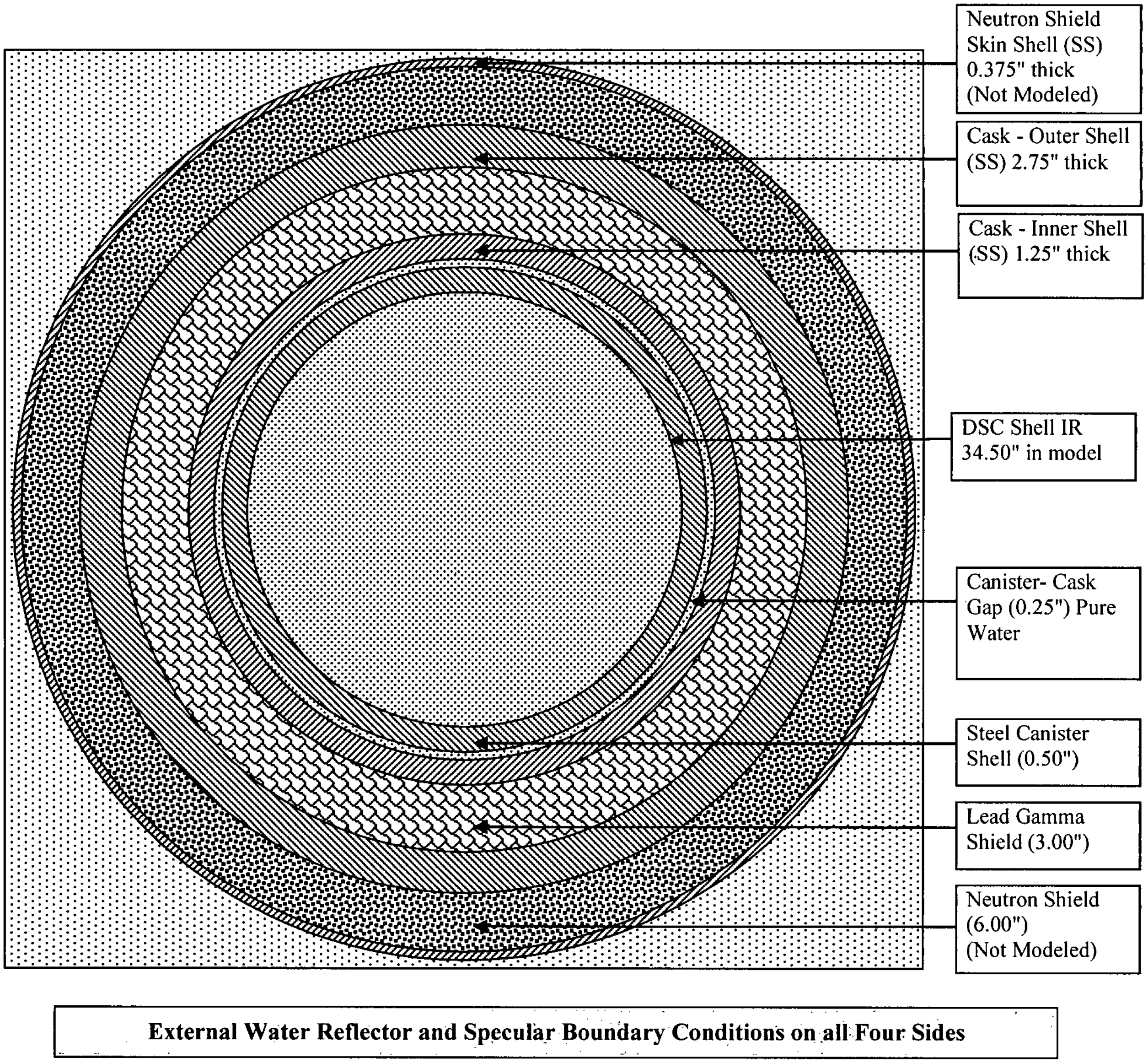

Figure A.6.5.4-5
Criticality Calculational KENO Model

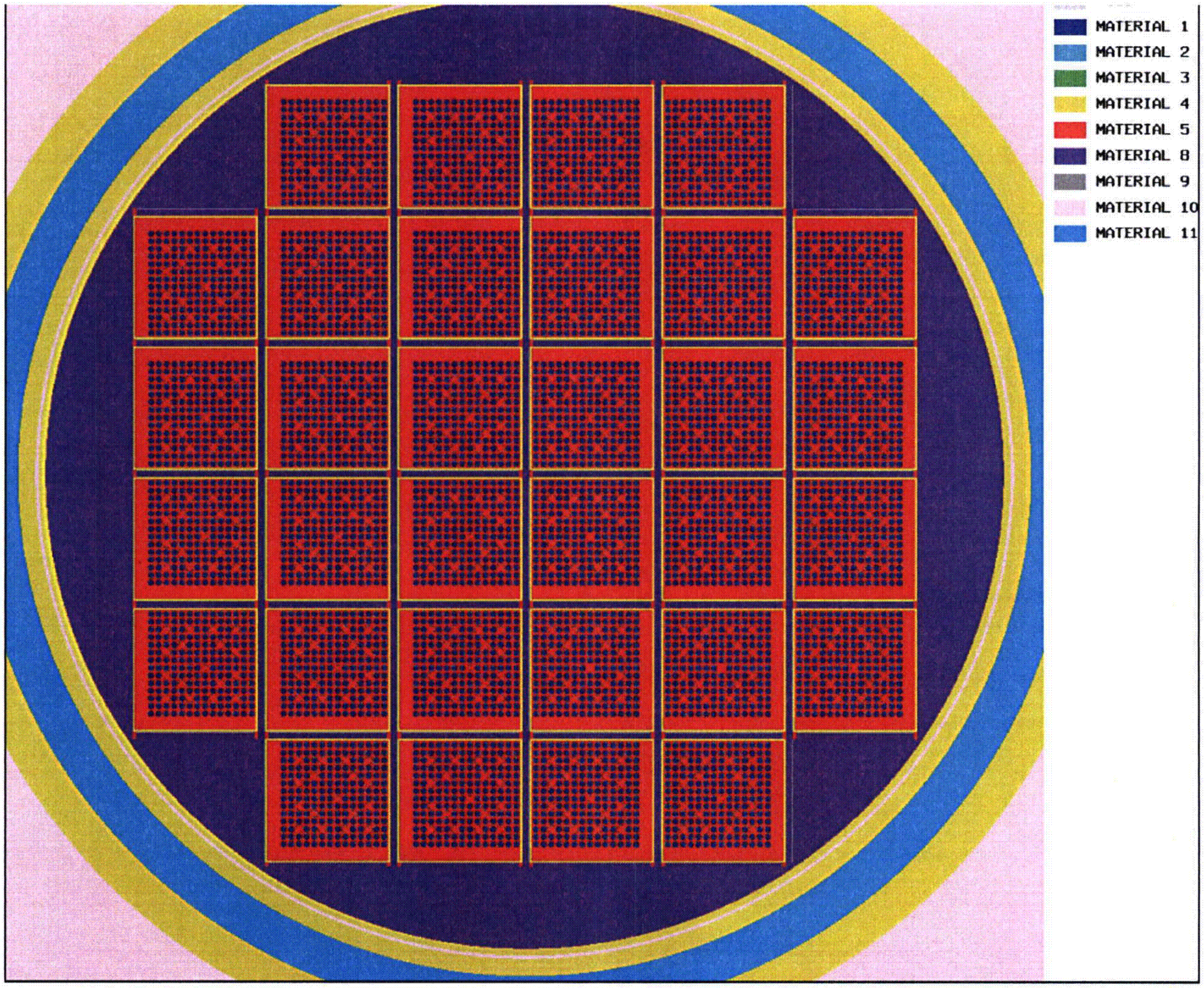

Figure A.6.5.4-7
WE 14x14 Class Assembly KENO Model

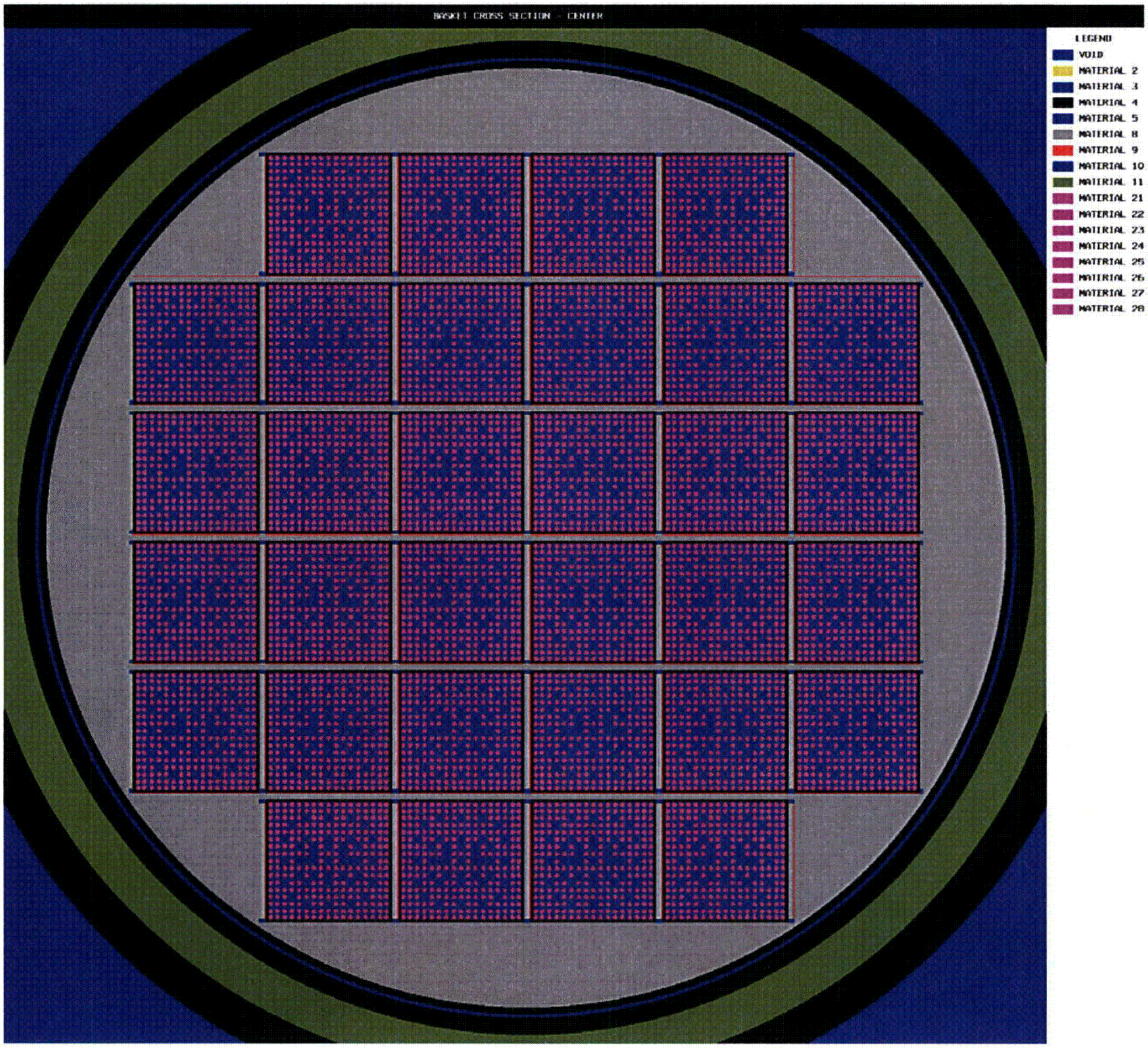

Figure A.6.5.4-8
WE *17x17* Class *Damaged* Assembly KENO Model

Appendix A.6.5.5
NUHOMS®-24PTH DSC Criticality Evaluation

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Appendix A.6.5.5
NUHOMS®-24PTH DSC Criticality Evaluation

NOTE: References in this Appendix are shown as [1], [2], etc. and refer to the reference list in Section A.6.5.5.5.

This Appendix A.6.5.5 to Chapter A.6 demonstrates that the MP197HB package when transporting the NUHOMS®-24PTH DSC payload meets the criticality performance requirements specified in Sections 71.55 and 71.59 of 10 CFR Part 71 [2]. The criticality control design ensures that the effective multiplication factor (k_{eff}) of the contained fuel is no greater than an Upper Subcritical Limit (USL) for the most reactive configuration. The USL includes a confidence band with an administrative safety margin of 0.05. The design has a Criticality Safety Index (CSI, given in 10 CFR 71.59(b) as CSI = 50/"N") of 0 because "N" is infinity (∞). The number "N" is based on all of the following conditions being satisfied, assuming packages are stacked together in any arrangement and with close full reflection on all sides of the stack by water:

1. Five times "N" undamaged packages with nothing between the packages are subcritical;
2. Two times "N" damaged packages, if each package is subjected to the tests specified in 10 CFR Part 71.73 (HAC) is subcritical with optimum interspersed hydrogenous moderation; and
3. The value of "N" cannot be less than 0.5.

A.6.5.5.1 Discussion and Results

The NUHOMS® -24PTH DSC design is described in detail in Chapter A.1, Appendix A.1.4.3. Figure A.6.5.5-1 shows the radial cross section of the NUHOMS® -24PTH DSC. The NUHOMS® 24PTH DSC stainless steel basket consists of an "egg-crate" plate design. The fuel assemblies are housed in 24 stainless steel fuel compartment tubes. The basket structure, including the fuel compartment tubes, is held together with stainless steel insert plates and the poison and aluminum plates that form the "egg-crate" structure. The basket compartment structure is connected to perimeter transition rail assemblies, portions of it comprising of aluminum interface. The fuel compartment tube structure is connected to perimeter transition rail assemblies as shown on the drawings in Chapter A.1, Appendix A.1.4.10. The poison/aluminum plates are located between the fuel compartment tubes, as shown in Figure A.6.5.5-2.

The NUHOMS® -MP197HB Cask containing the NUHOMS® -24PTH DSC is shown to be subcritical for an infinite array of flooded undamaged casks and for an infinite array of damaged casks after being subjected to hypothetical accident conditions. "N" is equal to ∞. The cask is shown to be subcritical for five times "N" or an infinite number of undamaged packages with close full reflection between packages and no inleakage of water as required by 10 CFR Part 71.59(a)(1). In addition, as required by 10 CFR Part 71.59(a)(2), two times "N" or an infinite array of packages is shown to be subcritical with the fissile material in its most reactive configuration, optimum water moderation and close full water reflection consistent with its damaged condition. A CSI of 0 (less than 50) ensures that, per 10 CFR Part 71.59 (c)(1), the package may be shipped by a carrier in a nonexclusive conveyance.

Table A.6.5.5-1 lists the fuel assemblies considered as authorized contents of the NUHOMS® 24PTH DSC. A detailed criticality analysis of the NUHOMS® 24PTH DSC that meets the applicable requirements of Part 72 for storage is documented in Appendix P, Chapter P.6 of the Standardized NUHOMS® System UFSAR (CoC 1004) [6]. The results of the sensitivity calculations to determine the most reactive configuration of the fuel assemblies / basket materials is directly utilized herein. The design basis models from the storage calculations are utilized as starting models for the criticality analysis documented herein.

The criticality analysis is performed using *two* bounding fuel assembly classes identified in Table A.6.5.5-1. These are the Westinghouse (WE) 17x17 and the WE 14x14 classes. The results of the WE 17X17 class bound those of the WE 15x15, the Babcock and Wilcox (B&W) 15x15, the *Combustion Engineering (*CE*)* 14x14, the CE 16x16, and CE 15x15 classes.

Criticality calculations are performed to determine the minimum assembly average burnup as a function of initial enrichment and cooling time for the *two* fuel assembly classes as a function of basket poison type which are listed in Table A.6.5.5-9. The calculations determine k_{eff} with the CSAS25 control module of SCALE-4.4 [1] for each assembly *class* and initial enrichment, including all uncertainties to assure criticality safety under all credible conditions. Note that burnup credit is employed in the criticality analysis of the NUHOMS® -24PTH DSC.

The Control Components (CCs) are also authorized for storage in the 24PTH DSCs. The authorized CCs are Burnable Poison Rod Assemblies (BPRAs), Control Rod Assemblies (CRAs), Thimble Plug Assemblies (TPAs), Axial Power Shaping Rod Assemblies (APSRAs), Control Element Assemblies (CEAs), Vibration Suppressor Inserts (VSIs), Orifice Rod Assemblies (ORAs), Neutron Source Assemblies (NSAs), and Neutron Sources.

The results of the evaluation demonstrate that the maximum k_{eff}, including statistical uncertainty, is less than the USL determined from a statistical analysis of benchmark criticality experiments. The statistical analysis procedure includes a confidence band with an administrative safety margin of 0.05.

Proprietary information on pages A.6.5.5-4 to A.6.5.5-16, withheld pursuant to 10 CFR 2.390

A.6.5.5.5 References

1. Oak Ridge National Laboratory, RSIC Computer Code Collection, "SCALE: A Modular Code System for Performing Standardized Computer Analysis for Licensing Evaluations for Workstations and Personal Computers," NUREG/CR-0200, Revision 6, ORNL/NUREG/CSD-2/V2/R6.
2. 10 CFR 71, Packaging and Transportation of Radioactive Materials.
3. U.S. Nuclear Regulatory Commission, "Criticality Benchmark Guide for Light-Water-Reactor fuel in Transportation and Storage Packages," NUREG/CR-6361, Published March 1997, ORNL/TM-13211.
4. U.S. Nuclear Regulatory Commission, "Recommendations for Preparing the Criticality Safety Evaluation of Transportation Packages," NUREG/CR-5661, Published April 1997, ORNL/TM-11936.
5. *NOT USED*
6. NUH-003, Updated Final Safety Analysis Report for the Standardized NUHOMS® Horizontal Modular Storage System for the Irradiated Nuclear Fuel (UFSAR), Revision *11*.

Proprietary information on pages A.6.5.5-18 to A.6.5.4-34 and pages A.6.5.5-34a to A.6.5.5-34ff withheld pursuant to 10 CFR 2.390

Table A.6.5.5-1
Authorized Contents for NUHOMS®-*24PTH* System

Assembly Type[(1)]	Array	Assembly Class
Westinghouse 17x17 LOPAR/Standard	17x17	WE 17x17
Westinghouse 17x17 OFA/Vantage 5[(2)]	17x17	WE 17x17
Framatome 17x17 MK BW	17x17	WE 17x17
Westinghouse 17x17 RFA	17x17	WE 17x17
CE 16x16 System 80	16x16	CE 16x16
CE 16x16 Standard	16x16	CE 16x16
B&W 15x15 Mark B (through B11)	15x15	BW 15x15
B&W 17x17 Mark C	17x17	BW 15x15
CE 15x15 Palisades	15x15	CE 15x15
Exxon/ANF (ANP) 15x15 CE	15x15	CE 15x15
Exxon/ANF (ANP) 15x15 WE	15x15	WE 15x15
Westinghouse 15x15 Standard/ZC	15x15	WE 15x15
Westinghouse 15x15 LOPAR/OFA/ DRFA/Vantage 5	15x15	WE 15x15
CE 14x14 Standard/Generic	14x14	CE 14x14
CE 14x14 Fort Calhoun	14x14	CE 14x14
Framatome-ANP 14x14 CE	14x14	CE 14x14
Exxon/ANF (ANP) 14x14 WE	14x14	WE 14x14
Exxon/ANF (ANP) 14x14 Toprod	14x14	WE 14x14
Westinghouse 14x14 Standard/LOPAR/ZCA/ZCB	14x14	WE 14x14
Westinghouse 14x14 OFA	14x14	WE 14x14

Notes:
(1) Reload fuel from other manufacturers with these parameters are also acceptable.
(2) Includes all Vantage versions (5, +, ++, 5H, etc.).

Proprietary information on pages A.6.5.5-37 to A.6.5.5-39 withheld pursuant to 10 CFR 2.390

Proprietary information on pages A.6.5.5-41 to A.6.5.5-52 withheld pursuant to 10 CFR 2.390

Figure A.6.5.5-4
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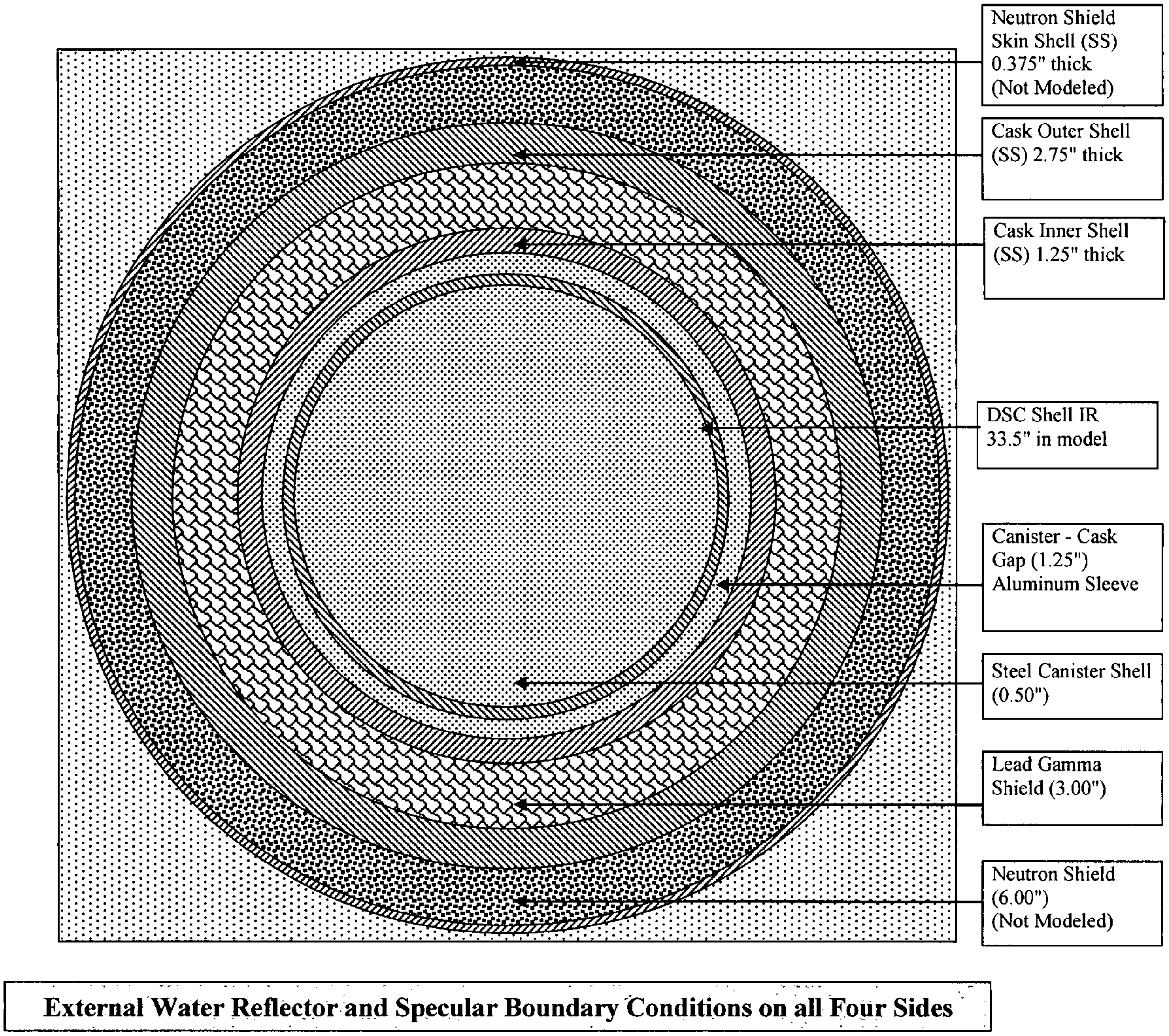

Figure A.6.5.5-7
Criticality Calculational KENO Model

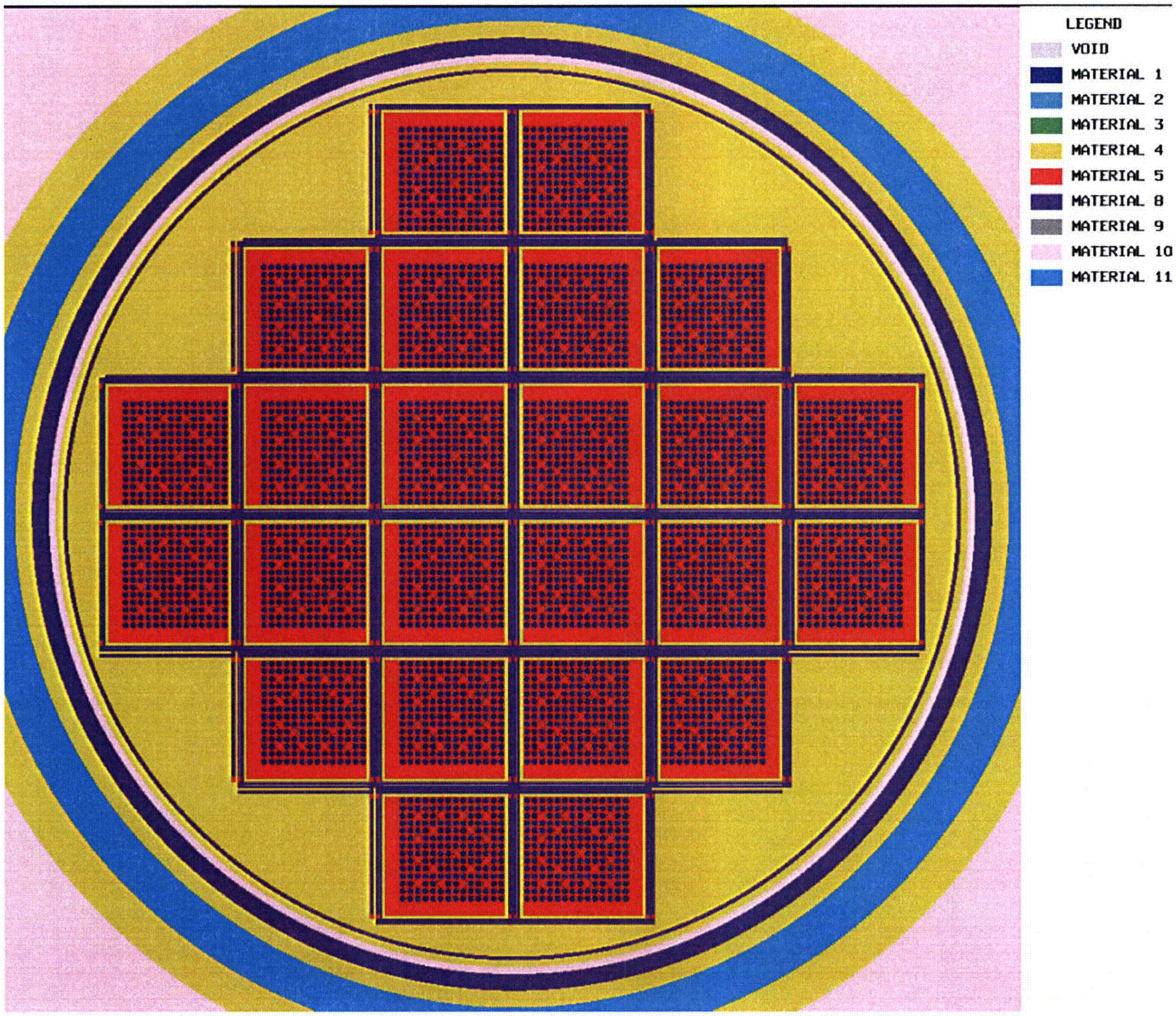

Figure A.6.5.5-9
WE 14x14 Class Assembly KENO Model

Figure A.6.5.5-10
DELETED

Appendix A.6.5.6
NUHOMS®-32PT DSC Criticality Evaluation

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because assuming a higher B_4C content is not expected to reduce the reactivity of the system because PRA rods are already "black" to the neutrons in the system.

Three different basket types are applicable to the 32PT DSC depending on the number and orientation of the L-shaped poison/aluminum inserts. They are described as follows:

- 16-plate configuration (16PP) containing fixed poison in 16 compartments. Fuel assemblies containing PRAs are not authorized in this configuration
- 20-plate configuration (20PP) containing fixed poison in 20 compartments. Fuel assemblies containing 4, 8 or 16 PRAs are authorized in this configuration.
- 24-plate configuration (24PP) containing fixed poison in 24 compartments. Fuel assemblies containing 4, 8 or 16 PRAs are authorized in this configuration.

The arrangement of poison/aluminum plates in the fuel compartments of the basket for these three configurations is shown in Figure A.6.5.6-6 through Figure A.6.5.6-8. The mandatory location of the PRAs for the 4, 8 or 16 PRA configurations is shown in Figure A.6.5.6-2 through Figure A.6.5.6-4.

The NUHOMS®-MP197HB Cask containing the NUHOMS®-32PT DSC is shown to be subcritical for an infinite array of flooded undamaged casks and for an infinite array of damaged casks after being subjected to hypothetical accident conditions. "N" is equal to ∞. The cask is shown to be subcritical for five times "N" or an infinite number of undamaged packages with close full reflection between packages and no inleakage of water as required by 10 CFR Part 71.59(a)(1). In addition, as required by 10 CFR Part 71.59(a)(2), two times "N" or an infinite array of packages is shown to be subcritical with the fissile material in its most reactive configuration, optimum water moderation and close full water reflection consistent with its damaged condition. A CSI of 0 (less than 50) ensures that, per 10 CFR Part 71.59 (c)(1), the package may be shipped by a carrier in a nonexclusive conveyance.

Table A.6.5.6-1 lists the fuel assemblies considered as authorized contents of the NUHOMS®-32PT DSC. A detailed criticality analysis of the NUHOMS®-32PT DSC that meets the applicable requirements of Part 72 for storage is documented in Appendix M, Chapter M.6 of the Standardized NUHOMS® System (CoC-1004) [6]. The results of the sensitivity calculations to determine the most reactive configuration of the fuel assemblies / basket materials is directly utilized herein. The design basis models from the storage calculations are utilized as starting models for the criticality analysis documented herein.

The criticality analysis is performed using *two* bounding fuel assembly classes identified in Table A.6.5.6-1. These are the Westinghouse (WE) 17x17, and the WE 14x14 classes. The results of the WE 17X17 class bound those of the WE 15x15, the Babcock and Wilcox (B&W) 15x15, *the Combustion Engineering (CE) 14x14,* the CE 16x16 and CE 15x15 classes.

Criticality calculations are performed to determine the minimum assembly average burnup as a function of initial enrichment and cooling time for the *two* fuel assembly classes as a function of basket/poison type which are listed in Table A.6.5.6-8. The calculations determine k_{eff} with the CSAS25 control module of SCALE-4.4 [1] for each assembly type and initial enrichment,

Proprietary information on pages A.6.5.6-5 to A.6.5.6-13 withheld pursuant to 10 CFR 2.390

A.6.5.6.5 References

1. Oak Ridge National Laboratory, RSIC Computer Code Collection, "SCALE: A Modular Code System for Performing Standardized Computer Analysis for Licensing Evaluations for Workstations and Personal Computers," NUREG/CR-0200, Revision 6, ORNL/NUREG/CSD-2/V2/R6.
2. 10 CFR 71, Packaging and Transportation of Radioactive Materials.
3. U.S. Nuclear Regulatory Commission, "Criticality Benchmark Guide for Light-Water-Reactor fuel in Transportation and Storage Packages," NUREG/CR-6361, Published March 1997, ORNL/TM-13211.
4. U.S. Nuclear Regulatory Commission, "Recommendations for Preparing the Criticality Safety Evaluation of Transportation Packages," NUREG/CR-5661, Published April 1997, ORNL/TM-11936.
5. *NOT USED*
6. NUH-003, Updated Final Safety Analysis Report for the Standardized NUHOMS® Horizontal Modular Storage System for the Irradiated Nuclear Fuel (UFSAR), Revision *11*.

Proprietary information on pages A.6.5.6-15 to A.6.5.6-24 and page A.6.5.6-24a withheld pursuant to 10 CFR 2.390

Proprietary information on pages A.6.5.6-27 and A.6.5.6-28 withheld pursuant to 10 CFR 2.390

Proprietary information on pages A.6.5.6-30 to A.6.5.6-45 withheld pursuant to 10 CFR 2.390

Tables A.6.5.6-20 through A.6.5.6-30 have been deleted along with corresponding pages A.6.5.6-47 through A.6.5.6-56.

Figure A.6.5.6-5
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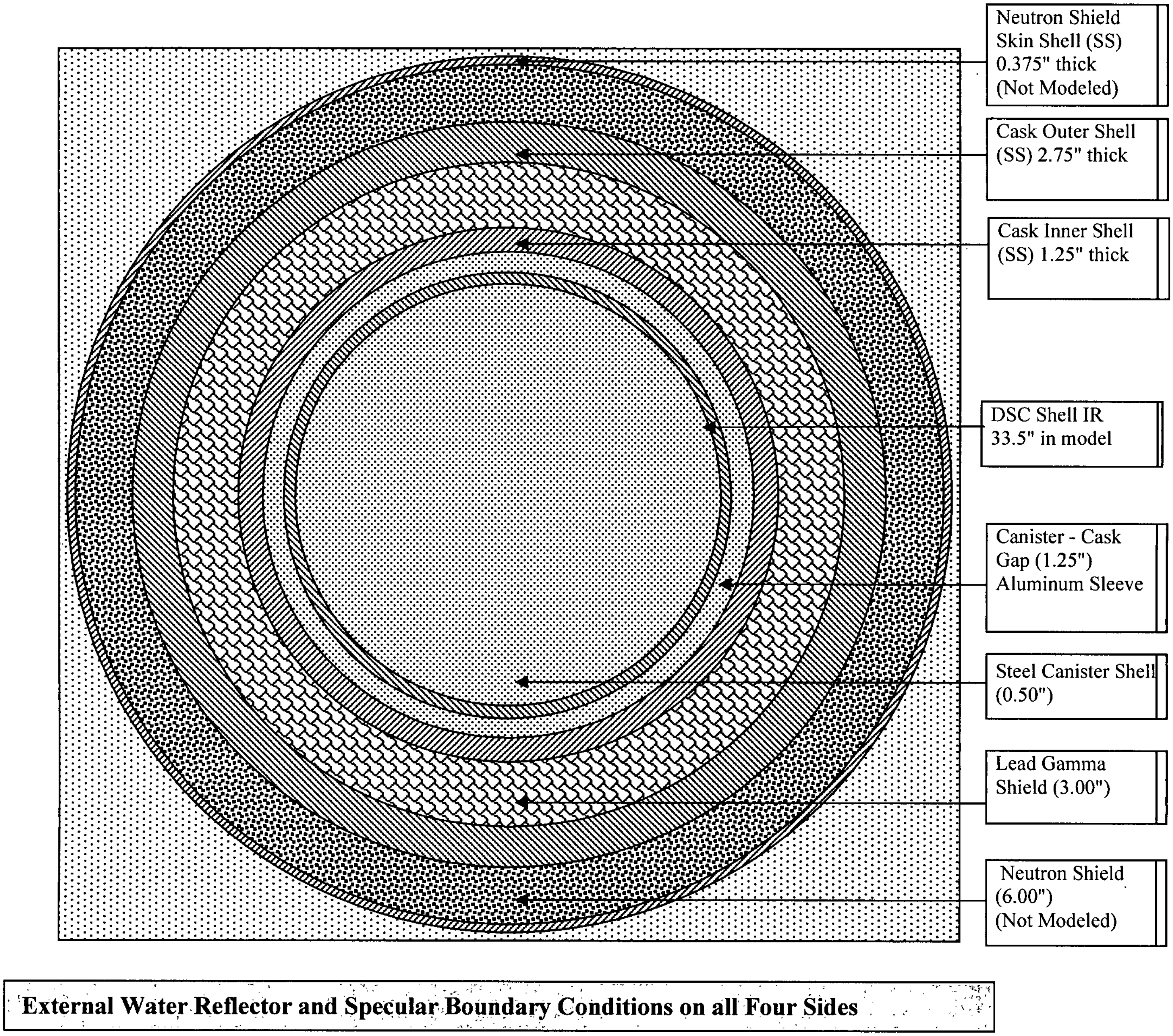

Figure A.6.5.6-9
Criticality Calculational KENO Model

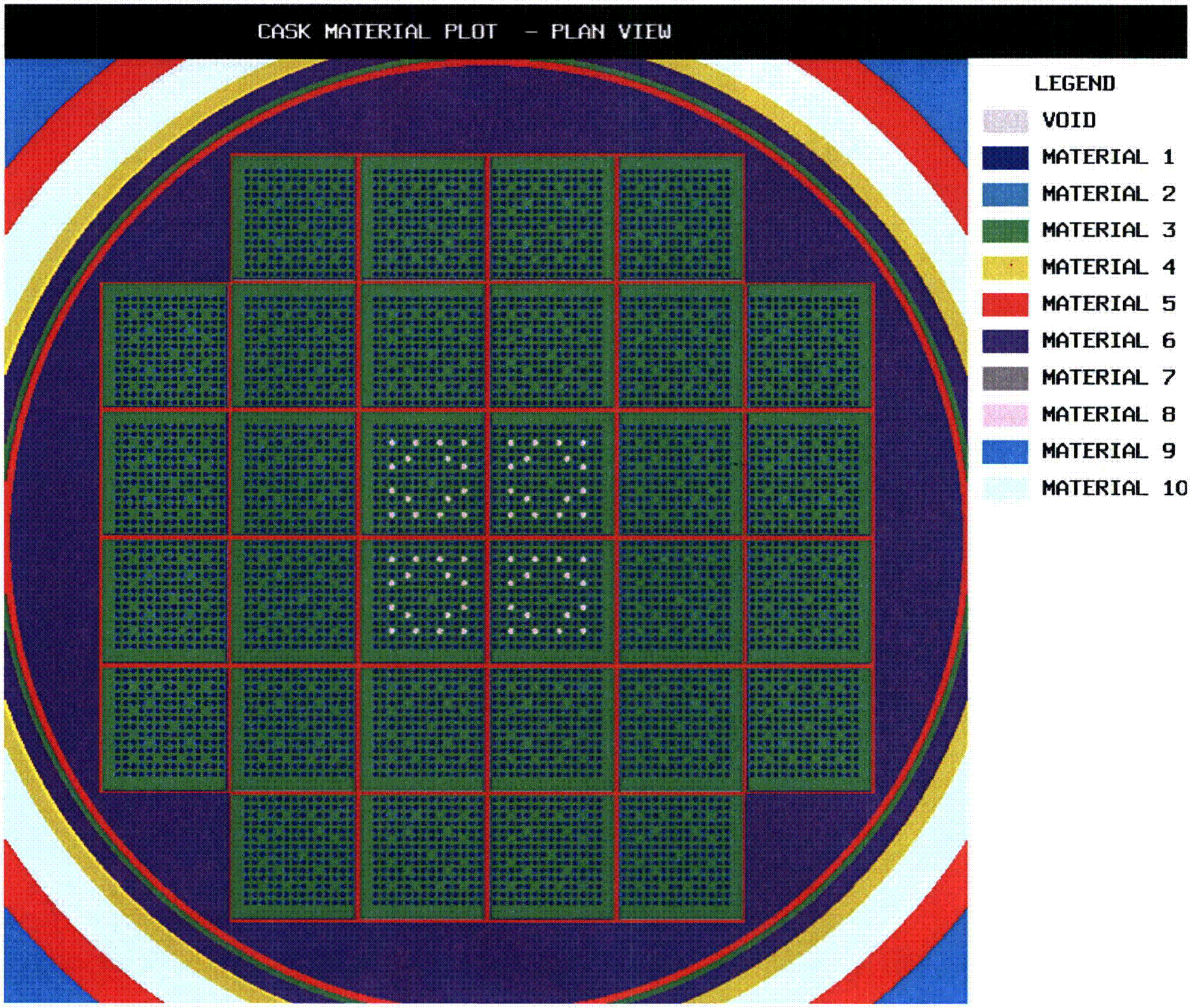

Figure A.6.5.6-12
Criticality Calculational KENO Model–24 Poison Plates 4 PRA–WE14x14

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Figure A.6.5.6-13

Appendix A.6.5.7
NUHOMS®-37PTH DSC Criticality Evaluation

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The NUHOMS®-MP197HB Cask containing the NUHOMS®-37PTH DSC is shown to be subcritical for an infinite array of flooded undamaged casks and for an infinite array of damaged casks after being subjected to hypothetical accident conditions. "N" is equal to ∞. The cask is shown to be subcritical for five times "N" or an infinite number of undamaged packages with close full reflection between packages and no inleakage of water as required by 10 CFR Part 71.59(a)(1). In addition, as required by 10 CFR Part 71.59(a)(2), two times "N" or an infinite array of packages is shown to be subcritical with the fissile material in its most reactive configuration, optimum water moderation and close full water reflection consistent with its damaged condition. A CSI of 0 (less than 50) ensures that, per 10 CFR Part 71.59 (c)(1), the package may be shipped by a carrier in a nonexclusive conveyance.

Table A.6.5.7-1 lists the fuel assemblies considered as authorized contents of the NUHOMS®-37PTH DSC. The criticality analysis is performed using *two* bounding fuel assembly classes identified in Table A.6.5.7-1. These are the Westinghouse (WE) 17x17 and the WE 14x14 classes. The results of the WE 17x17 class bound those of the WE 15x15, *Combustion Engineering (*CE*)* 14x14, CE 16x16 and CE 15x15 classes.

Criticality calculations are performed to determine the minimum assembly average burnup as a function of initial enrichment and cooling time for the *two* fuel assembly classes which are listed in Table A.6.5.7-9. The calculations determine k_{eff} with the CSAS25 control module of SCALE-4.4 [1] for each assembly *class* and initial enrichment, including all uncertainties to assure criticality safety under all credible conditions. Note that burnup credit is employed in the criticality analysis of the NUHOMS®-37PTH DSC.

The Control Components (CCs) are also authorized for storage in the 37PTH DSCs. The authorized CCs are Burnable Poison Rod Assemblies (BPRAs), Control Rod Assemblies (CRAs), Thimble Plug Assemblies (TPAs), Axial Power Shaping Rod Assemblies (APSRAs), Control Element Assemblies (CEAs), Vibration Suppressor Inserts (VSIs), Orifice Rod Assemblies (ORAs), Neutron Source Assemblies (NSAs), and Neutron Sources.

The results of the evaluation demonstrate that the maximum k_{eff}, including statistical uncertainty, is less than the USL determined from a statistical analysis of benchmark criticality experiments. The statistical analysis procedure includes a confidence band with an administrative safety margin of 0.05.

Proprietary information on pages A.6.5.7-4 to A.6.5.7-15 withheld pursuant to 10 CFR 2.390

A.6.5.7.5 References

1. Oak Ridge National Laboratory, RSIC Computer Code Collection, "SCALE: A Modular Code System for Performing Standardized Computer Analysis for Licensing Evaluations for Workstations and Personal Computers," NUREG/CR-0200, Revision 6, ORNL/NUREG/CSD-2/V2/R6.
2. 10 CFR 71, Packaging and Transportation of Radioactive Materials.
3. U.S. Nuclear Regulatory Commission, "Criticality Benchmark Guide for Light-Water-Reactor fuel in Transportation and Storage Packages," NUREG/CR-6361, Published March 1997, ORNL/TM-13211.
4. U.S. Nuclear Regulatory Commission, "Recommendations for Preparing the Criticality Safety Evaluation of Transportation Packages," NUREG/CR-5661, Published April 1997, ORNL/TM-11936.
5. *NUH-003, Updated Final Safety Analysis Report for the Standardized NUHOMS® Horizontal Modular Storage System for the Irradiated Nuclear Fuel (UFSAR), Revision 11.* The Certificate of Compliance (CoC) for Amendment 10 to Part 72 CoC 1004 *was* issued on *August 24th*, 2009.

Proprietary information on pages A.6.5.7-17 to A.6.5.7-28 and A.6.5.7-28a to A.6.5.7-28w withheld pursuant to 10 CFR 2.390

Table A.6.5.7-2
NUHOMS®-37PTH Basket Dimensions

Basket Component Description	***Actual Dimension, inches***
Compartment Inside width (4 corner compartments)	*9.000 (Nominal)*
Compartment Inside width (Remaining 33 compartments)	*8.675 (Nominal)* *8.625 (Minimum)*
Compartment wall thickness (1)	*0.25 or 0.31*
Aluminum Plate thickness if poison plate is present	*0.040 (minimum)*
Aluminum Plate thickness if poison plate is absent	*0.115 (minimum)*
Poison plate thickness when paired with Aluminum	*0.075 (nominal)*
Width of the Absorber Plate (L-insert)	*8.125* *(minimum)*
DSC inside radius	*34.40 (nominal)*
DSC wall thickness	*0.500 (nominal)*

Note: (1) *Several fuel compartments are based on a wall thickness of 0.25" in one direction and 0.31" in the other direction. The center fuel compartment has a uniform wall thickness of 0.31" on all four sides.*

Proprietary information on pages A.6.5.7-31 and A.6.5.7-32 withheld pursuant to 10 CFR 2.390

Proprietary information on pages A.6.5.7-34 to A.6.5.7-38 withheld pursuant to 10 CFR 2.390

Proprietary information on pages A.6.5.7-40 to A.6.5.7-44 withheld pursuant to 10 CFR 2.390

Figure A.6.5.7-3
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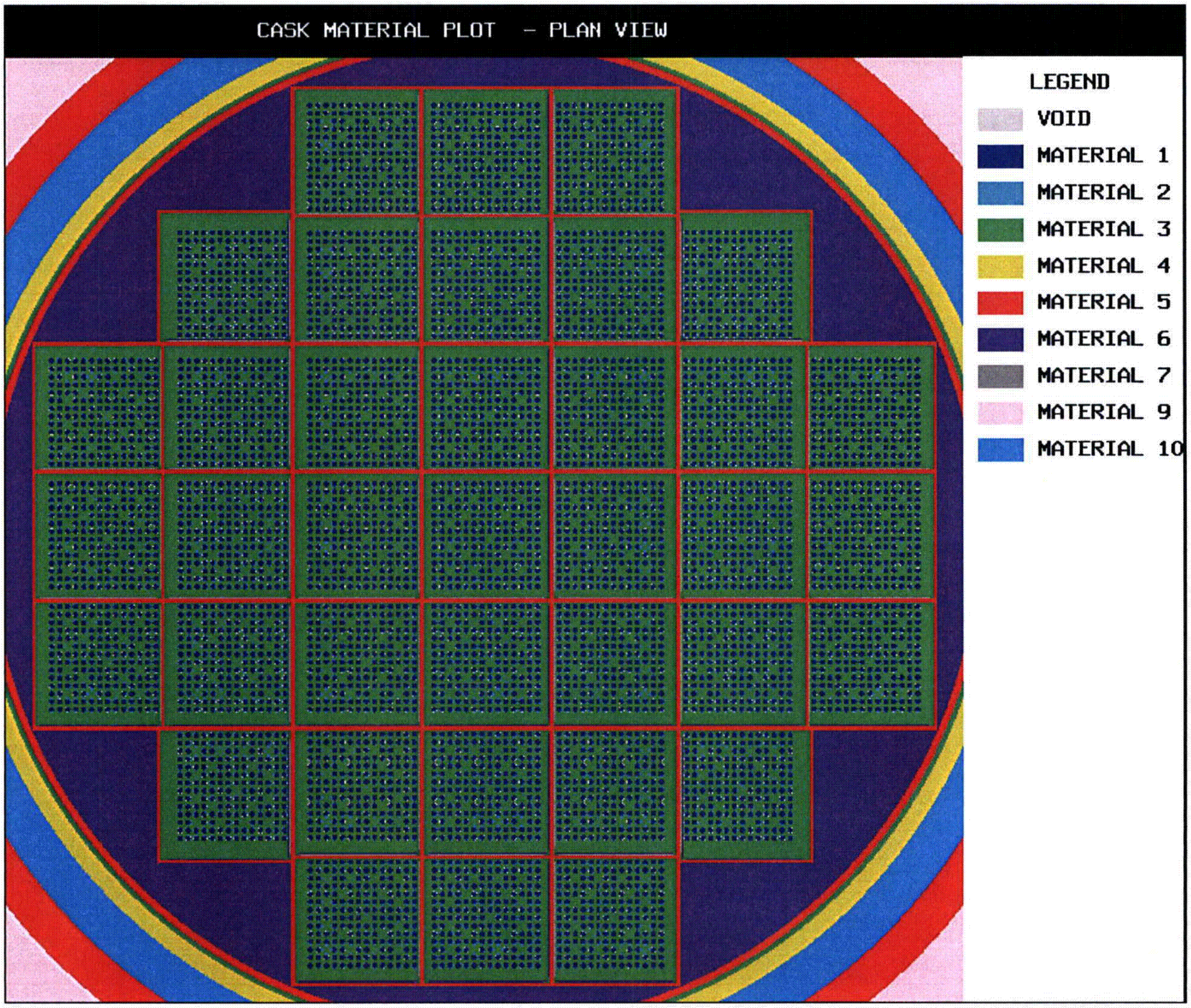

Figure A.6.5.7-8
Criticality Calculational KENO Model–*WE*14x14

Figure A.6.5.7-9
DELETED

Chapter A.7
Package Operations

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A.7 PACKAGE OPERATIONS

NOTE: References in this *c*hapter are shown as [1], [2], etc., and refer to the reference list in Section A.7.5. *A glossary of terms used in this chapter is provided in Section A.7.6.*

This chapter contains NUHOMS®-MP197HB *c*ask loading and unloading procedures that are intended to show the general approach to cask operational activities. The procedures in this chapter are intended to show the types of operations that will be performed and are not intended to be limiting. Site specific conditions and requirements may require *the* use of different equipment and ordering of steps to accomplish the same objectives *or acceptance criteria which must be met to ensure the integrity of the package.*

A separate *o*perations *m*anual (OM) will be prepared for the NUHOMS®-MP197HB *c*ask to describe the operational steps in greater detail. The OM, along with the information in this chapter, will be used to prepare the site-specific procedures that will address the particular operational considerations related to the cask.

A.7.1 *NUHOMS®-MP197HB* Package Loading

The use of the NUHOMS®-MP197HB *c*ask to transport fuel offsite involves (1) preparation of the cask for use; (2) verification that the fuel assemblies loaded in the *dry shielded canister (*DSC*)* meet the criteria set forth in this document; and (3) installation of a DSC into the cask. Also included herein are procedures to prepare and load fuel in a*n empty* DSC *contained in a* NUHOMS®-MP197HB cask and to close the DSC.

The use of the NUHOMS®-MP197HB *c*ask to transport dry irradiated and/or contaminated non-fuel bearing solid materials in *radioactive waste canisters (RWCs)* involves (1) preparation of the cask for use; (2) verification that the waste to be loaded meet the criteria set forth in this document; and (3) loading of the *RWC* and waste into the cask.

Offsite transport involves (1) preparation of the cask for transport; (2) assembly verification leakage-rate testing of the packaging containment boundary; (3) placement of the cask onto a transportation vehicle; and (4) installation of the impact limiters.

During shipment, the packaging contains any one of the DSCs with its authorized contents as described in Chapter A.1, Appendices A.1.4.1 through A.1.4.9 or a*n RWC* with dry irradiated and/or contaminated non-fuel bearing solid material *as described in Appendix A.1.4.9A.* Procedures are provided in this section for (1) transport of the cask/DSC/*RWC* directly from the plant spent fuel pool and (2) transport of a DSC/*RWC* which was previously stored in a NUHOMS® *h*orizontal *s*torage *m*odule (HSM). *Section A.7.7 contains an appendix for each DSC model detailing its loading procedures. Table A.7-3 lists these appendices.*

A.7.1.1 *NUHOMS®-MP197HB Cask* Preparation for Loading

Procedures for preparing the cask for use after receipt at the loading site are provided in this section and are applicable for shipment of DSCs loaded with fuel or of *RWC*s loaded with dry irradiated and/or contaminated non-fuel bearing solid materials.

1. Remove the impact limiter attachment bolts from each impact limiter and remove the impact limiters from the cask. Wash the cask and impact limiters to remove mud, dirt and grime, then touch-up paint as required.
2. Anytime prior to removing the lid, sample the cask cavity atmosphere through the vent port. Flush the cask interior gases to the site radwaste systems if necessary.
3. Remove the transportation skid personnel barrier and tie down assembly.
4. Take contamination smears on the outside surfaces of the cask. If necessary, decontaminate the cask until smearable contamination is at an acceptable level.
5. Inspect the cask hardware (including closure plates/lids and vent/drain/test ports) for damage which may have occurred during transportation. Repair or replace as required. O-ring seals shall be discarded after each use.
6. Install the front and rear trunnions, if required. Lubricate, install and preload the trunnion bolts and torque them using multiple passes to 1000 -1100 ft-lbs in the final pass following the torquing sequence shown in Figure A.7-1.
7. Place suitable slings around the cask front and rear trunnions, lift the cask and place it on the onsite transfer trailer or upending frame, or lift the cask/transport skid and place them in the appropriate location.
8. Remove the slings from the cask.
9. Install the onsite transfer skid pillow block covers, if not installed.
10. If transporting any of the smaller diameter DSC models (NUHOMS®-24PT4, 32PT, 24PTH, 61BT, *or* 61BTH) or a*n RWC*, verify that the MP197HB cask has been fitted with an internal aluminum sleeve (Refer to Drawing MP197HB-71-1014 provided in Chapter A.1, Appendix A.1.4.10.1). This step, if required, can be performed at any time prior to placing the DSC or *RWC* in the cask.
11. If transporting a NUHOMS®-69BTH DSC with heat load greater than 26 kW, verify that the removable external aluminum fins are available to be fitted to the cask after the cask is closed (Refer to Drawing MP197HB-71-1011 provided in Appendix A.1.4.10.1). Note that fins are not required to meet the 10 CFR 71 requirements and are optional.
12. For a specific DSC model to be loaded inside the MP197HB cask, verify the canister/basket type (A, B, C, D or E as applicable) is appropriate for the fuel to be transported.
13. The candidate intact, damaged and failed fuel assemblies to be transported in a specific DSC model must be evaluated (by plant records or other means) to verify that they meet the physical, thermal and radiological criteria of the applicable *f*uel *s*pecification as listed in *Table A.7-2*. This includes maximum burnup, maximum initial enrichment, minimum cooling time, and maximum decay heat limits (Refer to Chapter A.1, Appendix A.1.4.1 through Appendix A.1.4.9 for a discussion of the authorized contents of each DSC).
14. *For the transportation of fuel within the NUHOMS®-32PT, 24PTH, 32PTH, 32PTH1, or 37PTH DSCs where burnup credit is employed for criticality safety, additional*

administrative controls to prevent misloading are also outlined in the applicable appendices of this chapter.

NOTE: The fuel enrichment limit must correspond to the basket type verified in step 12 above.

A.7.1.2 *NUHOMS®-MP197HB Cask* Wet Loading

NOTE: The wet loading procedure described in this section is applicable only when using the MP197HB cask for loading fuel from a spent fuel pool into any one of the DSCs listed in Chapter A.1 or for loading irradiated waste into a RWC. This section also provides steps for closure of the DSC/RWC.

Site specific conditions and requirements may require the use of different equipment and ordering of steps than those described below to accomplish the same objectives or acceptance criteria which must be met to ensure the integrity of the package.

The NUHOMS®-MP197HB cask is designed to transport any one of the DSCs with limiting payloads as listed in Chapter A.1, Table A.1-2. *The NUHOMS®-MP197HB cask is also designed to transport RWCs as described in Chapter A.1, Section A.1.2.3.2.*

Verification that the burnup, enrichment and cooling time of the assemblies are all within acceptable ranges will be performed by site personnel prior to shipment, as discussed *in Appendices A.7.7.1 thru A.7.7.9.*

Verification that the dry irradiated and/or contaminated non-fuel bearing solid materials and RWC requirements in Chapter A.1, Section A.1.2.3.2 are all within acceptable ranges will be performed by site personnel, prior to shipment, as discussed in Appendix A.7.7.10.

1. Prior to being placed in service, the cask is to be cleaned or decontaminated as necessary to ensure an acceptable surface contamination level.
2. Position the cask below the plant crane.
3. Remove the ram access closure plate, inspect the sealing surfaces, replace the old seals with new seals, lubricate and re-install the ram access closure plate.
4. Remove the onsite transfer skid pillow block covers. *This step is optional.*
5. Engage the cask front trunnions with the lifting yoke using the plant crane, rotate the cask to a vertical orientation, lift the cask from the onsite transfer skid, and place the cask in the plant designated preparation area.

   NOTE: The empty cask may be uprighted and lifted using the lifting yoke either with the lid installed or removed.
6. *Install the shear key plug assembly.*
7. If the cask lid has not already been removed, remove the bolts from the cask lid and lift the lid from the cask.
8. Discard the used *lid O-rings.*
9. Examine the cask cavity for any physical damage.

10. *If loading any one of the smaller diameter DSC models (NUHOMS®-24PT4, 32PT, 24PTH, 61BT, or 61BTH) or RWCs from the MP197HB cask, install an unloading flange which is provided to ensure that the cask internal sleeve does not slide out, should the canister be required to be withdrawn.* Depending on the DSC model being *loaded*, verify that a cask spacer of appropriate height is placed at the bottom of the cask. *The height of spacer required for each type of DSC is listed in Table A.7-1.*

11. Place an empty DSC in the cask. Align the DSC to ensure proper positioning using the alignment marks on the DSC and cask.

12. If damaged fuel is to be loaded in the DSC, place the required number of bottom end caps into the cell locations that are to receive damaged fuel. *For* the *NUHOMS®-24PT4 DSC only,* verify that the *f*ailed *f*uel *c*ans, required for loading damaged fuel assemblies *if used*, have replaced the guide sleeves at the locations specified for the specific configurations *of* the 24PT4 DSC basket.

13. If failed fuel is to be loaded *in the DSC (24PTH or 61BTH DSCs only)*, put the appropriate empty failed fuel cans in the appropriate locations in the DSC. (Note: if the failed fuel is to be loaded into the failed fuel can prior to loading into the DSC, skip this step).

14. Fill the cask/DSC annulus with clean *or* demineralized water. Place the annulus seal in the upper cask liner recess and seal the cask/DSC annulus by pressurizing the seal with compressed air.

15. Fill the DSC cavity with water. *For the NUHOMS®-32PT, 24PTH, 32PTH, 32PTH1, and 37PTH DSCs where burnup credit is employed in the criticality analysis, a minimum soluble boron concentration is required during loading and unloading operations. (Appendices A.7.7.2 through A.7.7.6 provide additional details.)*

    NOTE: The *t*echnical *s*pecifications associated with the storage license for the NUHOMS®-32PT, 24PTH, 32PTH, or 32PTH1 DSC prescribe a minimum boron concentration in the DSC cavity during fuel loading/unloading operations. *The criticality analyses for the NUHOMS®-24PT4, 61BT, 61BTH, and 69BTH DSCs employ the fresh fuel methodology ensuring that soluble boron is not required during loading and unloading operations.*

16. Move the scaffolding away from the cask as necessary.

17. Position the cask lifting yoke and engage the cask lifting trunnions.

18. Visually inspect the yoke lifting hooks to insure that they are properly positioned and engaged on the cask lifting trunnions.

19. Lift the cask just far enough to allow the weight of the cask to be distributed onto the yoke lifting hooks. Reinspect the lifting hooks to insure that they are properly positioned on the cask trunnions.

20. Optionally, secure a sheet of suitable material to the bottom of the cask to minimize the potential for ground-in contamination. This may also be done prior to initial placement of the cask in the plant designated preparation area.

21. Prior to the cask being lifted into the fuel pool or other loading station (referred to as fuel pool through out remaining procedures), the water level in the pool should be adjusted as necessary to accommodate the cask/DSC volume. If the water placed in the DSC cavity was obtained from the fuel pool, a level adjustment may not be necessary.

A.7.1.2.1 DSC/*RWC Wet* Loading

The procedures for loading, vacuum drying, and sealing the DSC/RWC are described in detail in Appendices A.7.7.1 through A.7.7.10 as listed in Table A.7-3.

Following the completion of the wet loading activities described in a specific appendix listed in Table A.7-3, the MP197HB cask is prepared for downending as described in the next section.

A.7.1.2.2 *Preparing the NUHOMS®-MP197HB Cask for Downending*

1. Discard and install new drain port seals.
2. If transporting any one of the smaller diameter DSC models (NUHOMS®-24PT4, 32PT, 24PTH, 61BT, *or* 61BTH) *or RWC*, place a cask spacer ring at the top of the aluminum sleeve as shown in Drawing MP197HB-71-1014, Chapter A.1, Appendix A.1.4.10.1.
3. Verify that the lid O-ring seals are new. Discard any seals that have previously been installed in the cask and replace with new seals.
4. If necessary, apply vacuum grease to the seals and the adjoining sealing surfaces on the cask lid.
5. Install spacers, if required, to accommodate the recess of the outer top cover plate to the DSC shell.
6. Install the cask lid. Lubricate, install and preload the lid bolts *by* torqu*ing* them to *approximately* 200 ft-lbs. Follow the torquing sequence shown in Figure A.7-1. Repeat the torquing process following the sequence of Figure A.7-1. Torque to approximately 400 ft-lbs in the second pass, approximately 800 ft-lbs in the third pass and between *950* and 1040 ft-lbs in the final pass. A circular pattern of torquing may then be used to eliminate further bolt movement.
7. Install new cask vent port seals.
8. Discard and install new (2) cask test port s*eals*.
9. Evacuate the cavity between the cask and the DSC and backfill with helium.
10. Perform the assembly verification *leakage* test following the procedure given in Section A.7.4.1.

A.7.1.2.3 *NUHOMS®-MP197HB* Cask Downending

NOTE: For plants with limited space or crane travel, such that the downending cannot be completed with the trailer stationary, alternate procedures may be developed.

1. Re-attach the cask lifting yoke to the crane hook, as necessary. Ready the transfer trailer and onsite transfer skid for service. *Remove the shear key plug assembly from the cask.*
2. Move the scaffolding away from the cask as necessary. Engage the lifting yoke and lift the cask over the onsite transfer skid on the transfer trailer.
3. The transfer trailer should be positioned so that it is accessible to the crane with the trailer supported on the vertical jacks.
4. Position the cask rear trunnions onto the onsite transfer skid pillow blocks.
5. Move the crane forward while simultaneously lowering the cask until the cask front trunnions are just above the onsite transfer 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 onsite transfer 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 onsite transfer skid and install the *pillow block covers.*
9. Prepare the cask for transportation in accordance with the procedure described in Section *A.7.1.4*.

A.7.1.3 NUHOMS®-MP197HB Cask Dry Loading (Transferring a Loaded DSC or RWC from an Overpack into an MP197HB Cask)

A number of NUHOMS® DSCs are currently being used for onsite storage of spent fuel inside the NUHOMS® *h*orizontal *s*torage *m*odules (HSMs) *or the advanced horizontal storage modules (AHSMs)* under the provisions of 10 CFR 72.

This section summarizes the steps for transferring a *previously* loaded DSC *under a 10 CFR 72 license* from the HSM *or AHSM (generally referred here as HSM)* to the MP197HB cask for transportation. Depending on the most recent use of the cask, several of the initial steps listed below may not be necessary.

An RWC may be stored in an HSM, AHSM or other allowed overpack on the plant site. When the MP197HB cask is dry loaded with an RWC, operational steps similar to dry loading a DSC from an HSM into the MP197HB cask should be used depending on the storage overpack.

CAUTION:

Before initiating any steps described in this section:

- *For the DSCs that are already in dry storage under the requirements of 10 CFR 72, the licensee shall review the loading records to ensure that the DSC was not damaged during the insertion or extraction process and that if necessary, appropriate evaluations were performed to verify the integrity of the DSC shell.*
- *If the storage license of a DSC has been extended beyond the initial licensed term of 20 years, the licensee shall verify that an appropriate time-limited aging analysis (TLAA) has been performed and an aging management program has been implemented to assure that the DSC, basket, and its contents are within the analyzed conditions. The TLAA should consider the effect of fatigue, radiation, depletion of neutron absorbing material, and environmental conditions including internal temperature and pressures. The aging management program should consider use of periodic in-service inspections of accessible canister surfaces to monitor for adverse indications along with radiation and contamination monitoring.*
- *The licensee shall perform an audit of spent fuel pool records from the time of canister loading for the identification of the loaded fuel assemblies, and*
- *The licensee shall compare the irradiation parameters of the loaded contents against those shown in Table A.6-17 to ensure compliance with the isotopic depletion analysis.*

1. Depending on the DSC model to be transported, verify that the contents are in compliance with the *f*uel *s*pecification requirements or waste requirements in the Certificate of Compliance (CoC). *This includes verification that the burnup, enrichment, and cooling time of all the fuel assemblies contained within the candidate DSC comply with the corresponding requirements in the CoC. A documented review of the site loading records for the DSCs being transported may be used for this verification. An independent check of this verification is also required.*

2. Depending on the DSC model being transported, verify that the prerequisites for the preparation of the *NUHOMS®*-MP197HB cask for transport in Section A.7.1.1 have been met.
3. If loading any one of the smaller diameter DSC models (NUHOMS®-24PT4, 32PT, 24PTH, 61BT, *or* 61BTH) *in* the *NUHOMS®*-MP197HB cask, install an unloading flange which is provided to ensure that the cask internal sleeve does not slide out should the canister be required to be *inserted* back into the HSM. *Depending on the DSC model being loaded, verify that a cask spacer of appropriate height is placed at the bottom of the cask. The height of spacer required for each type of DSC is listed in Table A.7-1.*
4. Remove the ram access closure plate and the lid.
5. Install the ram trunnion support assembly.
6. Using a suitable prime mover, bring the onsite transfer trailer and the *NUHOMS®*-MP197HB cask to the ISFSI site and back the trailer in front of the module face.
7. Remove the HSM door and the DSC seismic restraint assembly from the HSM.
8. *Move and rough align the transfer trailer within few inches of the HSM and stabilize the trailer by extending vertical jacks onto the jack stands.*
9. Use the trailer skid positioning system and optical surveying transits to align and dock the cask with the HSM.
10. Install the cask/HSM restraints.
11. *A*lign the hydraulic ram cylinder in the ram trunnion support assembly.
12. Extend the ram hydraulic cylinder until the grapple contacts the DSC bottom cover.
13. Engage the DSC grapple ring with the ram grapple.
14. Retract the ram hydraulic cylinder until the DSC is fully *retracted into* the cask.
15. Disengage the grapple from the DSC.
16. Remove the hydraulic ram and ram trunnion support assembly.
17. Install the cask ram closure plate with new O-rings. Lubricate, install and preload the ram closure bolts and torque them to approximately 65 ft-lbs in the first pass and to 100–125 ft-lbs in the final pass by following the torquing sequence shown in Figure A.7-1.
18. Remove the cask/HSM restraints.
19. Using the skid positioning system, move the cask to the transfer position and secure the onsite support skid to the onsite transfer trailer.
20. Verify that the cask lid O-ring seals are new. Discard any seals that have previously been installed in the cask.
21. If necessary, apply vacuum grease to the seals and the adjoining sealing surfaces on the cask lid.
22. If transporting any one of the smaller diameter DSC models (NUHOMS®-24PT4, 32PT, 24PTH, 61BT, *or* 61BTH), place a cask spacer ring at the top of the aluminum sleeve as shown in Drawing MP197HB-71-1014, Chapter A.1, Appendix A.1.*4*.10.1.

23. Install spacers, if required, to accommodate the recess of the outer top cover plate to the DSC shell.

24. Install the cask lid. Lubricate, install and *preload the lid bolts by torquing them* to approximately 200 ft-lbs *following* the torquing sequence shown in Figure A.7-1. Repeat the torquing process. Torque to approximately 400 ft-lbs in the second pass, approximately 800 ft-lbs in the third pass and between *950* and 1040 ft-lbs in the final pass. A circular pattern of torquing may *then* be used to eliminate further bolt movement.

25. Discard and install new cask vent port seals if necessary.

26. Discard and install new (2) cask test port seals.

27. Evacuate the cavity between the cask and the *DSC* and backfill with helium.

28. *Remove the shear key plug assembly from the cask.*

29. Perform the assembly verification *leakage* test following the procedure given in Section A.7.4.1.

30. Prepare the cask for transportation in accordance with the procedure described in Section *A.7.1.4.*

A.7.1.4 NUHOMS®-MP197HB Cask Preparation for Transport

Once the NUHOMS®-MP197HB cask *has been loaded using either the wet loading procedure described in Section A.7.1.2 or the dry loading procedure described in Section A.7.1.3 above*, the following tasks are performed to prepare the cask for transportation. The cask is assumed to be seated horizontally in the onsite transfer skid.

1. Verify that the cask surface removable contamination levels meet the requirements of 49 CFR 173.443 [2] and 10 CFR 71.87 [3].

2. Verify that the assembly verification leakage rate testing specified in Section A.7.4.1 has been performed. This test must be performed within 12 months prior to the shipment.

A.7.1.4.1 Placing the *NUHOMS®-MP197HB* Cask onto the Conveyance

The procedure for placement of the cask on the conveyance is given in this section. If cask is already on the transportation skid, rig the cask/skid, lift and place them on to the conveyance, then skip to Step 8.

1. Using a suitable prime mover, bring the cask and onsite transfer trailer to the conveyance.
2. Remove the onsite transfer skid pillow block covers.
3. Install suitable slings around the cask top and bottom ends. *(May also be rigged around the front and rear trunnions.)*
4. Lift the cask from the onsite transfer trailer.
5. Place the cask onto the transportation skid.
6. Remove the cask upper and lower trunnions and install the trunnion plugs.
7. Remove the lifting slings from the cask.

8. If necessary, install the *optional* external aluminum fins.
9. Install the transportation skid *tie-down straps.*
10. Install the impact limiters on the cask and torque the attachment bolts in accordance with the drawings in Chapter A.1, Appendix A.1.4.10.1.
11. Remove the impact limiter hoist rings and replace them with hex bolts provided prior to transport.
12. Install the cask tamperproof seals.
13. Install the transportation skid personnel barrier.
14. *Perform a final radiation survey to assure* the cask radiation levels *do not exceed* 49 CFR 173.441 [2] and 10 CFR 71.47 [3] requirements.
15. Verify that the temperature on all accessible surfaces is < 185°F.
16. Prepare the final shipping documentation and release the loaded cask for shipment.

A.7.2 *NUHOMS®-MP197HB* Package Unloading

Unloading the NUHOMS®-MP197HB *c*ask after transport involves removing the cask from the conveyance and removing the DSC/*RWC* from the cask. The cask is designed to allow the DSC/*RWC* to be unloaded from the cask into a NUHOMS® staging module, hot cell or other suitable overpack, and provisions exist to allow wet unloading into a fuel pool. The necessary procedures for these tasks are essentially the reverse of those described in Section A.7.1.

A.7.2.1 Receipt of Loaded *NUHOMS®-MP197HB* Package from Carrier

Procedures for receiving the loaded cask after shipment are described in this section. Procedures for receiving an empty cask are provided in Section A.7.1.1.

1. Verify that the tamperproof seals are intact.
2. Remove the tamperproof seals.
3. Remove the hex bolts from the impact limiters and replace them with the impact limiter hoist rings provided.
4. Remove the impact limiter attachment bolts from each impact limiter and remove the impact limiters from the cask.
5. Remove the transportation *skid personnel barrier and tie-down straps.*
6. Remove the external aluminum fins, if present.
7. Take contamination smears on the outside surfaces of the cask. If necessary, decontaminate the cask until smearable contamination is at an acceptable level.
8. Install the front and rear trunnions. Lubricate, install and preload the trunnion bolts and torque them with multiple passes to *1000-1100* ft-lbs in the final pass follow*ing* the torquing sequence shown in Figure A.7-1.
9. Place suitable slings around the cask front and rear trunnions or transport skid.

10. Using a suitable crane, lift the cask from the conveyance. Place cask onto the onsite transfer trailer or other location. Remove the slings from the cask.
11. Install the onsite transfer skid pillow block covers. *This step is optional.*
12. Transfer the cask to a staging module, fuel pool, dry cell or storage overpack and unload using the procedures described in the following sections.

A.7.2.2 Removal of Contents *from NUHOMS®-MP197HB Cask*

A.7.2.2.1 Unloading the NUHOMS®-MP197HB Cask to a Suitable Overpack

The procedure for unloading a DSC/*RWC* from the cask into an HSM or other authorized overpack is summarized in this section. This procedure is typical of NUHOMS® ISFSIs and some of the steps listed below may be performed in a different order *due to site-specific ALARA considerations*.

1. Depending on the DSC model/*RWC* being placed in the HSM/*o*verpack, verify that the prerequisites for the preparation of the MP197HB cask in Section A.7.1.1 have been met.
2. *If the shear key plug assembly is not in place, install the shear key plug assembly.*
3. Position the onsite transfer trailer in front of the module face.
4. Sample the cask cavity atmosphere through the vent port. Flush the cask interior gases to the site radwaste systems if necessary.
5. Remove the cask ram closure plate. Discard the ram closure seals.
6. Install the ram trunnion support assembly.
7. Remove the HSM/*o*verpack door.
8. Use the skid positioning system or other means and optical surveying transits to align the cask with the HSM/*o*verpack.
9. Remove the cask lid. Discard the lid seals.
10. If unloading any one of the smaller diameter DSC models (NUHOMS®-24PT4, 32PT, 24PTH, 61BT, *or* 61BTH) or smaller *RWC*s from the MP197HB cask, install an unloading flange which is provided to ensure that the cask internal sleeve does not slide out during unloading.
11. Dock the cask with the HSM/*o*verpack and install the cask/HSM restraints.
12. Install and align the hydraulic ram cylinder in the ram trunnion support assembly.
13. Extend the ram hydraulic cylinder until the grapple contacts the DSC/*RWC* bottom cover.
14. Engage the DSC/*RWC* grapple ring with the ram grapple.
15. Using the ram hydraulic cylinder move the DSC/*RWC* into the HSM/*o*verpack until it is fully inserted.
16. Disengage the grapple from the DSC/*RWC*.
17. Remove the hydraulic ram *and ram trunnion support assembly*.

18. Remove the cask/*HSM restraints and remove the cask* from the HSM/*o*verpack.

19. Install the cask lid *and cask ram closure plate*, if required.

20. Install the HSM/*o*verpack door and seismic restraint, as applicable.

21. Move the cask to a low-dose maintenance area.

22. Inspect the cask hardware (including covers and vent/drain/test ports) for damage that may have occurred during transportation. Repair or replace as necessary.

A.7.2.2.2 Unloading the NUHOMS®-MP197HB Cask to a Fuel Pool

The procedure for unloading the cask and DSC/*RWC* to a fuel pool is summarized in this section. *Site specific conditions and requirements may require the use of different equipment and ordering of steps than those descried below to accomplish the same objectives or acceptance criteria which must be met to ensure the integrity of the package.* Note that the NUHOMS®-MP197HB cask or an alternate suitable cask may be used for onsite movements of the DSC/*RWC*.

1. Depending on the DSC model/*RWC* being handled, verify that the prerequisites for the preparation of the *NUHOMS*®-MP197HB cask in Section A.7.1.1 have been met.
2. Place the cask in the fuel receiving area.
3. Remove the onsite transfer/transport skid pillow block covers.
4. Using the cask lifting yoke, engage the upper trunnions, rotate the cask to a vertical orientation, lift the cask from the onsite transfer skid, and place the cask in the decon pit.
5. *If the shear key plug assembly is not already in place, install the shear key plug assembly.*
6. Sample the cask cavity atmosphere through the vent port. Flush the cask interior gases to the site radwaste systems if necessary.
7. Remove the bolts from the cask lid and lift the lid from the cask.
8. Remove and discard the cask lid *O-rings*.
9. If the cask contains any one of the smaller diameter DSC models (NUHOMS®-24PT4, 32PT, 24PTH, 61BT, *or* 61BTH) *or RWC*, remove the cask spacer ring at the top of the aluminum sleeve as shown in Drawing MP197HB-71-1014, Appendix A.1.4.10.1. This step may be performed at any time prior to installing the annulus seal.
10. *Fill the cask/DSC or cask/RWC annulus with clean or demineralized water and install the cask/DSC or cask/RWC annulus seal.*

After completion of *the preparatory steps* described *above, depending* on the *DSC model being unloaded, follow the specific DSC unloading procedure as described in one of Appendices A.7.7.1* through *A.7.7.9* as *listed in Table A.7-4.*

Section A.7.2.2.4 describes the procedures used for unloading of a NUHOMS®-MP197HB cask with an RWC.

A.7.2.2.3 Unloading the NUHOMS®-MP197HB Cask to a Dry Cell

The procedure for handling a DSC in a dry cell is highly dependent on the design of the dry cell and on the intended future use of the DSC. The procedure described below is intended to show the type of operations that will be performed and is not intended to be limiting.

Tow the onsite transfer trailer to the hot cell area.

2. Remove the onsite transfer skid pillow block covers.
3. Using the cask lifting yoke, engage the upper trunnions, rotate the cask to a vertical orientation, lift the cask from the onsite transfer skid, and place the cask in the appropriate handling area.
4. Sample the cask cavity atmosphere through the vent port. Flush the cask interior gases to the site radwaste systems if necessary.
5. Install the shear key plug assembly, if required.
6. Remove the bolts from the cask lid and lift the lid from the cask.
7. Remove and discard the cask lid *O-rings*.
8. Transfer the cask to the unloading area using suitable handling equipment.
9. Remove the contents from the cask and handle according to appropriate procedures.
10. Decontaminate the cask inner and outer surfaces as necessary.
11. Inspect the cask hardware (including covers and vent/drain/test ports) for damage that may have occurred during transportation. Repair or replace as necessary.

A.7.2.2.4 *Horizontal* Unloading *of an RWC from* the NUHOMS®-MP197HB Cask

This procedure is for handling *a NUHOMS®-MP197HB cask with an RWC* at a disposal site. The procedure described below is intended to show the type of operations that will be performed and is not intended to be limiting.

1. Attach the horizontal lift device to a suitable crane and then engage the front and rear trunnions.
2. Lift the cask slowly in the horizontal position and transfer it onto an unloading cradle.
3. Disengage the lift device from the cask.
4. Install a horizontal lid lifting fixture to the lid.
5. Detorque the lid bolts in an approved sequence.

   Note: Perform the following steps remotely using a manipulator crane, appropriate remote tooling, viewing equipment and personnel radiation protection as appropriate for the payload and facility.

6. Slowly remove the lid from the cask.
7. Install sealing surface protection, as appropriate.

8. Attach liner or waste removal tools.
9. Unload the cask contents into the disposal area in accordance with site-approved procedures.

A.7.3 Preparation of Empty Package for Transport

Previously used and empty NUHOMS®-MP197HB *c*asks shall be prepared for transport per the requirements of 49 CFR 173.427 [2].

A.7.4 Other Operations

A.7.4.1 Leakage Testing of the Containment Boundary

The procedure for *leakage* testing *of* the cask containment boundary prior to shipment is given in this section. Assembly verification *leakage* testing shall conform to the requirements of ANSI N14.5 [1] or ISO -12807 [11]. A flow chart of the assembly verification *leakage* test is provided in Figure A.7-2. The order in which the *leakage* tests of the various seals are performed may vary. If more than one *leakage* detector is available then more than one seal may be tested at a time. Personnel performing the *leakage* test shall be specifically trained in *leakage* testing in accordance with SNT-TC-1A [7].

Note: For leakage testing of the cask drain port plug and the bottom test port (steps 24 thru 41), it may be more convenient if the cask is horizontal.

1. Remove the cask vent port plug.
2. Install the cask port tool in the cask vent port. (The port tool is designed to replace the vent/drain and test port plugs and provide a means for loosening the vent/drain and test port *bolt* in a controlled volume. This volume can be isolated from the cask volume by an externally accessible valve to ensure personnel protection during cask venting operations.)
3. Turn the cask port tool handle to open the cask vent port.
4. Attach a suitable vacuum pump to the cask port tool.
5. Reduce the cask cavity pressure to below 1.0 psia.
6. Attach a source of helium to the cask port tool.
7. Fill the cask cavity with helium to atmospheric pressure.
8. Close the vent port *bolt* by turning the cask port tool handle. Tighten the vent port screw in accordance with Drawing MP197HB-71-1002 in Chapter A.1, Appendix A.1.4.10.1.
9. Remove the helium-saturated cask port tool and install a clean (helium free) cask port tool.
10. Connect a mass spectrometer leak detector capable of detecting a *leakage rate* of 5×10^{-8} ref·cm^3/s to the cask port tool.
11. Evacuate the vent port until the vacuum is sufficient to operate the *leakage* detection equipment per the manufacturer's recommendations.

12. Perform the *leakage* test. If the leakage rate is greater than $1x10^{-7}$ ref·cm^3/s repair or replace the vent port *bolt* and/or seal as required and retest.

    NOTE: Upon removing the vent port *bolt*, it will be necessary to reduce the cask cavity pressure below 1.0 psia and refill with helium through the vent port.

13. Remove the *leakage* detection equipment from the cask port tool.
14. Remove the cask port tool from the vent port and replace the vent port plug.
15. Remove the lid test port plug.
16. Install the cask port tool in the lid test port.
17. Turn the cask port tool handle to open the lid test port.
18. Connect the vacuum pump to the cask port tool.
19. Connect the *leakage* detector to the cask port tool.
20. Evacuate the lid test port until the vacuum is sufficient to operate the *leakage* detection equipment per the manufacturer's recommendations. Perform a pressure rise *leakage* test to confirm leakage *rate* past the outer seal is less than $7x10^{-3}$ ref·cm^3/s of air.
21. Perform the helium *leakage* test. If the leakage rate is greater than $1x10^{-7}$ ref·cm^3/s repair or replace the cask lid or the cask lid O-ring seals as required and retest.

    NOTE: Upon removing and reinstalling the cask lid, it will be necessary to reduce the cask cavity pressure below 1.0 psia and refill with helium through the vent port. The vent port assembly verification *leakage* test must also be retested as described above.

22. Remove the *leakage* detection equipment from the cask port tool.
23. Tighten the lid test port screw in accordance with Drawing MP197HB-71-1002 in Chapter A.1, Appendix A.1.4.10.1. Remove the cask port tool from the lid test port and replace the lid test port plug.
24. Remove the cask drain port plug.
25. Install the cask port tool in the cask drain port.
26. Turn the cask port tool handle to verify that the cask drain port is closed.
27. Connect the vacuum pump to the cask port tool.
28. Connect the *leakage* detector to the cask port tool.
29. Evacuate the drain port until the vacuum is sufficient to operate the *leakage* detection equipment per the manufacturer's recommendations.
30. Perform the *leakage* test. If the leakage rate is greater than $1x10^{-7}$ ref·cm^3/s repair or replace the drain port *bolt* and/or seal as required and retest.

    NOTE: Upon removing the drain port *bolt*, it will be necessary to reduce the cask cavity pressure below 1.0 psia and refill with helium through the vent port. The vent port assembly verification test must also be retested as described above.

31. Remove the *leakage* detection equipment from the cask port tool.

32. Tighten the drain port *bolt* in accordance with Drawing MP197HB-71-1002 in Chapter A.1, Appendix A.1.4.10.1. Remove the cask port tool from the cask drain port and replace the drain port plug.
33. Remove the bottom test port plug.
34. Install the cask port tool in the bottom test port.
35. Turn the cask port tool handle to open the bottom test port.
36. Connect the vacuum pump to the cask port tool.
37. Connect the *leakage* detector to the cask port tool.
38. Evacuate the bottom test port until the vacuum is sufficient to operate the *leakage* detection equipment per the manufacturer's recommendations. Perform a pressure rise *leakage* test to confirm leakage *rate* past the outer seal is less than 7×10^{-3} ref·cm^3/s of air.
39. Perform the helium *leakage* test. If the leakage rate is greater than 1×10^{-7} ref·cm^3/s repair or replace the cask ram access closure plate or the cask ram access closure plate O-ring seals as required and retest.

    NOTE: Upon removing the cask ram access closure plate, it will be necessary to reduce the cask cavity pressure below 1.0 psia and refill with helium through the vent port. The vent port assembly verification test must also be retested as described above.
40. Remove the *leakage* detection equipment from the cask port tool.
41. Tighten the bottom test port *bolt* in accordance with Drawing MP197HB-71-1002 in Chapter A.1, Appendix A.1.4.10.1. Remove the cask port tool from the bottom test port and replace the bottom test port *plug*.

This concludes the assembly verification *leakage* test procedure.

A.7.5 References

1. ANSI N14.5-1997, "American National Standard for Radioactive Materials - Leakage Tests on Packages for Shipment," American National Standards Institute, Inc., New York, 1997.
2. Title 49, Code of Federal Regulations, Part 173 (49 CFR 173), "Shippers - General Requirements for Shipments and Packaging."
3. Title 10, Code of Federal Regulations, Part 71 (10 CFR 71), "Packaging and Transportation of Radioactive Material."
4. U.S. Nuclear Regulatory Commission, Office of the Nuclear Material Safety and Safeguards, "Safety Evaluation of VECTRA Technologies' Response to Nuclear Regulatory Commission Bulletin 96-04 for the NUHOMS®-24P and NUHOMS®-7P."
5. U.S. Nuclear Regulatory Commission Bulletin 96-04, "Chemical, Galvanic or Other Reactions in Spent Fuel Storage and Transportation Casks," July 5, 1996.
6. U.S. Nuclear Regulatory Commission, Interim Staff Guidance (ISG)-22, "Potential Rod Splitting Due to Exposures to an Oxidizing Atmosphere during Short-term Cask Loading Operations in LWR or Other Uranium Oxide Based Fuel."
7. SNT-TC-1A, "American Society for Nondestructive Testing, Personnel Qualification and Certification in Nondestructive Testing."
8. Updated Final Safety Analysis Report *for* The Standardized Advanced NUHOMS® Horizontal Modular Storage System For Irradiated Nuclear Fuel (CoC 1029) Revision 3.
9. *Not used.*
10. *Not used.*
11. ISO-12807, "Safety Transport of Radioactive Materials – Leakage Testing on Packages," First Edition, 1996.

A.7.6 Glossary

The terms used in the above procedures are defined below.

***a*nnulus *s*eal:** Pneumatic seal placed between the cask and DSC/*RWC* during operations in the fuel pool.

cask *l*ifting *y*oke: Passive, open hook lifting yoke used for vertical lifts of the cask.

cask/HSM *r*estraints: Provides the load path between the cask and HSM during DSC transfer operation.

***c*onveyance:** Any suitable conveyance such as a railcar, heavy haul trailer, barge, ship, etc.

***h*orizontal *s*torage *m*odule (HSM):** Concrete shielded structure used for onsite storage of DSCs. HSM references herein refer to all models of HSM (e.g., HSM Model 80, Model 102, Model 152, Model 202, HSM-H, HSM-HS, AHSM, etc.) HSM also includes any other overpack authorized to accept a DSC or *RWC* via a horizontal transfer.

***h*ydraulic *r*am:** Hydraulic cylinder used to insert/withdraw DSCs to/from HSMs.

***o*nsite *t*ransfer *s*kid:** Skid present on the onsite transfer trailer used to support the cask during onsite movements. Note in some cases the transportation skid may function as the onsite transfer skid.

***o*nsite *t*ransfer *t*railer:** A trailer used for onsite movements of the cask.

***r*am *t*runnion *s*upport *a*ssembly:** Frame attached to the *skid* which provides an anchor for the hydraulic ram during DSC insertion and retrieval.

skid *p*ositioning *s*ystem: Hydraulically operated alignment system that provides the interface between the onsite transfer trailer and the onsite transfer skid. *It is used to align the skid (and cask) with the HSM prior to transfer.*

A.7.7 APPENDICES

A.7.7.1 NUHOMS®-24PT4 DSC Wet Loading and Unloading
A.7.7.2 NUHOMS®-32PT DSC Wet Loading and Unloading
A.7.7.3 NUHOMS®-24PTH DSC Wet Loading and Unloading
A.7.7.4 NUHOMS®-32PTH DSC Wet Loading and Unloading
A.7.7.5 NUHOMS®-32PTH1 DSC Wet Loading and Unloading
A.7.7.6 NUHOMS®-37PTH DSC Wet Loading and Unloading
A.7.7.7 NUHOMS®-61BT DSC Wet Loading and Unloading
A.7.7.8 NUHOMS®-61BTH DSC Wet Loading and Unloading
A.7.7.9 NUHOMS®-69BTH DSC Wet Loading and Unloading
A.7.7.10 RWC Wet Loading

Table A.7-1
Height of Spacer for Each Type of DSC

Canister Type	61BT 61BTH	69BTH	24PTH			24PT4	32PT				32PTH	32PTH Type 1	32PTH1			37PTH	
			S	L	S-LC		S-100	S-125	L-100	L-125			S	M	L	S	M
Spacer Height	2.20	2.20	11.70	5.70	11.70	2.20	11.70	11.70	5.70	5.70	12.50	5.25	12.50	5.25	N/A	16.25	9.00

Table A.7-2
Applicable Fuel Specification for Various DSCs

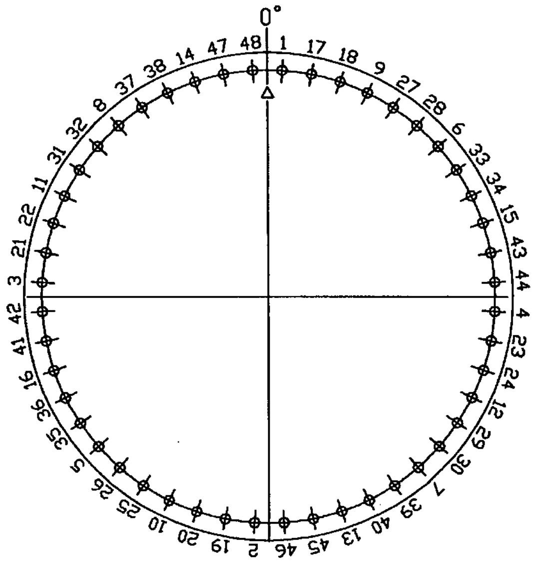
DSC MODEL	***Applicable Fuel Specification from Chapter A.1***
NUHOMS®-24PT4	*Tables A.1.4.1-1 and A.1.4.1-2*
NUHOMS®-32PT	*Table A.1.4.2-2*
NUHOMS®-24PTH	*Table A.1.4.3-2*
NUHOMS®-32PTH	*Table A.1.4.4-2*
NUHOMS®-32PTH1	*Table A.1.4.5-2*
NUHOMS®-37PTH	*Table A.1.4.6-2*
NUHOMS®-61BT	*Table A.1.4.7-2*
NUHOMS®-61BTH	*Table A.1.4.8-2*
NUHOMS®-69BTH	*Table A.1.4.9-1*

Table A.7-3
Appendices Containing Loading Procedures for Various DSCs

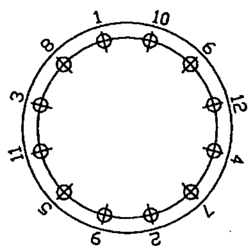
DSC Model	***Appendix***
NUHOMS®-24PT4	*A.7.7.1*
NUHOMS®-32PT	*A.7.7.2*
NUHOMS®-24PTH	*A.7.7.3*
NUHOMS®-32PTH	*A.7.7.4*
NUHOMS®-32PTH1	*A.7.7.5*
NUHOMS®-37PTH	*A.7.7.6*
NUHOMS®-61BT	*A.7.7.7*
NUHOMS®-61BTH	*A.7.7.8*
NUHOMS®-69BTH	*A.7.7.9*
RWC	*A.7.7.10*

Table A.7-4
Appendices Containing Unloading Procedures for Various DSCs

DSC Model	***Appendix***
NUHOMS®-24PT4	*A.7.7.1, Section A.7.7.1.4*
NUHOMS®-32PT	*A.7.7.2, Section A.7.7.2.4*
NUHOMS®-24PTH	*A.7.7.3, Section A.7.7.3.4*
NUHOMS®-32PTH	*A.7.7.4, Section A.7.7.4.4*
NUHOMS®-32PTH1	*A.7.7.5, Section A.7.7.5.4*
NUHOMS®-37PTH	*A.7.7.6, Section A.7.7.6.4*
NUHOMS®-61BT	*A.7.7.7, Section A.7.7.7.4*
NUHOMS®-61BTH	*A.7.7.8, Section A.7.7.8.4*
NUHOMS®-69BTH	*A.7.7.9, Section A.7.7.9.4*



MP197HB Cask Lid



Trunnion and Ram Closure Plate

Figure A.7-1
Torquing Patterns

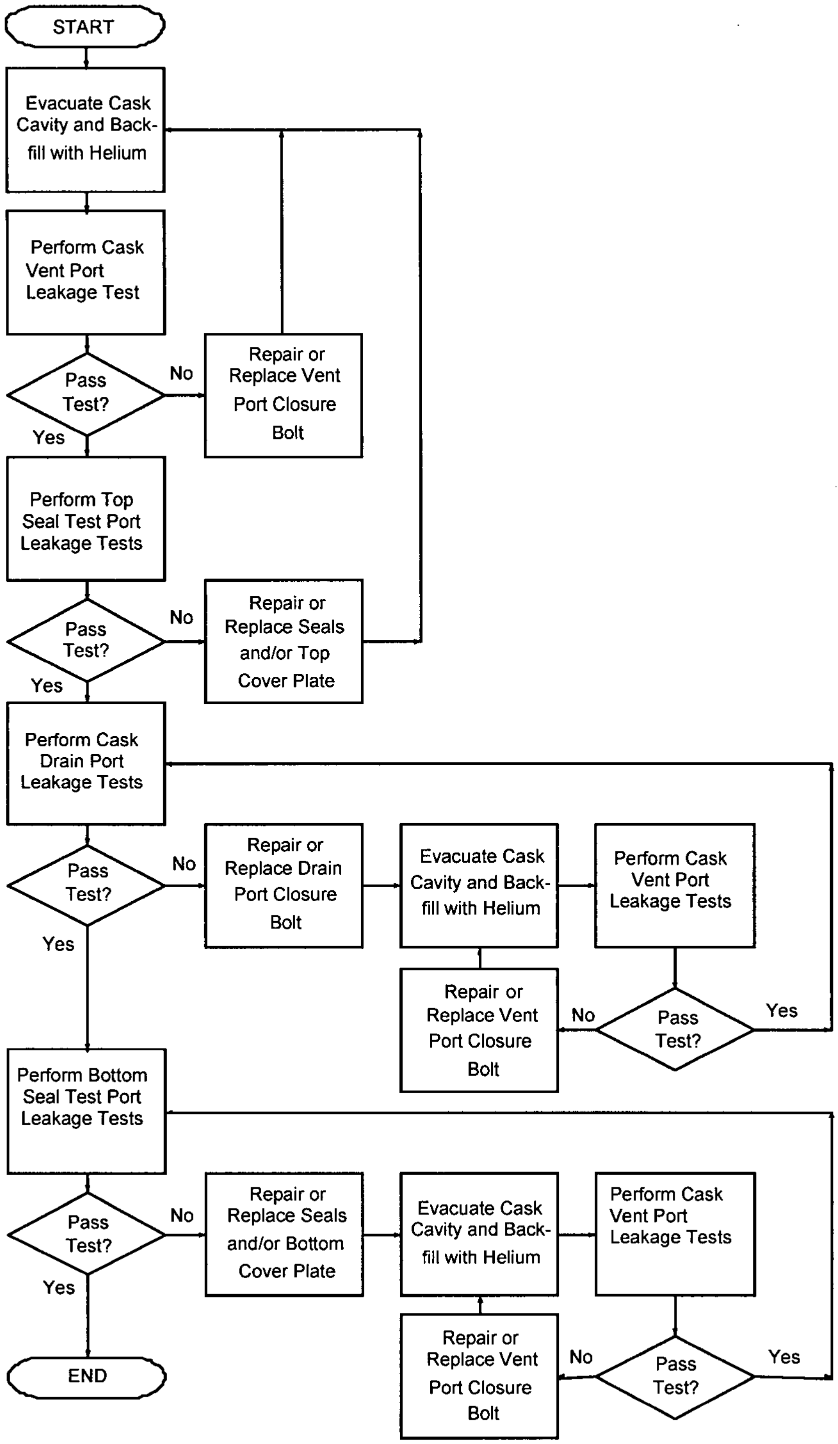


Figure A.7.2
Assembly Verification *Leakage* Test

APPENDIX A.7.7.1
NUHOMS®-24PT4 DSC Wet Loading and Unloading

Appendix A.7.7.1
NUHOMS®-24PT4 DSC Wet Loading and Unloading Procedures

NOTE: References in this chapter are shown as [1], [2], etc., and refer to the reference list in Section A.7.7.1.5. The term DSC as used in this appendix refers to the NUHOMS®-24PT4 DSC.

A.7.7.1.1 NUHOMS®-24PT4 DSC Fuel Loading

The starting condition for the following steps assumes completion of the cask preparation steps in Section A.7.1.2.

1. *Lift the cask/DSC and position it over the cask loading area of the spent fuel pool in accordance with the plant's 10 CFR 50 cask handling procedures.*
2. *Lower the cask into the fuel pool. As the cask is lowered into the pool, spray the exterior surface of the cask with clean water.*
3. *Place the cask in the location of the fuel pool designated as the cask loading area.*
4. *Disengage the lifting yoke from the cask lifting trunnions and move the yoke clear of the cask. Spray the lifting yoke with clean water if it is raised out of the fuel pool.*
5. *The potential for fuel misloading is essentially eliminated through the implementation of procedural and administrative controls. The controls instituted to ensure that damaged and/or intact fuel assemblies are placed into a known cell location within a DSC will typically consist of the following:*
   - *A cask/DSC loading plan is developed to verify that the intact and damaged fuel assemblies meet the burnup, enrichment, and cooling time parameters of the applicable sections as listed in step 13 of Section A.7.1.1 above.*
   - *The loading plan is independently verified and approved before the fuel load.*
   - *A fuel movement schedule is then written, verified, and approved based upon the loading plan. All fuel movements from any rack location are performed under strict compliance with the fuel movement schedule.*
   - *If loading damaged fuel assemblies, verify that the required number of failed fuel cans for the 24PT4 DSC have replaced the guide sleeves at the authorized locations within the 24PT4 DSC basket.*
6. *Prior to loading of a spent fuel assembly (SFA) into the DSC, the identity of the assembly is to be verified by two individuals using an underwater video camera or other means. Read and record the identification number from the fuel assembly and check this identification number against the DSC loading plan which indicates which fuel assemblies are acceptable for transport.*

Note: If poison rodlets are required for criticality control, they must be present in the assembly prior to insertion into the DSC. The presence and location of the poison rodlets shall be verified to be correct by two individuals.

7. *Position the fuel assembly for insertion into the selected DSC compartment and load the fuel assembly. Repeat steps 6-7 for each SFA loaded into the DSC. After the DSC has*

been fully loaded, check and record the identity and location of each fuel assembly in the DSC.

8. *After all the SFAs have been placed into the DSC and their identities verified, position the lifting yoke and the top shield plug (shield plug assembly) and lower the shield plug into the DSC. Optionally the shield plug may be installed using alternate rigging in lieu of the yoke.*
9. *Visually verify that the top shield plug is properly seated in the DSC.*
10. *Position the lifting yoke arms under the cask trunnions and verify that they are properly engaged.*
11. *Raise the cask to the pool surface. Prior to raising the top of the cask above the water surface, stop vertical movement.*
12. *Inspect the top shield plug to verify that it is properly seated within the DSC. If not, lower the cask and reposition the top shield plug. Repeat steps 9 through 12 as necessary.*
13. *Continue to raise the cask from the pool and spray the exposed portion of the cask with demineralized water until the top region of the cask is accessible.*
14. *Drain any excess water from the top of the DSC shield plug back to the fuel pool.*
15. *Check the radiation levels at the center of the top shield plug and around the perimeter of the cask.*
16. *As required for crane load limitations, drain water from the DSC. Use 1 to 3 psig of helium to backfill the DSC per ISG-22 [6] guidance as water is being removed from the DSC cavity.*
17. *Lift the cask from the fuel pool. As the cask is raised from the pool, continue to spray the cask with clean water.*
18. *Move the cask with loaded DSC to the plant designated preparation area.*
19. *Water removed at step 16 may be replaced with spent fuel pool water or equivalent.*

A.7.7.1.2 NUHOMS®-24PT4 DSC Drying and Backfilling

1. *Check the radiation levels along the perimeter of the cask. The cask exterior surface should be decontaminated as necessary. Temporary shielding may be installed as necessary to minimize personnel exposure.*
2. *Place scaffolding or other suitable work platform(s) around the cask so that any point on the surface of the cask is easily accessible to personnel.*
3. *Disengage the rigging cables from the top shield plug and remove the eye bolts. Disengage the lifting yoke from the trunnions and position it clear of the cask.*
4. *Decontaminate the exposed surfaces of the DSC shell perimeter and remove the annulus seal.*
5. *Connect a drain line to the cask, open the cask drain port and allow water from the annulus to drain out until the water level is approximately twelve inches below the top*

edge of the DSC shell. Take swipes around the outer top 1 foot surface of the DSC shell and check for smearable contamination as required.

CAUTION: *Radiation dose rates are expected to be high at the DSC vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

6. *Prior to the start of the welding operations, drain approximately 60 gallons of water from the DSC using the vacuum drying system (VDS) or an optional liquid pump. Consistent with ISG-22 [6] guidance, use helium at 1-3 psig to backfill the DSC with an inert gas as water is being removed from the DSC.*
7. *Disconnect the hose from the DSC siphon port.*
8. *Install the automated welding machine onto the inner top cover and place the inner top cover with the automated welding machine onto the DSC. Verify proper fit-up of the inner top cover plate with the DSC shell. Alternately, the inner top cover may be placed on the DSC separately or the inner top cover may be part of the shield plug; in these cases the automated welding machine is installed on the inner top cover already installed in the DSC.*
9. *Check radiation levels along the surface of the inner top cover plate. Temporary shielding may be installed as necessary to minimize personnel exposure throughout the subsequent welding operations.*
10. *Insert suitable tubing through the vent port such that it terminates just below the DSC top shield plug. Connect the tubing to a hydrogen monitor to allow continuous monitoring of the hydrogen atmosphere in the DSC cavity during welding of the inner top cover plate. Optionally, other methods may be used for continuous monitoring of the hydrogen atmosphere in the DSC cavity during welding of the inner top cover plate.*
11. *Cover the cask/DSC annulus to prevent debris and weld splatter from entering the annulus.*
12. *Ready the automated welding machine and tack weld the inner top cover plate to the DSC shell. Complete the inner top cover plate weld to the DSC shell and remove the automated welding machine.*

    CAUTION: *Continuously monitor the hydrogen concentration in the DSC cavity using the tube arrangement described in step 10 during the inner top cover plate cutting/welding operations. Verify that the measured hydrogen concentration does not exceed a safety limit of 2.4% [4] and [5]. If this limit is exceeded, stop all welding operations and purge the DSC cavity with 2-3 psig helium to reduce the hydrogen concentration safely below the 2.4% limit.*
13. *Perform dye penetrant examination of the weld surface.*
14. *Connect the VDS and/or a water pump to the DSC siphon and vent ports.*

    NOTE: *Do not use strongback during blowdown with 24PT4 DSC.*

15. *Use a water pump (may be part of VDS or separate pump) connected to the siphon port to remove remaining bulk water from the DSC cavity. Consistent with ISG-22 [6] guidance, use helium to backfill the DSC as water is being removed from the DSC. Alternately, pressurized helium may be introduced through the vent port to force the water from the DSC cavity through the siphon port.*

16. *Once the water stops flowing from the DSC, close the DSC siphon port and disengage the gas source.*

17. *Connect the hose from the vent port and the siphon port to the intake of the vacuum pump. Connect a hose from the discharge side of the VDS to the plant's radioactive waste system or spent fuel pool. Connect the VDS to a helium source.*

    NOTE: *Proceed cautiously when evacuating the DSC to avoid freezing consequences.*

18. *Open the valve on the suction side of the pump, start the VDS and draw a vacuum on the DSC cavity. The cavity pressure should be reduced in steps of approximately 100 torr, 50 torr, 25 torr, 15 torr, 10 torr, 5 torr, and 3 torr. (These specific vacuum steps are a guideline only; other stepped vacuum drying processes are acceptable.) After pumping down to each level, the pump is valved off and the cavity pressure monitored. The cavity pressure will rise as water and other volatiles in the cavity evaporate. When the cavity pressure stabilizes, the pump is valved in to continue the vacuum drying process. It may be necessary to repeat some steps, depending on the rate and extent of the pressure increase. Vacuum drying is complete when the pressure stabilizes for a minimum of 30 minutes at 3 torr or less.*

    NOTE: *The user shall ensure that the vacuum pump is isolated from the canister cavity when demonstrating compliance with <3 torr for 30 minutes. Simply closing the valve between the canister and the vacuum pump is not sufficient, as a faulty valve allows the vacuum pump to continue to draw a vacuum on the canister. Turning off the pump, or opening the suction side of the pump to atmosphere are examples of ways to assure that the pump is not continuing to draw a vacuum on the canister.*

    CAUTION: *Radiation dose rates are expected to be high at the vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

19. *Open the valve to the vent port and allow the helium to flow into the DSC cavity.*

20. *Pressurize the DSC cavity with helium to 6.0 +1.0/-0.0 psig.*

21. *Perform a helium leakage test on the top shield plug assembly and vent/siphon block and verify that a criterion of* $\leq 1\times10^{-4}$ *ref.cm*^{3}*/sec is met.*

22. *If a leak is found, repair the weld in accordance with the Code of Construction. Re-pressurize the 24PT4-DSC and repeat the helium leakage test.*

23. *Once no leaks are detected, depressurize the DSC cavity by releasing the helium through the VDS to the plant's spent fuel pool or radioactive waste system, or other appropriate system.*

24. *Re-evacuate the 24PT4 DSC cavity using the VDS. The cavity pressure should be reduced in steps of approximately 10 torr, 5 torr, and 3 torr. After pumping down to each level, the pump is valved off and the cavity pressure monitored. When the cavity pressure stabilizes, the pump is valved in to continue the vacuum drying process. Vacuum drying is complete when the pressure stabilizes for a minimum of 30 minutes at 3 torr.*

25. *Open the valve on the vent port and allow helium to flow into the DSC cavity to pressurize the 24PT4 DSC to 6.0 +1.0/-0.0 psig (stable for 30 minutes after filling).*

    CAUTION: *Radiation dose rates are expected to be high at the vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

26. *Close the valves on the helium source.*

A.7.7.1.3 NUHOMS®-24PT4 DSC Sealing Operations

1. *Disconnect the VDS from the DSC. Seal weld the prefabricated covers over the vent and siphon ports, inject helium into the blind space just prior to completing welding, and perform a dye penetrant weld examination.*

    NOTE: *At licensee discretion, a strongback may be installed on the outer top cover plate to flatten the plate. This will require that the outer top cover plate to the 24PT4 DSC shell tack welds be made manually, as the AWS will not fit over the strongback. Remove the strongback after tack welding and install AWS prior to placing the outer top cover plate-weld root pass.*

2. *Install the automated welding machine onto the outer top cover plate and place the outer top cover plate with the automated welding system onto the 24PT4 DSC. Verify proper fit up of the outer top cover plate.*

3. *Tack weld the outer top cover plate to the 24PT4 DSC shell. Weld outer top cover plate root pass. Perform dye penetrant examination of the root pass weld.*

4. *Weld out the outer top cover plate to the shell and perform dye penetrant examination on the weld surface.*

5. *Remove the automated welding machine from the 24PT4 DSC.*

6. *Open the cask drain port valve and drain the water from the cask/DSC annulus.*

The cask/DSC is now ready to be prepared for downending as described in Chapter A.7, Section A.7.1.2.2.

A.7.7.1.4 Unloading the NUHOMS®-24PT4 DSC to a Fuel Pool

CAUTION: *The process of DSC unloading is similar to that used for DSC loading. DSC opening operations described below are to be carefully controlled in accordance with site procedures. This operation is to be performed under the site's standard health physics guidelines for welding, grinding, and handling of potentially highly contaminated equipment. These are to include the use of prudent housekeeping measures and monitoring of airborne* *particles. Procedures may require tenting, respirators, supplied air, or other measures to contain contamination and minimize the impact on the health and safety of workers.*

1. *Locate the DSC siphon and vent ports using the indications on the DSC outer top cover plate.*
2. *Drill a hole in the DSC outer top cover plate and remove the siphon cover plate to expose the siphon port quick connect.*
3. *Drill a hole in the DSC outer top cover plate and remove the vent cover plate to expose the vent port quick connect.*
4. *Sample the DSC cavity atmosphere. If necessary, flush the DSC cavity gases to the site radwaste systems.*

CAUTION: *(a) The water fill rate must be regulated during this reflooding operation to ensure that the 24PT4 DSC vent pressure does not exceed 20 psig.*

(b) Provide for continuous hydrogen monitoring of the 24PT4 DSC cavity atmosphere during all subsequent cutting operations to ensure that a safety limit of 2.4% hydrogen concentration is not exceeded [4] and [5]. Purge with 2-3 psig helium (or any other inert medium) as necessary to maintain the hydrogen concentration safely below this limit.

5. *Fill the DSC with spent fuel pool water (or other plant-designated water source) through the siphon port with the vent port open and routed to the plant's off-gas system.*
6. *Install a debris shield over the cask/DSC annulus.*
7. *Use a mechanical cutting system, plasma arc-gouging, or other suitable means to remove the closure weld from the outer top cover plate.*

CAUTION: *Monitor the hydrogen concentration in the DSC cavity during this step to ensure that it does not exceed 2.4% by volume [4] and [5].*

8. *Remove the DSC outer top cover plate.*
9. *Continue with cutting equipment and remove the closure weld from the DSC inner top cover plate.*
10. *Remove the DSC inner top cover plate.*
11. *NOT USED*
12. *Remove excess material on the DSC inside shell surface which may interfere with top shield plug removal.*
13. *Clean the cask surface of dirt and debris that may have accumulated during transportation or weld removal.*
14. *Engage the cask lifting yoke to the upper trunnions and install the shield plug cables between the yoke and the DSC top shield plug.*

15. *Prior to lowering the cask into the pool, adjust the pool water, if necessary, to accommodate the volume of water which will be displaced by the cask during the operation.*
16. *Lower the cask slowly into the fuel pool while spraying the exterior of the cask with clean water.*
17. *Disengage the lifting yoke from the cask trunnions and remove the top shield plug.*
18. *Remove the fuel assemblies (or fuel cans as applicable for damaged fuel assemblies) from the DSC.*
19. *Engage the lifting yoke to the cask upper trunnions, remove the cask from the pool, and place it in the decon area.*
20. *Remove the water from the DSC cavity and cask/DSC annulus.*
21. *Remove the DSC from the cask and handle in accordance with low-level waste procedures.*
22. *Decontaminate the cask inner and outer surfaces as necessary.*
23. *Inspect the cask hardware (including covers and valves) for damage that may have occurred during transportation. Repair or replace as necessary.*

A.7.7.1.5 References

1. *Not Used.*
2. *Not Used*
3. *Not Used*
4. *U.S. Nuclear Regulatory Commission, Office of the Nuclear Material Safety and Safeguards, "Safety Evaluation of VECTRA Technologies' Response to Nuclear Regulatory Commission Bulletin 96-04 for the NUHOMS®-24P and NUHOMS®-7P."*
5. *U.S. Nuclear Regulatory Commission Bulletin 96-04, "Chemical, Galvanic or Other Reactions in Spent Fuel Storage and Transportation Casks," July 5, 1996.*
6. *U.S. Nuclear Regulatory Commission, Interim Staff Guidance (ISG)-22, "Potential Rod Splitting Due to Exposures to an Oxidizing Atmosphere during Short-term Cask Loading Operations in LWR or Other Uranium Oxide Based Fuel."*

APPENDIX A.7.7.2
NUHOMS®-32PT DSC Wet Loading and Unloading

Appendix A.7.7.2
NUHOMS®-32PT DSC Wet Loading and Unloading Procedures

NOTE: References in this chapter are shown as [1], [2], etc., and refer to the reference list in Section A.7.7.2.5. The term DSC as used in this appendix refers to the NUHOMS®-32PT DSC.

A.7.7.2.1 NUHOMS®-32PT DSC Fuel Loading

The starting condition for the following steps assumes completion of the cask preparation steps in Section A.7.1.2.

1. *Lift the cask/DSC and position it over the cask loading area of the spent fuel pool in accordance with the plant's 10 CFR 50 cask handling procedures.*
2. *Lower the cask into the fuel pool. As the cask is lowered into the pool, spray the exterior surface of the cask and lifting yoke with clean water.*
3. *Place the cask in the location of the fuel pool designated as the cask loading area.*
4. *Disengage the lifting yoke from the cask lifting trunnions and move the yoke clear of the cask. Spray the lifting yoke with clean water if it is raised out of the fuel pool.*
5. *The potential for fuel misloading is essentially eliminated through the implementation of procedural and administrative controls. The controls instituted to ensure that intact spent fuel assemblies (SFAs) and control components (CCs), if applicable, are placed into a known cell location within a DSC will typically consist of the following:*
    - *A cask/DSC loading plan is developed to verify that the fuel assemblies, and CCs, if applicable, meet the burnup, enrichment and cooling time parameters of the applicable section as listed in step 13 of Section A.7.1.1. If poison rod assemblies (PRAs) are determined to be needed, record the number required and the DSC cell location for each of the PRAs on the loading plan.*
    - *The loading plan is independently verified and approved before the fuel load.*
    - *A fuel movement schedule is then written, verified and approved based upon the loading plan. All fuel movements from any rack location are performed under strict compliance with the fuel movement schedule.*

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Proprietary information withheld pursuant to 10 CFR 2.390

6. *Prior to loading of an SFA (and CC, if applicable) into the DSC, the identity of the assembly (and CC, if applicable) is to be verified by two individuals using an underwater video camera or other means. Verification of CC identification is optional if the CC has not been moved from the host fuel assembly since its last verification. Read and record the identification number from the fuel assembly (and CC, if applicable) and check this identification number against the DSC loading plan which indicates which fuel assemblies (and CCs, if applicable) are acceptable for transport.*
7. *Position the fuel assembly for insertion into the selected DSC compartment and load the fuel assembly. Repeat steps 6-7 for each SFA loaded into the DSC. If applicable, insert the required number of PRAs at specific locations called out in the loading plan. After the DSC has been fully loaded, check and record the identity and location of each fuel assembly and CC, if applicable, in the DSC. Also record the location of each PRA inserted in the DSC (if applicable).*
8. *After all the SFAs, CCs, and PRAs, if applicable, have been placed into the DSC and their identities verified, position the lifting yoke and the top shield plug and lower the shield plug onto the DSC.*
9. *Visually verify that the top shield plug is properly seated in the DSC.*
10. *Position the lifting yoke arms under the cask trunnions and verify that they are properly engaged.*
11. *Raise the cask to the pool surface. Prior to raising the top of the cask above the water surface, stop vertical movement.*
12. *Inspect the top shield plug to verify that it is properly seated within the DSC. If not, lower the cask and reposition the top shield plug. Repeat steps 9 through 12 as necessary.*
13. *Continue to raise the cask from the pool and spray the exposed portion of the cask with demineralized water until the top region of the cask is accessible.*
14. *Drain any excess water from the top of the DSC shield plug back to the fuel pool.*
15. *Check the radiation levels at the center of the top shield plug and around the perimeter of the cask.*
16. *Water may be drained from the DSC back into the fuel pool or other suitable location to meet the weight limit on the crane. Use 1-3 psig of helium to backfill the DSC per ISG-22 [6] guidance as water is being removed from the DSC.*
17. *Lift the cask from the fuel pool. As the cask is raised from the pool, continue to spray the cask with clean water.*

18. *Move the cask with loaded DSC to the plant designated preparation area.*
19. *Water removed at step 16 may be replaced with spent fuel pool water or equivalent.*

A.7.7.2.2 NUHOMS®-32PT DSC Drying and Backfilling

1. *Check the radiation levels along the perimeter of the cask. The cask exterior surface should be decontaminated as necessary. Temporary shielding may be installed as necessary to minimize personnel exposure.*
2. *Place scaffolding or other suitable work platform(s) around the cask so that the surface of the cask is easily accessible to personnel.*
3. *Disengage the rigging cables from the top shield plug and remove the eyebolts. Disengage the lifting yoke from the trunnions and position it clear of the cask.*
4. *Decontaminate the exposed surfaces of the DSC shell perimeter and remove the annulus seal.*
5. *Connect a drain line to the cask, open the cask drain port and allow water from the annulus to drain out until the water level is approximately twelve inches below the top edge of the DSC shell. Take swipes around the outer top 1 foot surface of the DSC shell and check for smearable contamination as required.*

   CAUTION: *Radiation dose rates are expected to be high at the DSC vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

6. *Prior to the start of the welding operations, drain a minimum of 750 gallons of water from the DSC using the vacuum drying system (VDS) or an optional liquid pump. Consistent with ISG-22 [6] guidance, use 1-3 psig helium to backfill the DSC as water is being removed from the DSC.*
7. *Disconnect the hose from the DSC siphon port.*
8. *Install the automated welding machine onto the inner top cover and place the inner top cover with the automated welding machine onto the DSC. Verify proper fit-up of the inner top cover plate with the DSC shell. Alternately, the inner top cover may be placed on the DSC separately or the inner top cover may be part of the shield plug; in these cases the automated welding machine is installed on the inner top cover already installed in the DSC.*
9. *Check radiation levels along the surface of the inner top cover plate. Temporary shielding may be installed as necessary to minimize personnel exposure throughout the subsequent welding operations.*
10. *Insert suitable tubing through the vent port such that it terminates just below the DSC top shield plug. Connect the tubing to a hydrogen monitor to allow continuous monitoring of the hydrogen atmosphere in the DSC cavity during welding of the inner top cover plate. Optionally, other methods may be used for continuous monitoring of the hydrogen atmosphere in the DSC cavity during welding of the inner top cover plate.*

11. *Cover the cask/DSC annulus to prevent debris and weld splatter from entering the annulus.*

12. *Ready the automated welding machine and tack weld the inner top cover plate to the DSC shell. Complete the inner top cover plate weld to the DSC shell and remove the automated welding machine.*

    ***CAUTION**: Continuously monitor the hydrogen concentration in the DSC cavity using the tube arrangement described in step 10 during the inner top cover plate cutting/welding operations. Verify that the measured hydrogen concentration does not exceed a safety limit of 2.4% [4] and [5]. If this limit is exceeded, stop all welding operations and purge the DSC cavity with 2-3 psig helium to reduce the hydrogen concentration safely below the 2.4% limit.*

13. *Perform dye penetrant examination of the weld surface.*

14. *Connect the VDS and/or a water pump to the DSC siphon and vent ports.*

15. *Use a water pump (may be part of VDS or separate pump) connected to the siphon port to remove remaining bulk water from the DSC cavity. Consistent with ISG-22 [6] guidance, use helium to backfill the DSC as water is being removed from the DSC. Alternately, pressurized helium may also be introduced through the vent port to force the water from the DSC cavity through the siphon port.*

16. *Once the water stops flowing from the DSC, close the DSC siphon port and disengage the gas source.*

17. *Connect the hose from the vent port and the siphon port to the intake of the vacuum pump. Connect a hose from the discharge side of the VDS to the plant's radioactive waste system or spent fuel pool. Connect the VDS to a helium source.*

    ***NOTE**: Proceed cautiously when evacuating the DSC to avoid freezing consequences.*

18. *Open the valve on the suction side of the pump, start the VDS and draw a vacuum on the DSC cavity. The cavity pressure should be reduced in steps of approximately 100 mm Hg, 50 mm Hg, 25 mm Hg, 15 mm Hg, 10 mm Hg, 5 mm Hg, and 3 mm Hg (these specific vacuum steps are a guideline only; other stepped vacuum drying processes are acceptable). After pumping down to each level, the pump is valved off and the cavity pressure monitored. The cavity pressure will rise as water and other volatiles in the cavity evaporate. When the cavity pressure stabilizes, the pump is valved in to continue the vacuum drying process. It may be necessary to repeat some steps, depending on the rate and extent of the pressure increase. Vacuum drying is complete when the pressure stabilizes for a minimum of 30 minutes at 3 mm Hg or less.*

    ***NOTE**: The user shall ensure that the vacuum pump is isolated from the canister cavity when demonstrating compliance with <3 mm Hg for 30 minutes. Simply closing the valve between the canister and the vacuum pump is not sufficient, as a faulty valve allows the vacuum pump to continue to draw a vacuum on the canister. Turning off the pump, or opening the suction side of the pump to atmosphere are examples of ways to assure that the pump is not continuing to draw a vacuum on the canister.*

CAUTION: *Radiation dose rates are expected to be high at the vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

19. *Open the valve to the vent port and allow the helium to flow into the DSC cavity.*
20. *If the optional leakage test of step 21 is not to be performed, skip to step 24. Otherwise, pressurize the DSC with helium to a pressure between 24 psia and 34 psia.*
21. *Perform helium leakage test of the inner top cover plate weld for a leakage rate of* $\leq 1 \times 10^{-5}$ *ref cm³/sec. This test is optional.*
22. *If a leak is found, repair the weld, repressurize the DSC and repeat the helium leakage test.*
23. *Once no leaks are detected, depressurize the DSC cavity by releasing the helium through the VDS to the plant's spent fuel pool or radioactive waste system, or other appropriate system.*
24. *Re-evacuate the DSC cavity using the VDS. The cavity pressure should be reduced in steps of approximately 10 mm Hg, 5 mm Hg, and 3 mm Hg. After pumping down to each level, the pump is valved off and the cavity pressure monitored. When the cavity pressure stabilizes, the pump is valved in to continue the vacuum drying process. Vacuum drying is complete when the pressure stabilizes for a minimum of 30 minutes at 3 mm Hg.*
25. *Open the valve on the vent port and allow helium to flow into the DSC cavity to pressurize the DSC to 2.5 ± 1.0 psig backfill pressure (stable for 30 minutes).*

    CAUTION: *Radiation dose rates are expected to be high at the vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

26. *Close the valves on the helium source.*

A.7.7.2.3 NUHOMS®-32PT DSC Sealing Operations

1. *Disconnect the VDS from the DSC. Seal weld the prefabricated covers over the vent and siphon ports, inject helium into the blind space just prior to completing welding, and perform a dye penetrant weld examination.*
2. *Temporary shielding may be installed as necessary to minimize personnel exposure. Install the automated welding machine onto the outer top cover plate and place the outer top cover plate with the automated welding system onto the DSC (or place cover and welding system separately). Verify proper fit up of the outer top cover plate with the DSC shell.*
3. *Tack weld the outer top cover plate to the DSC shell. Place the outer top cover plate weld root pass.*
4. *Perform a helium leakage test of the inner top cover plate and vent/siphon port plate welds using the test port in the outer top cover plate and verify that the "leak-tight" criterion of* $\leq 1 \times 10^{-7}$ *ref.cm³/sec as defined in ANSI N14.5 [1] is met. Verify that the*

personnel performing the leakage test are qualified in accordance with SNT-TC-1A [7]. Alternatively, this leakage test can be done with a test head following step 1.

5. *If a leak is found, remove the outer cover plate root pass (if not using the test head), the vent and siphon port plugs and repair the inner cover plate welds. Then repeat applicable procedure steps from Section A.7.7.2.2, step 17.*
6. *Perform dye penetrant examination of the root pass weld. Weld out the outer top cover plate to the DSC shell and perform dye penetrant examination on the weld surface.*
7. *Seal weld the prefabricated plug (when applicable) over the outer cover plate test port and perform dye penetrant weld examinations.*
8. *Remove the automated welding machine from the DSC.*
9. *Open the cask drain port valve and drain the water from the cask/DSC annulus.*

The cask/DSC is now ready to be prepared for downending as described in Chapter A.7, Section A.7.1.2.2.

A.7.7.2.4 Unloading a NUHOMS®-32PT DSC to a Fuel Pool

CAUTION: *The process of DSC unloading is similar to that used for DSC loading. DSC opening operations described below are to be carefully controlled in accordance with site procedures. This operation is to be performed under the site's standard health physics guidelines for welding, grinding, and handling of potentially highly contaminated equipment. These are to include the use of prudent housekeeping measures and monitoring of airborne particles. Procedures may require tenting, respirators, supplied air or other measures to contain contamination and minimize the impact on the health and safety of workers.*

1. *Locate the DSC siphon and vent ports using the indications on the DSC outer top cover plate.*
2. *Drill a hole in the DSC outer top cover plate and remove the siphon cover plate to expose the siphon port quick connect.*
3. *Drill a hole in the DSC outer top cover plate and remove the vent cover plate to expose the vent port quick connect.*
4. *Sample the DSC cavity atmosphere. If necessary, flush the DSC cavity gases to the site radwaste systems.*
5. *Fill the DSC with spent fuel pool water (or other plant designated water source) through the siphon port with the vent port open and routed to the plant's off-gas system. Soluble boron requirements per step 5.A of Section A.7.7.2.1 are applicable for the pool and DSC cavity water.*

CAUTION:
(a) The water fill rate must be regulated during this reflooding operation to ensure that the DSC vent pressure does not exceed 20.0 psig.

(b) Provide for continuous hydrogen monitoring of the DSC cavity atmosphere during all subsequent cutting operations to ensure that a safety limit of 2.4% is not exceeded [4] and [5]. Purge with 2-3 psig helium (or any other inert medium) as necessary to maintain the hydrogen concentration safely below this limit.

6. *Install a debris shield over the cask/DSC annulus.*
7. *Use a mechanical cutting system, plasma arc-gouging, or other suitable means to remove the closure weld from the outer top cover plate.*

   CAUTION: *Monitor the hydrogen concentration in the DSC cavity during this step to ensure that it does not exceed 2.4% by volume [4] and [5].*

8. *Remove the DSC outer top cover plate.*
9. *Continue with cutting equipment and remove the closure weld from the DSC inner top cover plate.*
10. *Remove the DSC inner top cover plate.*
11. *NOT USED*
12. *Remove excess material on the DSC inside shell surface which may interfere with top shield plug removal.*
13. *Clean the cask surface of dirt and debris that may have accumulated during transportation or weld removal.*
14. *Engage the cask lifting yoke to the upper trunnions and install the shield plug cables between the yoke and the DSC top shield plug.*
15. *Prior to lowering the cask into the pool, adjust the pool water, if necessary, to accommodate the volume of water which will be displaced by the cask during the operation.*
16. *Lower the cask slowly into the fuel pool while spraying the exterior of the cask with clean water.*
17. *Disengage the lifting yoke from the cask trunnions and remove the top shield plug.*
18. *Remove the fuel assemblies from the DSC.*
19. *Engage the lifting yoke to the cask upper trunnions, remove the cask from the pool, and place it in the decon area.*
20. *Remove the water from the DSC cavity and cask/DSC annulus.*
21. *Remove the DSC from the cask and handle in accordance with low-level waste procedures.*
22. *Decontaminate the cask inner and outer surfaces as necessary.*
23. *Inspect the cask hardware (including covers and valves) for damage that may have occurred during transportation. Repair or replace as necessary.*

A.7.7.2.5 References

1. *ANSI N14.5-1997, "American National Standard for Radioactive Materials - Leakage Tests on Packages for Shipment," American National Standards Institute, Inc., New York, 1997.*
2. *Not Used*
3. *Not Used*
4. *U.S. Nuclear Regulatory Commission, Office of the Nuclear Material Safety and Safeguards, "Safety Evaluation of VECTRA Technologies' Response to Nuclear Regulatory Commission Bulletin 96-04 for the NUHOMS®-24P and NUHOMS®-7P."*
5. *U.S. Nuclear Regulatory Commission Bulletin 96-04, "Chemical, Galvanic or Other Reactions in Spent Fuel Storage and Transportation Casks," July 5, 1996.*
6. *U.S. Nuclear Regulatory Commission, Interim Staff Guidance (ISG)-22, "Potential Rod Splitting Due to Exposures to an Oxidizing Atmosphere during Short-term Cask Loading Operations in LWR or Other Uranium Oxide Based Fuel."*
7. *SNT-TC-1A, "American Society for Nondestructive Testing, Personnel Qualification and Certification in Nondestructive Testing."*

APPENDIX A.7.7.3
NUHOMS®-24PTH DSC Wet Loading and Unloading

Appendix A.7.7.3
NUHOMS®-24PTH DSC Wet Loading and Unloading Procedures

NOTE: References in this chapter are shown as [1], [2], etc. and refer to the reference list in Section A.7.7.3.5. The term DSC as used in this appendix refers to the NUHOMS®-24PTH DSC.

A.7.7.3.1 NUHOMS®-24PTH DSC Fuel Loading

The starting condition for the following steps assumes completion of the cask preparation steps in Section A.7.1.2.

1. *Lift the cask/DSC and position it over the cask loading area of the spent fuel pool in accordance with the plant's 10 CFR 50 cask handling procedures.*
2. *Lower the cask into the fuel pool. As the cask is lowered into the pool, spray the exterior surface of the cask and the lifting yoke with clean water.*
3. *Place the cask in the location of the fuel pool designated as the cask loading area.*
4. *Disengage the lifting yoke from the cask lifting trunnions and move the yoke clear of the cask. Spray the lifting yoke with clean water if it is raised out of the fuel pool.*
5. *The potential for fuel misloading is essentially eliminated through the implementation of procedural and administrative controls. The controls instituted to ensure that failed, damaged and/or intact spent fuel assemblies (SFAs) and control components (CCs), if applicable, are placed into a known cell location within a DSC will typically consist of the following:*
   - *A cask/DSC loading plan is developed to verify that the intact, damaged and failed SFAs, and CCs, if applicable, meet the burnup, enrichment and cooling time parameters of the applicable sections as listed in step 13 of Section A.7.1.1 above.*
   - *The loading plan is independently verified and approved before the fuel load.*
   - *A fuel movement schedule is then written, verified and approved based upon the loading plan. All fuel movements from any rack location are performed under strict compliance with the fuel movement schedule.*
   - *If loading damaged fuel assemblies, verify that the required number of bottom end caps are installed in appropriate locations in the basket.*
   - *If loading failed fuel, verify that the required number of failed fuel cans are installed in the appropriate locations, or, once loaded with fuel, are installed in the appropriate locations in the basket.*

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6. *Prior to loading of an SFA (and CC, if applicable) into the DSC, the identity of the SFA (and CC, if applicable) is to be verified by two individuals using an underwater video camera or other means. Verification of CC identification is optional if the CC has not been moved from the host fuel assembly since its last verification. Read and record the identification number from the SFA (and CC, if applicable) and check this identification number against the DSC loading plan which indicates which SFAs (and CCs, if applicable) are acceptable for transportation.*

7. *Position the fuel assembly for insertion into the selected DSC storage cell and load the fuel assembly. Repeat step 6 for each SFA loaded into the DSC. If loading damaged fuel assemblies, place top end caps over each damaged fuel assembly placed into the basket. If loading failed fuel, ensure that the failed fuel can lids are installed. After the DSC has been fully loaded, check and record the identity and location of each fuel assembly and CC, if applicable, in the DSC.*

8. *After all the SFAs and CCs, if applicable, have been placed into the DSC and their identities verified, position the lifting yoke and the top shield plug (shield plug assembly) and lower the shield plug into the DSC. Optionally the shield plug may be installed using alternate rigging in lieu of the yoke.*

9. *Visually verify that the top shield plug is properly seated in the DSC.*

10. *Position the lifting yoke arms under the cask trunnions and verify that they are properly engaged.*

11. *Raise the cask to the pool surface. Prior to raising the top of the cask above the water surface, stop vertical movement.*

12. *Inspect the top shield plug to verify that it is properly seated within the DSC. If not, lower the cask and reposition the top shield plug. Repeat steps 9 through 12 as necessary.*

13. *Continue to raise the cask from the pool and spray the exposed portion of the cask with demineralized water until the top region of the cask is accessible.*

14. *Drain any excess water from the top of the DSC shield plug back to the fuel pool.*

15. *Check the radiation levels at the center of the top shield plug and around the perimeter of the cask.*
16. *As required for crane load limitations, drain water from the DSC. Use 1 to 3 psig of helium to backfill the DSC per ISG-22[6] guidance as water is being removed from the DSC cavity.*
17. *Lift the cask from the fuel pool. As the cask is raised from the pool, continue to spray the cask with clean water.*
18. *Move the cask with loaded DSC to the plant designated preparation area.*
19. *Water removed at step 16 may be replaced with spent fuel pool water or equivalent.*

A.7.7.3.2 NUHOMS®-24PTH DSC Drying and Backfilling

CAUTION: *During performance of steps listed in this section, monitor the cask/DSC annulus water level and replenish as necessary to maintain cooling.*

1. *Check the radiation levels along the perimeter of the cask. The cask exterior surface should be decontaminated as necessary. Temporary shielding may be installed as necessary to minimize personnel exposure.*
2. *Place scaffolding or other suitable work platform(s) around the cask so that the surface of the cask is easily accessible to personnel.*
3. *Disengage the rigging cables from the top shield plug and remove the eyebolts. Disengage the lifting yoke from the trunnions and position it clear of the cask.*
4. *Decontaminate the exposed surfaces of the DSC shell perimeter and remove the annulus seal.*
5. *Connect a drain line to the cask, open the cask drain port and allow water from the annulus to drain out until the water level is approximately twelve inches below the top edge of the DSC shell. Take swipes around the outer top 1 foot surface of the DSC shell and check for smearable contamination as required.*

   CAUTION: *Radiation dose rates are expected to be high at the DSC vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*
6. *Prior to the start of the welding operations, drain a minimum of 750 gallons of water from the DSC using the vacuum drying system (VDS) or an optional liquid pump. Consistent with ISG-22 [6] guidance, use 1-3 psig helium to backfill the DSC gas as water is being removed from the DSC.*
7. *Disconnect the hose from the DSC siphon port.*
8. *Install the automated welding machine onto the inner top cover and place the inner top cover with the automated welding machine onto the DSC. Verify proper fit-up of the inner top cover plate with the DSC shell. Alternately, the inner top cover may be placed on the DSC separately or the inner top cover may be part of the shield plug; in these*

cases the automated welding machine is installed on the inner top cover already installed in the DSC.

9. *Check radiation levels along the surface of the inner top cover plate. Temporary shielding may be installed as necessary to minimize personnel exposure throughout the subsequent welding operations.*

10. *Insert suitable tubing through the vent port such that it terminates just below the DSC top shield plug. Connect the tubing to a hydrogen monitor to allow continuous monitoring of the hydrogen atmosphere in the DSC cavity during welding of the inner top cover plate. Optionally, other methods may be used for continuous monitoring of the hydrogen atmosphere in the DSC cavity during welding of the inner top cover plate.*

11. *Cover the cask/DSC annulus to prevent debris and weld splatter from entering the annulus.*

12. *Ready the automated welding machine and tack weld the inner top cover plate to the DSC shell. Complete the inner top cover plate weld to the DSC shell and remove the automated welding machine.*

    ***CAUTION**: Continuously monitor the hydrogen concentration in the DSC cavity using the tube arrangement described in step 10 during the inner top cover plate cutting/welding operations. Verify that the measured hydrogen concentration does not exceed a safety limit of 2.4% [4] and [5]. If this limit is exceeded, stop all welding operations and purge the DSC cavity with 2-3 psig helium to reduce the hydrogen concentration safely below the 2.4% limit.*

13. *Perform dye penetrant examination of the weld surface.*

14. *Connect the VDS and or a water pump to the DSC siphon and vent ports.*

15. *Use a water pump (may be part of VDS or separate pump) connected to the siphon port to remove remaining bulk water from the DSC cavity. Consistent with ISG-22 [6] guidance, use helium to backfill the DSC as water is being removed from the DSC. Alternately, pressurized helium may be introduced through the vent port to force the water from the DSC cavity through the siphon port.*

16. *Once the water stops flowing from the DSC, close the DSC siphon port and disengage the gas source.*

17. *Connect the hose from the vent port and the siphon port to the intake of the vacuum pump. Connect a hose from the discharge side of the VDS to the plant's radioactive waste system or spent fuel pool. Connect the VDS to a helium source.*

    ***NOTE**: Proceed cautiously when evacuating the DSC to avoid freezing consequences.*

18. *Open the valve on the suction side of the pump, start the VDS and draw a vacuum on the DSC cavity. The cavity pressure should be reduced in steps of approximately 100 mm Hg, 50 mm Hg, 25 mm Hg, 15 mm Hg, 10 mm Hg, 5 mm Hg, and 3 mm Hg (these specific vacuum steps are a guideline only; other stepped vacuum drying processes are acceptable). After pumping down to each level, the pump is valved off and the cavity pressure monitored. The cavity pressure will rise as water and other volatiles in the*

cavity evaporate. When the cavity pressure stabilizes, the pump is valved in to continue the vacuum drying process. It may be necessary to repeat some steps, depending on the rate and extent of the pressure increase. Vacuum drying is complete when the pressure stabilizes for a minimum of 30 minutes at 3 mm Hg or less.

NOTE: *The user shall ensure that the vacuum pump is isolated from the canister cavity when demonstrating compliance with <3 mm Hg for 30 minutes. Simply closing the valve between the canister and the vacuum pump is not sufficient, as a faulty valve allows the vacuum pump to continue to draw a vacuum on the canister. Turning off the pump, or opening the suction side of the pump to atmosphere are examples of ways to assure that the pump is not continuing to draw a vacuum on the canister.*

CAUTION: *Radiation dose rates are expected to be high at the vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

19. *Open the valve to the vent port and allow the helium to flow into the DSC cavity.*
20. *If the optional leakage test of step 21 is not to be performed, skip to step 24. Otherwise, pressurize the DSC with helium to a pressure between 24 psia and 34 psia.*
21. *Perform helium leakage test the inner top cover plate weld for a leakage rate of $\leq 1 \times 10^{-4}$ ref.cm^3/sec. This test is optional.*
22. *If a leak is found, repair the weld, repressurize the DSC and repeat the helium leakage test.*
23. *Once no leaks are detected, depressurize the DSC cavity by releasing the helium through the VDS to the plant's spent fuel pool or radioactive waste system, or other appropriate system.*
24. *Re-evacuate the DSC cavity using the VDS. The cavity pressure should be reduced in steps of approximately 10 mm Hg, 5 mm Hg, and 3 mm Hg. After pumping down to each level, the pump is valved off and the cavity pressure monitored. When the cavity pressure stabilizes, the pump is valved in to continue the vacuum drying process. Vacuum drying is complete when the pressure stabilizes for a minimum of 30 minutes at 3 mm Hg or less.*
25. *Open the valve on the vent port and allow helium to flow into the DSC cavity to pressurize the DSC cavity to 2.5 ± 1.0 psig (stable for 30 minutes).*

    CAUTION: *Radiation dose rates are expected to be high at the vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

26. *Close the valves on the helium source.*

A.7.7.3.3 NUHOMS®-24PTH DSC Sealing Operations

CAUTION: *During performance of steps listed in this section, monitor the cask/DSC annulus water level and replenish as necessary to maintain cooling.*

1. Disconnect the VDS from the DSC. Seal weld the prefabricated covers over the vent and siphon ports, inject helium into the blind space just prior to completing welding, and perform a dye penetrant weld examination.

2. Temporary shielding may be installed as necessary to minimize personnel exposure. Install the automated welding machine onto the outer top cover plate and place the outer top cover plate with the automated welding system onto the DSC. Alternately, the welding machine may be mounted onto the cover plate and then placed together on the DSC. Verify proper fit up of the outer top cover plate with the DSC shell.

3. Tack weld the outer top cover plate to the DSC shell. Place the outer top cover plate weld root pass.

4. Perform a helium leakage test of the inner top cover plate and vent/siphon port plate welds using the test port in the outer top cover plate and verify that the "leak-tight" criterion of $\leq 1x10^{-7}$ ref.cm^3/sec as defined in ANSI N14.5 [1] is met. Verify that the personnel performing the leakage test are qualified in accordance with SNT-TC-1A [7]. Alternatively, this leakage test can be done with a test head following step 1 above.

5. If a leak is found, remove the outer cover plate root pass (if not using a test head), the vent and siphon port plugs and repair the inner cover plate welds. Then repeat the applicable procedure steps from Section A.7.7.3.2, step 17.

6. Perform dye penetrant examination of the root pass weld. Weld out the outer top cover plate to the DSC shell and perform dye penetrant examination on the weld surface.

7. Seal weld the prefabricated plug (when applicable) over the outer cover plate test port and perform dye penetrant weld examinations.

8. Remove the automated welding machine from the DSC.

9. Open the cask drain port valve and drain the water from the cask/DSC annulus.

The cask/DSC is now ready to be prepared for downending as described in Chapter A.7, Section A.7.1.2.2.

A.7.7.3.4 Unloading the NUHOMS®- 24PTH DSC to a Fuel Pool

CAUTION: *The process of DSC unloading is similar to that used for DSC loading. DSC opening operations described below are to be carefully controlled in accordance with site procedures. This operation is to be performed under the site's standard health physics guidelines for welding, grinding, and handling of potentially highly contaminated equipment. These are to include the use of prudent housekeeping measures and monitoring of airborne particles. Procedures may require tenting, respirators, supplied air or other measures to contain contamination and minimize the impact on the health and safety of workers.*

1. Locate the DSC siphon and vent ports using the indications on the DSC outer top cover plate.

2. Drill a hole in the DSC outer top cover plate and remove the siphon cover plate to expose the siphon port quick connect.

3. *Drill a hole in the DSC outer top cover plate and remove the vent cover plate to expose the vent port quick connect.*

4. *Sample the DSC cavity atmosphere. If necessary, flush the DSC cavity gases to the site radwaste systems.*

   CAUTION: *(a) The water fill rate must be regulated during this reflooding operation to ensure that the DSC vent pressure does not exceed 20.0 psig.*

   (b) Provide for continuous hydrogen monitoring of the DSC cavity atmosphere during all subsequent cutting operations to ensure that a safety limit of 2.4% is not exceeded [4] and [5]. Purge with 2-3 psig helium (or any other inert medium) as necessary to maintain the hydrogen concentration safely below this limit.

5. *Fill the DSC with spent fuel pool water (or other plant-designated water source) through the siphon port with the vent port open and routed to the plant's off-gas system. Soluble boron requirements per step 5.A of Section A.7.7.3.1 are applicable for the pool and DSC cavity water.*

6. *Install a debris shield over the cask/DSC annulus.*

7. *Use a mechanical cutting system, plasma arc-gouging, or other suitable means to remove the closure weld from the outer top cover plate.*

   CAUTION: *Monitor the hydrogen concentration in the DSC cavity during this step to ensure that it does not exceed 2.4% by volume [4] and [5].*

8. *Remove the DSC outer top cover plate.*

9. *Continue with the cutting equipment and remove the closure weld from the DSC inner top cover plate.*

10. *Remove the DSC inner top cover plate.*

11. *NOT USED*

12. *Remove excess material on the DSC inside shell surface which may interfere with top shield plug removal.*

13. *Clean the cask surface of dirt and debris that may have accumulated during transportation or weld removal.*

14. *Engage the cask lifting yoke to the upper trunnions and install the shield plug cables between the yoke and the DSC top shield plug.*

15. *Prior to lowering the cask into the pool, adjust the pool water, if necessary, to accommodate the volume of water which will be displaced by the cask during the operation.*

16. *Lower the cask slowly into the fuel pool while spraying the exterior of the cask surface with clean water.*

17. *Disengage the lifting yoke from the cask trunnions and remove the top shield plug.*

18. Remove the fuel assemblies (or fuel cans/end caps as applicable for failed/damaged fuel assemblies) from the DSC.

19. Engage the lifting yoke to the cask upper trunnions, remove the cask from the pool, and place it in the decon area.

20. Remove the water from the DSC cavity and cask/DSC annulus.

21. Remove the DSC from the cask and handle in accordance with low-level waste procedures.

22. Decontaminate the cask inner and outer surfaces as necessary.

23. Inspect the cask hardware (including covers and valves) for damage that may have occurred during transportation. Repair or replace as necessary.

A.7.7.3.5 References

1. *ANSI N14.5-1997, "American National Standard for Radioactive Materials - Leakage Tests on Packages for Shipment," American National Standards Institute, Inc., New York, 1997.*

2. *Not Used*

3. *Not Used*

4. *U.S. Nuclear Regulatory Commission, Office of the Nuclear Material Safety and Safeguards, "Safety Evaluation of VECTRA Technologies' Response to Nuclear Regulatory Commission Bulletin 96-04 for the NUHOMS®-24P and NUHOMS®-7P."*

5. *U.S. Nuclear Regulatory Commission Bulletin 96-04, "Chemical, Galvanic or Other Reactions in Spent Fuel Storage and Transportation Casks," July 5, 1996.*

6. *U.S. Nuclear Regulatory Commission, Interim Staff Guidance (ISG)-22, "Potential Rod Splitting Due to Exposures to an Oxidizing Atmosphere during Short-term Cask Loading Operations in LWR or Other Uranium Oxide Based Fuel."*

7. *SNT-TC-1A, "American Society for Nondestructive Testing, Personnel Qualification and Certification in Nondestructive Testing."*

APPENDIX A.7.7.4
NUHOMS®-32PTH DSC Wet Loading and Unloading

Appendix A.7.7.4
NUHOMS®-32PTH DSC Wet Loading and Unloading Procedures

NOTE: References in this chapter are shown as [1], [2], etc., and refer to the reference list in Section A.7.7.4.5. The term DSC as used in this appendix refers to the NUHOMS®-32PTH DSC.

A.7.7.4.1 NUHOMS®-32PTH DSC Fuel Loading

The starting condition for the following steps assumes completion of the cask preparation steps in Section A.7.1.2.

1. *Lift the cask/DSC and position it over the cask loading area of the spent fuel pool in accordance with the plant's 10 CFR 50 cask handling procedures.*
2. *Lower the cask into the fuel pool. As the cask is lowered into the pool, spray the exterior surface of the cask and lifting yoke with clean water.*
3. *Place the cask in the location of the fuel pool designated as the cask loading area.*
4. *Disengage the lifting yoke from the cask lifting trunnions and move the yoke clear of the cask. Spray the lifting yoke with clean water if it is raised out of the fuel pool.*
5. *The potential for fuel misloading is essentially eliminated through the implementation of procedural and administrative controls. The controls instituted to ensure that damaged and/or intact spent fuel assemblies (SFAs) and control components (CCs), if applicable, are placed into a known cell location within a DSC will typically consist of the following:*
    - *A cask/DSC loading plan is developed to verify that the intact, damaged SFAs and CCs, if applicable, meet the burnup, enrichment and cooling time parameters of the applicable sections as listed in step 13 of Section A.7.1.1 above.*
    - *The loading plan is independently verified and approved before the fuel load.*
    - *A fuel movement schedule is then written, verified and approved based upon the loading plan. All fuel movements from any rack location are performed under strict compliance with the fuel movement schedule.*
    - *If loading damaged fuel assemblies, verify that the required number of bottom end caps are installed in appropriate locations in the basket.*

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6. *Prior to loading of an SFA (and CCs, if applicable) into the DSC, the identity of the assembly (and CCs, if applicable) is to be verified by two individuals using an underwater video camera or other means. Verification of CC identification is optional if the CC has not been moved from the host SFA since its last verification. Read and record the identification number from the SFA (and CCs, if applicable) and check this identification number against the DSC loading plan which indicates which SFA (and CC, if applicable) are acceptable for transport.*
7. *Position the fuel assembly for insertion into the selected DSC compartment and load the fuel assembly. Repeat steps 6–7 for each SFA loaded into the DSC. After the DSC has been fully loaded, check and record the identity and location of each fuel assembly and CCs, if applicable, in the DSC. If loading damaged fuel assemblies, place top end caps over each damaged fuel assembly placed into the basket.*
8. *After all the SFAs and CCs, if applicable, have been placed into the DSC and their identities verified, position the lifting yoke and the top shield plug (shield plug assembly) and lower the shield plug into the DSC. Optionally the shield plug may be installed using alternate rigging in lieu of the yoke.*
9. *Visually verify that the top shield plug is properly seated in the DSC.*
10. *Position the lifting yoke arms under the cask trunnions and verify that they are properly engaged.*
11. *Raise the cask to the pool surface. Prior to raising the top of the cask above the water surface, stop vertical movement.*
12. *Inspect the top shield plug to verify that it is properly seated within the DSC. If not, lower the cask and reposition the top shield plug. Repeat steps 9 through 12 as necessary.*
13. *Continue to raise the cask from the pool and spray the exposed portion of the cask with demineralized water until the top region of the cask is accessible.*
14. *Drain any excess water from the top of the DSC shield plug back to the fuel pool.*
15. *Check the radiation levels at the center of the top shield plug and around the perimeter of the cask.*
16. *As required for crane load limitations, drain water from the DSC. Use 1 to 3 psig of helium to backfill the DSC per ISG-22[6] guidance as water is being removed from the DSC cavity.*
17. *Lift the cask from the fuel pool. As the cask is raised from the pool, continue to spray the cask with clean water.*

18. *Move the cask with loaded DSC to the plant designated preparation area.*
19. *Water removed at step 16 may be replaced with spent fuel pool water or equivalent.*

A.7.7.4.2 NUHOMS®-32PTH DSC Drying and Backfilling

CAUTION: *During performance of steps listed in this section, monitor the cask/DSC annulus water level and replenish as necessary to maintain cooling.*

1. *Check the radiation levels along the perimeter of the cask. The cask exterior surface should be decontaminated as necessary. Temporary shielding may be installed as necessary to minimize personnel exposure.*
2. *Place scaffolding or other suitable work platform(s) around the cask so that the surface of the cask is easily accessible to personnel.*
3. *Disengage the rigging cables from the top shield plug and remove the eyebolts. Disengage the lifting yoke from the trunnions and position it clear of the cask.*
4. *Decontaminate the exposed surfaces of the DSC shell perimeter and remove the annulus seal.*
5. *Connect a drain line to the cask, open the cask drain port and allow water from the annulus to drain out until the water level is approximately twelve inches below the top edge of the DSC shell. Take swipes around the outer top 1 foot surface of the DSC shell and check for smearable contamination as required.*

   CAUTION: *Radiation dose rates are expected to be high at the DSC vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

6. *If water was not drained from the DSC earlier, connect a pump to the DSC drain port and remove up to 1300 gallons of water. Only use helium to assist the removal of water. Up to 15 psig of helium gas may be applied at the vent port to assist the water pump down.*
7. *Disconnect the hose from the DSC siphon port.* Monitor TC/DSC annulus water level to be approximately twelve inches below the top of the DSC shell and replenish as necessary until drained.
8. *Install the automated welding machine onto the inner top cover and place the inner top cover with the automated welding machine onto the DSC. Verify proper fit-up of the inner top cover plate with the DSC shell. Alternately, the inner top cover may be placed on the DSC separately or the inner top cover may be part of the shield plug; in these cases the automated welding machine is installed on the inner top cover already installed in the DSC.*
9. *Check radiation levels along the surface of the inner top cover plate. Temporary shielding may be installed as necessary to minimize personnel exposure throughout the subsequent welding operations.*

10. *Insert suitable tubing through the vent port such that it terminates just below the DSC top shield plug. Connect the tubing to a hydrogen monitor to allow continuous monitoring of the hydrogen atmosphere in the DSC cavity during welding of the inner top cover plate. Optionally, other methods may be used for continuous monitoring of the hydrogen atmosphere in the DSC cavity during welding of the inner top cover plate.*
11. *Cover the cask/DSC annulus to prevent debris and weld splatter from entering the annulus.*
12. *Ready the automated welding machine and tack weld the inner top cover plate to the DSC shell. Complete the inner top cover plate weld to the DSC shell and remove the automated welding machine.*

    ***CAUTION**: Continuously monitor the hydrogen concentration in the DSC cavity using the tube arrangement described in step 10 during the inner top cover plate cutting/welding operations. Verify that the measured hydrogen concentration does not exceed a safety limit of 2.4% [4] and [5]. If this limit is exceeded, stop all welding operations and purge the DSC cavity with 2-3 psig helium to reduce the hydrogen concentration safely below the 2.4% limit.*

13. *Perform dye penetrant examination of the weld surface.*
14. *Remove the automated welding machine.*
15. *Pump/blow down remaining water from the DSC. Up to 15 psig of helium gas may be applied at the vent port to assist the water pump down.*
16. *Engage the helium supply and open the valve on the vent port and allow helium to force the water from the DSC cavity through the siphon port.*
17. *Once the water stops flowing from the DSC, close the DSC siphon port and disengage the gas source.*

    ***NOTE**: Proceed cautiously when evacuating the DSC to avoid freezing consequences.*

18. *Connect a vacuum pump/helium backfill manifold to the vent port or to both the vent and drain ports. The quick connect fittings may be removed and replaced with stainless steel pipe nipple/vacuum hose adapters to improve vacuum conductance. Provide appropriate measures as required to control any airborne radionuclides in the vacuum pump exhaust.*

    Optionally, leak test the manifold and the connections to the DSC. The DSC may be pressurized to no more than 15 psig for leakage testing.

    When the cavity pressure stabilizes, the pump is valved in to complete the vacuum drying process. It may be necessary to repeat some steps, depending on the rate and extent of the pressure increase. Vacuum drying is complete when the pressure stabilizes for a minimum of 30 minutes at 3 mm Hg or less.

    ***NOTE**: The user shall ensure that the vacuum pump is isolated from the canister cavity when demonstrating compliance with <3 mm Hg for 30 minutes. Simply closing the valve between the canister and the vacuum pump is not* *sufficient, as a faulty valve allows the vacuum pump to continue to draw a vacuum on the canister. Turning off the pump, or opening the suction side of the pump to atmosphere are examples of ways to assure that the pump is not continuing to draw a vacuum on the canister.*

CAUTION: *Radiation dose rates are expected to be high at the vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

19. *If the DSC cavity pressure remains below the specified limit for the required duration with the pump isolated, continue to the next step. If not, repeat step 19.*
20. *Purge air from the backfill manifold, open the isolation valve, and backfill the DSC cavity with helium to 16.5 to 18 psig and hold for 10 minutes.*
21. *Reduce the DSC cavity pressure to atmospheric pressure, or slightly over.*
22. *If the quick connect fittings were removed for vacuum drying, remove the vacuum line adapters from the ports, and re-install the quick connect fittings using suitable pipe thread sealant.*

CAUTION: *Radiation dose rates are expected to be high at the vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

23. *Evacuate the DSC through the vent port quick connect fitting to a pressure 100 mbar or less.*
24. *Purge air from the backfill manifold, open the isolation valve, and backfill the DSC cavity with helium to 2.5 ± 1 psig (stable for 30 minutes).*
25. *Close the valves on the helium source.*

A.7.7.4.3 NUHOMS®-32PTH DSC Sealing Operations

CAUTION: *During performance of steps listed in this section, monitor the cask/DSC annulus water level and replenish as necessary to maintain cooling.*

1. *Disconnect the VDS from the DSC. Weld the covers over the vent and drain ports, performing non-destructive examination of the weld surface.*
2. *Temporary shielding may be installed as necessary to minimize personnel exposure throughout the subsequent welding operations. Install a temporary test head fixture (or any other alternative means). Perform a helium leakage test of the inner top cover/shield plug to the DSC shell welds and siphon/vent cover welds to demonstrate that these welds meet the "leak-light" criterion ($\leq 1.0 \times 10^{-7}$ ref. cm^3/sec) as defined in ANSI N14.5 [1]. If the leakage rate exceeds 1.0×10^{-7} atm. cm^3/sec, check and repair these welds. Verify that the personnel performing the leakage test are qualified in accordance with SNT-TC-1A [7].*
3. *Place the outer top cover plate onto the DSC and verify proper fit-up of the outer top cover plate and the DSC shell. Install the automated welding machine onto the outer top*

cover plate. As an option, the welding machine may be mounted onto the cover plate and then placed together on the DSC.

4. *Tack weld the outer top cover plate to the DSC shell. Place the outer top cover plate weld root pass.*

5. *If not previously performed, perform helium leakage test of the inner top cover plate and vent/siphon port plate welds using the test port in the outer top cover plate and verify that the "leak-tight" criterion of ≤1x10^{-7} ref.cm^3/sec as defined in ANSI N14.5 [1] is met. Verify that the personnel performing the leakage test are qualified in accordance with SNT-TC-1A [7]. Alternatively, this leakage test can be done with a test head in step 2.*

    a. *If a leak is found, remove the outer cover plate root pass (if not using a test head), the vent and siphon port plugs and repair the inner cover plate welds. Then repeat applicable procedure steps from Section A.7.7.4.2, step 18.*

6. *Perform dye penetrant examination of the root pass weld. Weld out the outer top cover plate to the DSC shell and perform dye penetrant examination on the weld surface.*

7. *Seal weld the prefabricated plug (when applicable) over the outer cover plate test port and perform dye penetrant weld examinations.*

8. *Remove the automated welding machine and all other equipment from the cask/DSC top.*

9. *Open the cask drain port valve and drain the water from the cask/DSC annulus.*

The cask/DSC is now ready to be prepared for downending as described in Chapter A.7, Section A.7.1.2.2.

A.7.7.4.4 Unloading a NUHOMS®-32PTH DSC to a Fuel Pool

CAUTION: *The process of DSC unloading is similar to that used for DSC loading. DSC opening operations described below are to be carefully controlled in accordance with site procedures. This operation is to be performed under the site's standard health physics guidelines for welding, grinding, and handling of potentially highly contaminated equipment. These are to include the use of prudent housekeeping measures and monitoring of airborne particles. Procedures may require tenting, respirators, supplied air or other measures to contain contamination and minimize the impact on the health and safety of workers.*

1. *Locate the DSC siphon and vent ports using the indications on the DSC outer top cover plate.*

2. *Drill a hole in the DSC outer top cover plate and remove the siphon cover plate to expose the siphon port quick connect.*

3. *Drill a hole in the DSC outer top cover plate and remove the vent cover plate to expose the vent port quick connect.*

4. *Sample the DSC cavity atmosphere. If necessary, flush the DSC cavity gases to the site radwaste systems.*

CAUTION:
(a) The water fill rate must be regulated during this reflooding operation to ensure that the DSC vent pressure does not exceed 15.0 psig.

(b) Provide for continuous hydrogen monitoring of the DSC cavity atmosphere during all subsequent cutting operations to ensure that a safety limit of 2.4% is not exceeded [4] and [5]. Purge with 2-3 psig helium (or any other inert medium) as necessary to maintain the hydrogen concentration safely below this limit.

5. *Fill the DSC with spent fuel pool water (or other plant-designated water source) through the siphon port with the vent port open and routed to the plant's off-gas system. Soluble boron requirements per step 5.A of Section A.7.7.4.1 are applicable for the pool and DSC cavity water. The vented cavity gas may include steam, water, and radioactive material, and should be routed accordingly. Monitor the vent pressure and regulate the water fill rate to ensure that the pressure does not exceed 15 psig.*
6. *Install a debris shield over the cask/DSC annulus.*
7. *Use a mechanical cutting system, plasma arc-gouging, or other suitable means to remove the closure weld from the outer top cover plate.*

   ***CAUTION**: Monitor the hydrogen concentration in the DSC cavity during this step to ensure that it does not exceed 2.4% by volume [4] and [5].*
8. *Remove the DSC outer top cover plate.*
9. *Continue with cutting equipment and remove the closure weld from the DSC inner top cover plate.*
10. *Remove the weld of the inner top cover/shield plug to the shell in the same manner as the outer cover plate. Do not remove the inner top cover/shield plug at this time.*
11. *NOT USED*
12. *Remove excess material on the DSC inside shell surface which may interfere with top shield plug removal.*
13. *Clean the cask surface of dirt and debris that may have accumulated during transportation or weld removal.*
14. *Engage the cask lifting yoke to the upper trunnions and install the shield plug cables between the yoke and the DSC top shield plug.*
15. *Prior to lowering the cask into the pool, adjust the pool water level, if necessary, to accommodate the volume of water which will be displaced by the cask during the operation.*
16. *Position the cask over the cask loading area in the spent fuel pool.*
17. *Lower the cask slowly into the fuel pool. As the cask is being lowered, the exterior surface of the cask should be sprayed with clean water.*
18. *Disengage the lifting yoke from the cask trunnions and remove the top shield plug.*

19. *Remove the fuel assemblies (end caps as applicable for damaged assemblies) from the DSC.*
20. *Engage the lifting yoke to the cask upper trunnions, remove the cask from the pool, and place it in the decon area.*
21. *Remove the water from the DSC cavity and cask/DSC annulus.*
22. *Remove the DSC from the cask and handle in accordance with low-level waste procedures.*
23. *Decontaminate the cask inner and outer surfaces as necessary.*
24. *Inspect the cask hardware (including covers and valves) for damage that may have occurred during transportation. Repair or replace as necessary.*

A.7.7.4.5 References

1. *ANSI N14.5-1997, "American National Standard for Radioactive Materials - Leakage Tests on Packages for Shipment," American National Standards Institute, Inc., New York, 1997.*
2. *Not Used*
3. *Not Used*
4. *U.S. Nuclear Regulatory Commission, Office of the Nuclear Material Safety and Safeguards, "Safety Evaluation of VECTRA Technologies' Response to Nuclear Regulatory Commission Bulletin 96-04 for the NUHOMS®-24P and NUHOMS®-7P."*
5. *U.S. Nuclear Regulatory Commission Bulletin 96-04, "Chemical, Galvanic or Other Reactions in Spent Fuel Storage and Transportation Casks," July 5, 1996.*
6. *U.S. Nuclear Regulatory Commission, Interim Staff Guidance (ISG)-22, "Potential Rod Splitting Due to Exposures to an Oxidizing Atmosphere during Short-term Cask Loading Operations in LWR or Other Uranium Oxide Based Fuel."*
7. *SNT-TC-1A, "American Society for Nondestructive Testing, Personnel Qualification and Certification in Nondestructive Testing."*

APPENDIX A.7.7.5
NUHOMS®-32PTH1 DSC Wet Loading and Unloading

Appendix A.7.7.5
NUHOMS®-32PTH1 DSC Wet Loading and Unloading Procedures

NOTE: References in this chapter are shown as [1], [2], etc. and refer to the reference list in Section A.7.7.5.5. The term DSC as used in this appendix refers to the NUHOMS®-32PTH1 DSC.

A.7.7.5.1 NUHOMS®-32PTH1 DSC Fuel Loading

The starting condition for the following steps assumes completion of the cask preparation steps in Section A.7.1.2.

1. *Lift the cask/DSC and position it over the cask loading area of the spent fuel pool in accordance with the plant's 10CFR50 cask handling procedures.*
2. *Lower the cask into the fuel pool. As the cask is lowered into the pool, spray the exterior surface of the cask and lifting yoke with clean water.*
3. *Place the cask in the location of the fuel pool designated as the cask loading area.*
4. *Disengage the lifting yoke from the cask lifting trunnions and move the yoke clear of the cask. Spray the lifting yoke with clean water if it is raised out of the fuel pool.*
5. *The potential for fuel misloading is essentially eliminated through the implementation of procedural and administrative controls. The controls instituted to ensure that failed, damaged and/or intact spent fuel assemblies (SFAs) and control components (CCs), if applicable, are placed into a known cell location within a DSC will typically consist of the following:*
   - *A cask/DSC loading plan is developed to verify that the SFAs, and CCs, if applicable, meet the burnup, enrichment and cooling time parameters of the applicable sections listed in step 13 of Section A.7.1.1 above.*
   - *The loading plan is independently verified and approved before the fuel load.*
   - *A fuel movement schedule is then written, verified and approved based upon the loading plan. All fuel movements from any rack location are performed under strict compliance with the fuel movement schedule.*
   - *If loading damaged fuel assemblies, verify that the required number of bottom end caps are installed in appropriate basket locations.*

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Proprietary information withheld pursuant to 10 CFR 2.390

6. Prior to loading of an SFA (and CC, if applicable) into the DSC, the identity of the assembly (and CC, if applicable) is to be verified by two individuals using an underwater video camera or other means. Verification of CC identification is optional if the CC has not been moved from the host fuel assembly since its last verification. Read and record the identification number from the SFA (and CC, if applicable) and check this identification number against the DSC loading plan which indicates which SFAs(and CCs, if applicable) are acceptable for transport.

7. Position the fuel assembly for insertion into the selected DSC compartment and load the fuel assembly. Repeat steps 6 thru 7 for each SFA loaded into the DSC. If loading damaged fuel assemblies, place top end caps over each damaged fuel assembly placed into the basket. After the DSC has been fully loaded, check and record the identity and location of each SFA and CC, if applicable, in the DSC.

8. After all the SFAs, and CCs, if applicable, have been placed into the DSC and their identities verified, position the lifting yoke and the top shield plug and lower the shield plug onto the DSC. Optionally, the shield plug may be installed using an alternate rigging in lieu of the yoke.

9. Visually verify that the top shield plug is properly seated in the DSC.

10. Position the lifting yoke arms under the cask trunnions and verify that they are properly engaged.

11. Raise the cask to the pool surface. Prior to raising the top of the cask above the water surface, stop vertical movement.

12. Inspect the top shield plug to verify that it is properly seated within the DSC. If not, lower the cask and reposition the top shield plug. Repeat steps 9 through 12 as necessary.

13. Continue to raise the cask from the pool and spray the exposed portion of the cask with demineralized water until the top region of the cask is accessible.

14. Drain any excess water from the top of the DSC shield plug back to the fuel pool.

15. Check the radiation levels at the center of the top shield plug and around the perimeter of the cask.

16. Drain a minimum of 50 gallons of water. Optionally water may be drained from the DSC back into the fuel pool or other suitable location to meet the weight limit on the crane. Use 1-3 psig of helium to backfill the DSC with helium gas per ISG-22 [6] guidance as water is being removed from the DSC.

17. Lift the cask from the fuel pool. As the cask is raised from the pool, continue to spray the cask with clean water. Provisions shall be made to assure that air will not enter the DSC cavity.

18. Move the cask with loaded DSC to the plant designated preparation area.

19. Water removed at step 16 may be replaced with spent fuel pool water or equivalent.

A.7.7.5.2 NUHOMS®-32PTH1 DSC Drying and Backfilling

CAUTION: *During performance of steps listed in this section, monitor the cask/DSC annulus water level and replenish as necessary to maintain cooling.*

1. Check the radiation levels along the perimeter of the cask. The cask exterior surface should be decontaminated as necessary. Temporary shielding may be installed as necessary to minimize personnel exposure.

2. Place scaffolding or other suitable work platform(s) around the cask so that any point on the surface of the cask is easily accessible to personnel.

3. Disengage the rigging cables from the top shield plug and remove the eyebolts. Disengage the lifting yoke from the trunnions and position it clear of the cask.

4. Decontaminate the exposed surfaces of the DSC shell perimeter and remove the annulus seal.

5. Connect a drain line to the cask, open the cask drain port and allow water from the annulus to drain out until the water level is approximately twelve inches below the top edge of the DSC shell. Take swipes around the outer top 1 foot surface of the DSC shell and check for smearable contamination as required.

CAUTION: *Radiation dose rates are expected to be high at the DSC vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

6. Prior to the start of the welding operations, drain approximately 900 gallons of water from the DSC back into the fuel pool or other suitable location using the vacuum drying system (VDS) or an optional liquid pump. Consistent with ISG-22 [6] guidance, use helium at 1-3 psig to backfill the DSC with an inert gas as water is being removed from the DSC.

7. Disconnect the hose from the DSC siphon port.

8. Install the automated welding machine onto the inner top cover and place the inner top cover with the automated welding machine onto the DSC. Verify proper fit-up of the inner top cover plate with the DSC shell. Alternately, the inner top cover may be placed on the DSC separately or the inner top cover may be part of the shield plug; in these cases the automated welding machine is installed on the inner top cover already installed in the DSC.

9. *Check radiation levels along the surface of the inner top cover plate. Temporary shielding may be installed as necessary to minimize personnel exposure throughout the subsequent welding operations.*

10. *Insert suitable tubing through the vent port such that it terminates just below the DSC top shield plug. Connect the tubing to a hydrogen monitor to allow continuous monitoring of the hydrogen atmosphere in the DSC cavity during welding of the inner top cover plate. Optionally, other methods may be used for continuous monitoring of the hydrogen atmosphere in the DSC cavity during welding of the inner top cover plate.*

11. *Cover the cask/DSC annulus to prevent debris and weld splatter from entering the annulus.*

12. *Ready the automated welding machine and tack weld the inner top cover plate to the DSC shell. Complete the inner top cover plate weld to the DSC shell and remove the automated welding machine.*

    ***CAUTION**: Continuously monitor the hydrogen concentration in the DSC cavity using the tube arrangement described in step 10 during the inner top cover plate cutting/welding operations. Verify that the measured hydrogen concentration does not exceed a safety limit of 2.4% [4] and [5]. If this limit is exceeded, stop all welding operations and purge the DSC cavity with 2-3 psig helium to reduce the hydrogen concentration safely below the 2.4% limit.*

13. *Perform dye penetrant examination of the weld surface.*

14. *Connect the VDS to the DSC siphon and vent ports.*

15. *Use a water pump (may be part of VDS or separate pump) connected to the siphon port to remove remaining bulk water from the DSC cavity. Consistent with ISG-22 [6] guidance, use helium to backfill the DSC as water is being removed from the DSC. Alternately, helium at up to 15.0 psig may be introduced through the vent port to force the water from the DSC cavity through the siphon port.*

16. *Once the water stops flowing from the DSC, close the DSC siphon port and disengage the gas source.*

17. *Connect the hose from the vent port and the siphon port to the intake of the vacuum pump. Connect a hose from the discharge side of the VDS to the plant's radioactive waste system or spent fuel pool. Connect the VDS to a helium source.*

    ***NOTE**: Proceed cautiously when evacuating the DSC to avoid freezing consequences.*

18. *Open the valve on the suction side of the pump, start the VDS and draw a vacuum on the DSC cavity. The cavity pressure should be reduced in steps of approximately 100 mm Hg, 50 mm Hg, 25 mm Hg, 15 mm Hg, 10 mm Hg, 5 mm Hg, and 3 mm Hg. (these specific vacuum steps are a guideline only; other stepped vacuum drying processes are acceptable). After pumping down to each level, the pump is valved off and the cavity pressure monitored. The cavity pressure will rise as water and other volatiles in the cavity evaporate. When the cavity pressure stabilizes, the pump is valved in to continue the vacuum drying process. It may be necessary to repeat some steps, depending on the*

rate and extent of the pressure increase. Vacuum drying is complete when the pressure stabilizes for a minimum of 30 minutes at 3 mm Hg or less.

NOTE: *The user shall ensure that the vacuum pump is isolated from the canister cavity when demonstrating compliance with <3 mm Hg for 30 minutes. Simply closing the valve between the canister and the vacuum pump is not sufficient, as a faulty valve allows the vacuum pump to continue to draw a vacuum on the canister. Turning off the pump, or opening the suction side of the pump to atmosphere are examples of ways to assure that the pump is not continuing to draw a vacuum on the canister.*

CAUTION: *Radiation dose rates are expected to be high at the vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

19. *Open the valve to the vent port and allow the helium to flow into the DSC cavity.*
20. *If the optional leakage test of step 21 is not to be performed, skip to step 24. Otherwise, pressurize the DSC with helium up to 15.0 psig.*
21. *Perform helium leakage test of the inner top cover plate weld for a leakage rate of 1×10^{-4} ref cm^3/sec. This test is optional.*
22. *If a leak is found, repair the weld, repressurize the DSC and repeat the helium leakage test.*
23. *Once no leaks are detected, depressurize the DSC cavity by releasing the helium through the VDS to the plant's spent fuel pool or radioactive waste system, or other appropriate system.*
24. *Re-evacuate the DSC cavity using the VDS. The cavity pressure should be reduced in steps of approximately 10 mm Hg, 5 mm Hg, and 3 mm Hg. After pumping down to each level, the pump is valved off and the cavity pressure monitored. When the cavity pressure stabilizes, the pump is valved in to continue the vacuum drying process. Vacuum drying is complete when the pressure stabilizes for a minimum of 30 minutes at 3 mm Hg.*
25. *Open the valve on the vent port and allow helium to flow into the DSC cavity to pressurize the DSC to between 16.5 psig to 18.0 psig and hold for about 10 minutes. Depressurize the DSC cavity by releasing the helium through the VDS to plant fuel pool or radioactive waste system to a backfill pressure of 2.5 ± 1.0 psig (stable for 30 minutes).*

CAUTION: *Radiation dose rates are expected to be high at the vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

26. *Close the valves on the helium source.*

A.7.7.5.3 NUHOMS®-32PTH1 DSC Sealing Operations

CAUTION: *During performance of steps listed in this section, monitor the cask/DSC annulus water level and replenish as necessary to maintain cooling.*

1. *Disconnect the VDS from the DSC. Seal weld the prefabricated covers over the vent and siphon ports, inject helium into the blind space just prior to completing welding, and perform a dye penetrant weld examination.*
2. *Install the automated welding machine onto the outer top cover plate and place the outer top cover plate with the automated welding system onto the DSC. Verify proper fit up of the outer top cover plate with the DSC shell.*
3. *Tack weld the outer top cover plate to the DSC shell. Place the outer top cover plate weld root pass.*
4. *Perform a helium leakage test of the inner top cover plate and vent/siphon port plate welds using the leak test port in the outer top cover plate and verify that the "leak-tight" criterion of* $\leq 1\times10^{-7}$ *ref.cm*^{3}*/sec as defined in ANSI N14.5 [1] is met. Verify that the personnel performing the leakage test are qualified in accordance with SNT-TC-1A [7]. Alternatively, this leak test can be done with a test head following step 1.*
5. *If a leak is found, remove the outer cover plate root pass (if not using a test head), the vent and siphon port plugs and repair the inner cover plate welds. Then repeat applicable procedure steps from Section A.7.7.5.2, step 17.*
6. *Perform dye penetrant examination of the root pass weld. Weld out the outer top cover plate to the DSC shell and perform dye penetrant examination on the weld surface.*
7. *Seal weld the prefabricated plug(when applicable) over the outer cover plate test port and perform dye penetrant weld examinations.*
8. *Remove the automated welding machine from the DSC.*
9. *Open the cask drain port valve and drain the water from the cask/DSC annulus.*

The cask/DSC is now ready to be prepared for downending as described in Chapter A.7, Section A.7.1.2.2.

A.7.7.5.4 Unloading a NUHOMS®-32PTH1 DSC to a Fuel Pool

CAUTION: *The process of DSC unloading is similar to that used for DSC loading. DSC opening operations described below are to be carefully controlled in accordance with site procedures. This operation is to be performed under the site's standard health physics guidelines for welding, grinding, and handling of potentially highly contaminated equipment. These are to include the use of prudent housekeeping measures and monitoring of airborne particles. Procedures may require tenting, respirators, supplied air or other measures to contain contamination and minimize the impact on the health and safety of workers.*

1. *Locate the DSC siphon and vent ports using the indications on the DSC outer top cover plate.*
2. *Drill a hole in the DSC outer top cover plate and remove the siphon cover plate to expose the siphon port quick connect.*
3. *Drill a hole in the DSC outer top cover plate and remove the vent cover plate to expose the vent port quick connect.*
4. *Sample the DSC cavity atmosphere. If necessary, flush the DSC cavity gases to the site radwaste systems.*

   CAUTION: *(a) The water fill rate must be regulated during this reflooding operation to ensure that the DSC vent pressure does not exceed 20.0 psig.*

   (b) Provide for continuous hydrogen monitoring of the DSC cavity atmosphere during all subsequent cutting operations to ensure that a safety limit of 2.4% is not exceeded [4] and [5]. Purge with 2-3 psig helium (or any other inert medium) as necessary to maintain the hydrogen concentration safely below this limit.

5. *Fill the DSC with spent fuel pool water (or other plant-designated water source) through the siphon port with the vent port open and routed to the plant's off-gas system. Soluble boron requirements per step 5.A of Section A.7.7.5.1 are applicable for the pool and DSC cavity water.*
6. *Install a debris shield over the cask/DSC annulus.*
7. *Use a mechanical cutting system, plasma arc-gouging, or other suitable means to remove the closure weld from the outer top cover plate.*

   CAUTION: *Monitor the hydrogen concentration in the DSC cavity during this step to ensure that it does not exceed 2.4% by volume [4] and [5].*

8. *Remove the DSC outer top cover plate.*
9. *Continue with cutting equipment and remove the closure weld from the DSC inner top cover plate.*
10. *Remove the DSC inner top cover plate.*
11. *NOT USED*
12. *Remove excess material on the DSC inside shell surface which may interfere with top shield plug removal.*
13. *Clean the cask surface of dirt and debris that may have accumulated during transportation or weld removal.*
14. *Engage the cask lifting yoke to the upper trunnions and install the shield plug cables between the yoke and the DSC top shield plug.*
15. *Prior to lowering the cask into the pool, adjust the pool water, if necessary, to accommodate the volume of water which will be displaced by the cask during the operation.*

16. *Lower the cask slowly into the fuel pool while spraying the exterior of the cask with clean water.*
17. *Disengage the lifting yoke from the cask trunnions and remove the top shield plug.*
18. *Remove the fuel assemblies (end caps as applicable for damaged fuel assemblies) from the DSC.*
19. *Engage the lifting yoke to the cask upper trunnions, remove the cask from the pool, and place it in the decon area.*
20. *Remove the water from the DSC cavity and cask/DSC annulus.*
21. *Remove the DSC from the cask and handle in accordance with low-level waste procedures.*
22. *Decontaminate the cask inner and outer surfaces as necessary.*
23. *Inspect the cask hardware (including covers and valves) for damage that may have occurred during transportation. Repair or replace as necessary.*

A.7.7.5.5 References

1. *ANSI N14.5-1997, "American National Standard for Radioactive Materials - Leakage Tests on Packages for Shipment," American National Standards Institute, Inc., New York, 1997.*
2. *Not Used*
3. *Not Used*
4. *U.S. Nuclear Regulatory Commission, Office of the Nuclear Material Safety and Safeguards, "Safety Evaluation of VECTRA Technologies' Response to Nuclear Regulatory Commission Bulletin 96-04 for the NUHOMS®-24P and NUHOMS®-7P."*
5. *U.S. Nuclear Regulatory Commission Bulletin 96-04, "Chemical, Galvanic or Other Reactions in Spent Fuel Storage and Transportation Casks," July 5, 1996.*
6. *U.S. Nuclear Regulatory Commission, Interim Staff Guidance (ISG)-22, "Potential Rod Splitting Due to Exposures to an Oxidizing Atmosphere during Short-term Cask Loading Operations in LWR or Other Uranium Oxide Based Fuel."*
7. *SNT-TC-1A, "American Society for Nondestructive Testing, Personnel Qualification and Certification in Nondestructive Testing."*

APPENDIX A.7.7.6
NUHOMS®-37PTH DSC Wet Loading and Unloading

Appendix A.7.7.6
NUHOMS®-37PTH DSC Wet Loading and Unloading Procedures

NOTE: References in this chapter are shown as [1], [2], etc., and refer to the reference list in Section A.7.7.6.5. The term DSC as used in this appendix refers to the NUHOMS®-37PTH DSC.

A.7.7.6.1 NUHOMS®-37PTH DSC Fuel Loading

The starting condition for the following steps assumes completion of the cask preparation steps in Section A.7.1.2.

1. *Lift the cask/DSC and position it over the cask loading area of the spent fuel pool in accordance with the plant's 10 CFR 50 cask handling procedures.*
2. *Lower the cask into the fuel pool. As the cask is lowered into the pool, spray the exterior surface of the cask and lifting yoke with clean water.*
3. *Place the cask in the location of the fuel pool designated as the cask loading area.*
4. *Disengage the lifting yoke from the cask lifting trunnions and move the yoke clear of the cask. Spray the lifting yoke with clean water if it is raised out of the fuel pool.*
5. *The potential for fuel misloading is essentially eliminated through the implementation of procedural and administrative controls. The controls instituted to ensure that damaged and/or intact spent fuel assemblies (SFAs) and control components (CCs), if applicable, are placed into a known cell location within a DSC will typically consist of the following:*
   - *A cask/DSC loading plan is developed to verify that the intact, damaged fuel assemblies, and CCs, if applicable, meet the burnup, enrichment and cooling time parameters of the applicable sections as listed in step 13 of Section A.7.1.1.*
   - *The loading plan is independently verified and approved before the fuel load.*
   - *A fuel movement schedule is then written, verified and approved based upon the loading plan. All fuel movements from any rack location are performed under strict compliance with the fuel movement schedule.*
   - *If loading damaged fuel assemblies, verify that the required number of bottom end caps are installed in appropriate basket locations.*

Proprietary information withheld pursuant to 10 CFR 2.390

Proprietary information withheld pursuant to 10 CFR 2.390

6. *Prior to loading of an SFA (and CC, if applicable) into the DSC, the identity of the SFA (and CC, if applicable) is to be verified by two individuals using an underwater video camera or other means. Verification of CC identification is optional if the CC has not been moved from the host fuel assembly since its last verification. Read and record the identification number from the SFAs (and CCs, if applicable) and check this identification number against the DSC loading plan which indicates which SFAs (and CCs, if applicable) are acceptable for transport.*
7. *Position the fuel assembly for insertion into the selected DSC compartment and load the fuel assembly. Repeat step 6-7 for each SFA loaded into the DSC. After the DSC has been fully loaded, check and record the identity and location of each fuel assembly and CC, if applicable, in the DSC. If loading damaged fuel assemblies, place top end caps over each damaged fuel assembly placed into the basket.*
8. *After all the SFAs and CCs, if applicable, have been placed into the DSC and their identities verified, position the lifting yoke and the top shield plug (shield plug assembly) and lower the shield plug into the DSC. Optionally the shield plug may be installed using alternate rigging in lieu of the yoke.*
9. *Visually verify that the top shield plug is properly seated in the DSC.*
10. *Position the lifting yoke arms under the cask trunnions and verify that they are properly engaged.*
11. *Raise the cask to the pool surface. Prior to raising the top of the cask above the water surface, stop vertical movement.*
12. *Inspect the top shield plug to verify that it is properly seated within the DSC. If not, lower the cask and reposition the top shield plug. Repeat steps 9 through 12 as necessary.*
13. *Continue to raise the cask from the pool and spray the exposed portion of the cask with demineralized water until the top region of the cask is accessible.*
14. *Drain any excess water from the top of the DSC shield plug back to the fuel pool.*
15. *Check the radiation levels at the center of the top shield plug and around the perimeter of the cask.*
16. *As required for crane load limitations, drain water from the DSC back into the fuel pool or other suitable location. Use 1 to 3 psig of helium to backfill the DSC per ISG-22[6] guidance as water is being removed from the DSC cavity.*

17. Lift the cask from the fuel pool. As the cask is raised from the pool, continue to spray the cask with clean water.

18. Move the cask with loaded DSC to the plant designated preparation area.

19. Water removed at step 16 may be replaced with spent fuel pool water or equivalent.

A.7.7.6.2 NUHOMS®-37PTH DSC Drying and Backfilling

CAUTION: *During performance of steps listed in this section, monitor the cask/DSC annulus water level and replenish as necessary to maintain cooling.*

1. Check the radiation levels along the perimeter of the cask. The cask exterior surface should be decontaminated as necessary. Temporary shielding may be installed as necessary to minimize personnel exposure.

2. Place scaffolding or other suitable work platform(s) around the cask so that the surface of the cask is easily accessible to personnel.

3. Disengage the rigging cables from the top shield plug and remove the eyebolts. Disengage the lifting yoke from the trunnions and position it clear of the cask.

4. Decontaminate the exposed surfaces of the DSC shell perimeter and remove the annulus seal.

5. Connect a drain line to the cask, open the cask drain port and allow water from the annulus to drain out until the water level is approximately twelve inches below the top edge of the DSC shell. Take swipes around the outer top 1 foot surface of the DSC shell and check for smearable contamination as required.

CAUTION: *Radiation dose rates are expected to be high at the DSC vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

6. Prior to the start of the welding operations, drain a minimum of 100 gallons of water from the DSC using the vacuum drying system (VDS) or an optional liquid pump. Consistent with ISG-22 [6] guidance, use 1-3 psig helium to backfill the DSC as water is being removed from the DSC.

7. Disconnect the hose from the DSC siphon port.

8. Install the automated welding machine onto the inner top cover and place the inner top cover with the automated welding machine onto the DSC. Verify proper fit-up of the inner top cover plate with the DSC shell. Alternately, the inner top cover may be placed on the DSC separately or the inner top cover may be part of the shield plug; in these cases the automated welding machine is installed on the inner top cover already installed in the DSC.

9. Check radiation levels along the surface of the inner top cover plate. Temporary shielding may be installed as necessary to minimize personnel exposure throughout the subsequent welding operations.

10. *Insert suitable tubing through the vent port such that it terminates just below the DSC top shield plug. Connect the tubing to a hydrogen monitor to allow continuous monitoring of the hydrogen atmosphere in the DSC cavity during welding of the inner top cover plate. Optionally, other methods may be used for continuous monitoring of the hydrogen atmosphere in the DSC cavity during welding of the inner top cover plate.*

11. *Cover the cask/DSC annulus to prevent debris and weld splatter from entering the annulus.*

12. *Ready the automated welding machine and tack weld the inner top cover plate to the DSC shell. Complete the inner top cover plate weld to the DSC shell and remove the automated welding machine.*

    ***CAUTION**: Continuously monitor the hydrogen concentration in the DSC cavity using the tube arrangement described in step 10 during the inner top cover plate cutting/welding operations. Verify that the measured hydrogen concentration does not exceed a safety limit of 2.4% [4] and [5]. If this limit is exceeded, stop all welding operations and purge the DSC cavity with 2-3 psig helium to reduce the hydrogen concentration safely below the 2.4% limit.*

13. *Perform dye penetrant examination of the weld surface.*

14. *Connect the VDS and/or a water pump to the DSC siphon and vent ports.*

15. *Use a water pump (may be part of VDS or separate pump) connected to the siphon port to remove remaining bulk water from the DSC cavity. Consistent with ISG-22 [6] guidance, use helium to backfill the DSC as water is being removed from the DSC. Alternately, helium at up to 15.0 psig may be introduced through the vent port to force the water from the DSC cavity through the siphon port.*

16. *Once the water stops flowing from the DSC, close the DSC siphon port and disengage the gas source.*

17. *Connect the hose from the vent port and the siphon port to the intake of the vacuum pump. Connect a hose from the discharge side of the VDS to the plant's radioactive waste system or spent fuel pool. Connect the VDS to a helium source.*

    ***NOTE**: Proceed cautiously when evacuating the DSC to avoid freezing consequences.*

18. *Open the valve on the suction side of the pump, start the VDS and draw a vacuum on the DSC cavity. The cavity pressure should be reduced in steps of approximately 100 mm Hg, 50 mm Hg, 25 mm Hg, 15 mm Hg, 10 mm Hg, 5 mm Hg, and 3 mm Hg. (these specific vacuum steps are a guideline only; other stepped vacuum drying processes are acceptable). After pumping down to each level, the pump is valved off and the cavity pressure monitored. The cavity pressure will rise as water and other volatiles in the cavity evaporate. When the cavity pressure stabilizes, the pump is valved in to continue the vacuum drying process. It may be necessary to repeat some steps, depending on the rate and extent of the pressure increase. Vacuum drying is complete when the pressure stabilizes for a minimum of 30 minutes at 3 mm Hg or less.*

    ***NOTE**: The user shall ensure that the vacuum pump is isolated from the canister cavity when demonstrating compliance with <3 mm Hg for 30 minutes.*

Simply closing the valve between the canister and the vacuum pump is not sufficient, as a faulty valve allows the vacuum pump to continue to draw a vacuum on the canister. Turning off the pump, or opening the suction side of the pump to atmosphere are examples of ways to assure that the pump is not continuing to draw a vacuum on the canister.

CAUTION: *Radiation dose rates are expected to be high at the vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

19. *Open the valve to the vent port and allow the helium to flow into the DSC cavity.*

20. *If the optional leak test of step 21 is not to be performed, skip to step 24. Otherwise, pressurize the DSC with helium up to 15.0 psig.*

21. *Perform helium leakage test of the inner top cover plate weld for a leakage rate of ≤ 1 x 10^{-4} ref. cm^3/sec. This test is optional.*

22. *If a leak is found, repair the weld, repressurize the DSC and repeat the helium leakage test.*

23. *Once no leaks are detected, depressurize the DSC cavity by releasing the helium through the VDS to the plant's spent fuel pool or radioactive waste system, or other appropriate system.*

24. *Re-evacuate the DSC cavity using the VDS. The cavity pressure should be reduced in steps of approximately 10 mm Hg, 5 mm Hg, and 3 mm Hg. After pumping down to each level, the pump is valved off and the cavity pressure monitored. When the cavity pressure stabilizes, the pump is valved in to continue the vacuum drying process. Vacuum drying is complete when the pressure stabilizes for a minimum of 30 minutes at 3 mm Hg.*

25. *Open the valve on the vent port and allow helium to flow into the DSC cavity to pressurize the DSC between 16.5 and 18.0 psig and hold for 10 minutes. Depressurize the DSC cavity to 2.5 ± 1.0 psig (stable for 30.0 minutes).*

    CAUTION: *Radiation dose rates are expected to be high at the vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

26. *Close the valves on the helium source.*

A.7.7.6.3 NUHOMS®-37PTH DSC Sealing Operations

CAUTION: *During performance of steps listed in this section, monitor the cask/DSC annulus water level and replenish as necessary to maintain cooling.*

1. *Disconnect the VDS from the DSC. Seal weld the prefabricated covers over the vent and siphon ports, inject helium into the blind space just prior to completing welding, and perform a dye penetrant weld examination.*

2. *Temporary shielding may be installed as necessary to minimize personnel exposure. Install the automated welding machine onto the outer top cover plate and place the outer top cover plate with the automated welding system onto the DSC. Alternately, the welding*

machine may be mounted onto the cover plate and then placed together on the DSC. Verify proper fit up of the outer top cover plate with the DSC shell.

3. *Tack weld the outer top cover plate to the DSC shell. Place the outer top cover plate weld root pass.*
4. *Perform a helium leakage test of the inner top cover plate and vent/siphon port plate welds using the test port in the outer top cover plate and verify that the "leak-tight" criterion of $\leq 1x10^{-7}$ ref.cm^3/sec as defined in ANSI N14.5 [1] is met. Verify that the personnel performing the leakage test are qualified in accordance with SNT-TC-1A [7]. Alternatively, this leakage test can be done with a test head following step 1 above.*
5. *If a leak is found, remove the outer cover plate root pass (if not using a test head), the vent and siphon port plugs and repair the inner cover plate welds. Then repeat applicable procedure steps from Section A.7.7.6.2, step 17.*
6. *Perform dye penetrant examination of the root pass weld. Weld out the outer top cover plate to the DSC shell and perform dye penetrant examination on the weld surface.*
7. *Seal weld the prefabricated plug (when applicable) over the outer cover plate test port and perform dye penetrant weld examinations.*
8. *Remove the automated welding machine from the DSC.*
9. *Open the cask drain port valve and drain the water from the cask/DSC annulus.*

The cask/DSC is now ready to be prepared for downending as described in Chapter A.7, Section A.7.1.2.2.

A.7.7.6.4 Unloading a NUHOMS®-37PTH DSC to a Fuel Pool

CAUTION: *The process of DSC unloading is similar to that used for DSC loading. DSC opening operations described below are to be carefully controlled in accordance with site procedures. This operation is to be performed under the site's standard health physics guidelines for welding, grinding, and handling of potentially highly contaminated equipment. These are to include the use of prudent housekeeping measures and monitoring of airborne particles. Procedures may require tenting, respirators, supplied air or other measures to contain contamination and minimize the impact on the health and safety of workers.*

1. *Locate the DSC siphon and vent ports using the indications on the DSC outer top cover plate.*
2. *Drill a hole in the DSC outer top cover plate and remove the siphon cover plate to expose the siphon port quick connect.*
3. *Drill a hole in the DSC outer top cover plate and remove the vent cover plate to expose the vent port quick connect.*
4. *Sample the DSC cavity atmosphere. If necessary, flush the DSC cavity gases to the site radwaste systems.*

CAUTION: *(a) The water fill rate must be regulated during this reflooding operation to ensure that the DSC vent pressure does not exceed 20.0 psig.*

(b) Provide for continuous hydrogen monitoring of the DSC cavity atmosphere during all subsequent cutting operations to ensure that a safety limit of 2.4% is not exceeded [4] and [5]. Purge with 2-3 psig helium (or any other inert medium) as necessary to maintain the hydrogen concentration safely below this limit.

5. *Fill the DSC with spent fuel pool water through the siphon port with the vent port open and routed to the plant's off-gas system. Soluble boron requirements per step 5.A of Section A.7.7.6.1 are applicable for the pool and DSC cavity water.*
6. *Install a debris shield over the cask/DSC annulus.*
7. *Use plasma arc-gouging, a mechanical cutting system, or other suitable means to remove the closure weld from the outer top cover plate.*

   CAUTION: *Monitor the hydrogen concentration in the DSC cavity during this step to ensure that it does not exceed 2.4% by volume [4] and [5].*
8. *Remove the DSC outer top cover plate.*
9. *Remove the closure weld from the DSC inner top cover plate.*
10. *Remove the DSC inner top cover plate.*
11. *NOT USED*
12. *Remove excess material on the DSC inside shell surface which may interfere with top shield plug removal.*
13. *Clean the cask surface of dirt and debris that may have accumulated during transportation or weld removal.*
14. *Engage the cask lifting yoke to the upper trunnions and install the shield plug cables between the yoke and the DSC top shield plug.*
15. *Prior to lowering the cask into the pool, adjust the pool water, if necessary, to accommodate the volume of water which will be displaced by the cask during the operation.*
16. *Lower the cask slowly into the fuel pool while spraying the exterior surface of the cask with clean water.*
17. *Disengage the lifting yoke from the cask trunnions and remove the top shield plug.*
18. *Remove the fuel assemblies (or end caps as applicable for damaged assemblies) from the DSC.*
19. *Engage the lifting yoke to the cask upper trunnions, remove the cask from the pool, and place it in the decon area.*
20. *Remove the water from the DSC cavity and cask/DSC annulus.*
21. *Remove the DSC from the cask and handle in accordance with low-level waste procedures.*

22. *Decontaminate the cask inner and outer surfaces as necessary.*
23. *Inspect the cask hardware (including covers and valves) for damage that may have occurred during transportation. Repair or replace as necessary.*

A.7.7.6.5 References

1. *ANSI N14.5-1997, "American National Standard for Radioactive Materials - Leakage Tests on Packages for Shipment," American National Standards Institute, Inc., New York, 1997.*
2. *Not Used*
3. *Not Used*
4. *U.S. Nuclear Regulatory Commission, Office of the Nuclear Material Safety and Safeguards, "Safety Evaluation of VECTRA Technologies' Response to Nuclear Regulatory Commission Bulletin 96-04 for the NUHOMS®-24P and NUHOMS®-7P."*
5. *U.S. Nuclear Regulatory Commission Bulletin 96-04, "Chemical, Galvanic or Other Reactions in Spent Fuel Storage and Transportation Casks," July 5, 1996.*
6. *U.S. Nuclear Regulatory Commission, Interim Staff Guidance (ISG)-22, "Potential Rod Splitting Due to Exposures to an Oxidizing Atmosphere during Short-term Cask Loading Operations in LWR or Other Uranium Oxide Based Fuel."*
7. *SNT-TC-1A, "American Society for Nondestructive Testing, Personnel Qualification and Certification in Nondestructive Testing."*

APPENDIX A.7.7.7
NUHOMS®-61BT DSC Wet Loading and Unloading

Appendix A.7.7.7
NUHOMS®-61BT DSC Wet Loading and Unloading Procedures

NOTE: References in this chapter are shown as [1], [2], etc., and refer to the reference list in Section A.7.7.7.5. The term DSC as used in this appendix refers to the NUHOMS®-61BT DSC.

A.7.7.7.1 NUHOMS®-61BT DSC Fuel Loading

The starting condition for the following steps assumes completion of the cask preparation steps in Section A.7.1.2.

1. *Lift the cask/DSC and position it over the cask loading area of the spent fuel pool in accordance with the plant's 10 CFR 50 cask handling procedures.*
2. *Lower the cask into the fuel pool. As the cask is lowered into the pool, spray the exterior surface of the cask and lifting yoke with clean water.*
3. *Place the cask in the location of the fuel pool designated as the cask loading area.*
4. *Disengage the lifting yoke from the cask lifting trunnions and move the yoke clear of the cask. Spray the lifting yoke with clean water if it is raised out of the fuel pool.*
5. *The potential for fuel misloading is essentially eliminated through the implementation of procedural and administrative controls. The controls instituted to ensure that damaged and/or intact spent fuel assemblies (SFAs) are placed into a known cell location within a DSC will typically consist of the following:*
   - *A cask/DSC loading plan is developed to verify that the SFAs meet the burnup, enrichment and cooling time parameters of the applicable sections as listed in step 13 of Section A.7.1.1 above.*
   - *The loading plan is independently verified and approved before the fuel load.*
   - *A fuel movement schedule is then written, verified and approved based upon the loading plan. All fuel movements from any rack location are performed under strict compliance with the fuel movement schedule.*
   - *If loading damaged fuel assemblies, verify that the required number of bottom end caps are installed in appropriate fuel compartment tube locations before fuel load.*
6. *Prior to insertion of an SFA into the DSC, the identity of the assembly is to be verified by two individuals using an underwater video camera or other means. Read and record the SFA identification number from the SFA and check this identification number against the DSC loading plan which indicates which SFAs are acceptable for transport.*
7. *Position the fuel assembly for insertion into the selected DSC fuel compartments and load the fuel assembly. Repeat steps 6 through 7 for each SFA loaded into the DSC. If loading damaged fuel assemblies, place top end caps over each damaged fuel assembly placed into the basket. After the DSC has been fully loaded, check and record the identity and location of each fuel assembly in the DSC.*

8. *After all the SFAs have been placed into the DSC and their identities verified, place the hold down ring. Alternately, the hold down ring may be placed on the basket before loading the SFAs. Position the lifting yoke and the top shield plug and lower the shield plug onto the DSC. Optionally the shield plug may be installed using alternate rigging in lieu of the yoke.*
9. *Visually verify that the top shield plug is properly seated in the DSC.*
10. *Position the lifting yoke arms under the cask trunnions and verify that they are properly engaged.*
11. *Raise the cask to the pool surface. Prior to raising the top of the cask above the water surface, stop vertical movement.*
12. *Inspect the top shield plug to verify that it is properly seated within the DSC. If not, lower the cask and reposition the top shield plug. Repeat steps 9 through 12 as necessary.*
13. *Continue to raise the cask from the pool and spray the exposed portion of the cask with demineralized water until the top region of the cask is accessible.*
14. *Drain any excess water from the top of the DSC shield plug back to the fuel pool.*
15. *Check the radiation levels at the center of the top shield plug and around the perimeter of the cask.*
16. *As required for crane load limitations, drain water from the DSC back into the fuel pool or other suitable location to meet the weight limit on the crane. Use 1-3 psig of helium to backfill the DSC per ISG-22 [6] guidance as water is being removed from the DSC.*
17. *Lift the cask from the fuel pool. As the cask is raised from the pool, continue to spray the cask with clean water.*
18. *Move the cask with loaded DSC to the plant designated preparation area.*
19. *Water removed at step 16 may be replaced with spent fuel pool water or equivalent.*

A.7.7.7.2 NUHOMS®-61BT DSC Drying and Backfilling

1. *Check the radiation levels along the perimeter of the cask. The cask exterior surface should be decontaminated as necessary. Temporary shielding may be installed as necessary to minimize personnel exposure.*
2. *Place scaffolding or other suitable work platform(s) around the cask so that the surface of the cask is easily accessible to personnel.*
3. *Disengage the rigging cables from the top shield plug and remove the eyebolts. Disengage the lifting yoke from the trunnions and position it clear of the cask.*
4. *Decontaminate the exposed surfaces of the DSC shell perimeter and remove the annulus seal.*
5. *Connect a drain line to the cask, open the cask drain port and allow water from the annulus to drain out until the water level is approximately twelve inches below the top edge of the DSC shell. Take swipes around the outer top 1 foot surface of the DSC shell and check for smearable contamination as required.*

CAUTION: *Radiation dose rates are expected to be high at the DSC vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

6. *Drain a minimum of 1100 gallons of water from the DSC using the vacuum drying system (VDS) or an optional liquid pump. Consistent with ISG-22 [6] guidance, use 1-3 psig helium to backfill the DSC as water is being removed from the DSC.*
7. *Disconnect the hose from the DSC siphon port.*
8. *Install the automated welding machine onto the inner top cover and place the inner top cover with the automated welding machine onto the DSC. Verify proper fit-up of the inner top cover plate with the DSC shell. Alternately, the inner top cover may be placed on the DSC separately or the inner top cover may be part of the shield plug; in these cases the automated welding machine is installed on the inner top cover already installed in the DSC.*
9. *Check radiation levels along the surface of the inner top cover plate. Temporary shielding may be installed as necessary to minimize personnel exposure throughout the subsequent welding operations.*
10. *Insert suitable tubing through the vent port such that it terminates just below the DSC top shield plug. Connect the tubing to a hydrogen monitor to allow continuous monitoring of the hydrogen atmosphere in the DSC cavity during welding of the inner top cover plate. Optionally, other methods may be used for continuous monitoring of the hydrogen atmosphere in the DSC cavity during welding of the inner top cover plate.*
11. *Cover the cask/DSC annulus to prevent debris and weld splatter from entering the annulus.*
12. *Ready the automated welding machine and tack weld the inner top cover plate to the DSC shell. Complete the inner top cover plate weld to the DSC shell and remove the automated welding machine.*

    CAUTION: *Continuously monitor the hydrogen concentration in the DSC cavity using the tube arrangement described in step 10 during the inner top cover plate cutting/welding operations. Verify that the measured hydrogen concentration does not exceed a safety limit of 2.4% [4] and [5]. If this limit is exceeded, stop all welding operations and purge the DSC cavity with 2-3 psig helium to reduce the hydrogen concentration safely below the 2.4% limit.*

13. *Perform dye penetrant examination of the weld surface.*
14. *Place the strongback so that it sits on the inner top cover plate and is oriented such that:*
    - *the DSC siphon and vent ports are accessible;*
    - *the strongback stud holes line up with the cask lid bolt holes.*
15. *Connect the VDS and/or water pump to the DSC siphon and vent ports.*

16. *Use a water pump (may be part of VDS or separate pump) connected to the siphon port to remove remaining bulk water from the DSC cavity. Consistent with ISG-22 [6] guidance, use helium to backfill the DSC as water is being removed from the DSC. Alternately, helium (up to 10 psig) may also be used on the vent port and allow helium to force the water from the DSC cavity through the siphon port.*

17. *Once the water stops flowing from the DSC, close the DSC siphon port and disengage the gas source.*

18. *Connect the hose from the vent port and the siphon port to the intake of the vacuum pump. Connect a hose from the discharge side of the VDS to the plant's radioactive waste system or spent fuel pool. Connect the VDS to a helium source.*

    NOTE: *Proceed cautiously when evacuating the DSC to avoid freezing consequences.*

19. *Open the valve on the suction side of the pump, start the VDS and draw a vacuum on the DSC cavity. The cavity pressure should be reduced in steps of approximately 100 mm Hg, 50 mm Hg, 25 mm Hg, 15 mm Hg, 10 mm Hg, 5 mm Hg, and 3 mm Hg (these specific vacuum steps are a guideline only; other stepped vacuum drying processes are acceptable). After pumping down to each level, the pump is valved off and the cavity pressure monitored. The cavity pressure will rise as water and other volatiles in the cavity evaporate. When the cavity pressure stabilizes, the pump is valved in to continue the vacuum drying process. It may be necessary to repeat some steps, depending on the rate and extent of the pressure increase. Vacuum drying is complete when the pressure stabilizes for a minimum of 30 minutes at 3 mm Hg or less.*

    NOTE: *The user shall ensure that the vacuum pump is isolated from the canister cavity when demonstrating compliance with <3 mm Hg for 30 minutes. Simply closing the valve between the canister and the vacuum pump is not sufficient, as a faulty valve allows the vacuum pump to continue to draw a vacuum on the canister. Turning off the pump, or opening the suction side of the pump to atmosphere are examples of ways to assure that the pump is not continuing to draw a vacuum on the canister.*

    CAUTION: *Radiation dose rates are expected to be high at the vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

20. *Open the valve to the vent port and allow the helium to flow into the DSC cavity.*

21. *If the optional leakage test of step 22 is not to be performed, skip to step25. Otherwise, pressurize the DSC with helium to a pressure between 24 psia and 34 psia.*

22. *Perform helium leakage test of the inner top cover plate weld for a leakage rate of* $\leq 1 \times 10^{-4}$ *ref* cm^3*/sec. This test is optional.*

23. *If a leak is found, repair the weld, repressurize the DSC, and repeat the helium leakage test.*

24. *Once no leaks are detected, depressurize the DSC cavity by releasing the helium through the VDS to the plant's spent fuel pool or radioactive waste system, or other appropriate system.*

25. *Re-evacuate the DSC cavity using the VDS. The cavity pressure should be reduced in steps of approximately 10 mm Hg, 5 mm Hg, and 3 mm Hg. After pumping down to each level, the pump is valved off and the cavity pressure monitored. When the cavity pressure stabilizes, the pump is valved in to continue the vacuum drying process. Vacuum drying is complete when the pressure stabilizes for a minimum of 30 minutes at 3 mm Hg.*

26. *Open the valve on the vent port and allow helium to flow into the DSC cavity to pressurize the DSC to 2.5 ± 1.0 psig backfill pressure (stable for 30 minutes).*

    ***CAUTION**: Radiation dose rates are expected to be high at the vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

27. *Close the valves on the helium source.*

28. *Remove the strongback.*

A.7.7.7.3 NUHOMS®-61BT DSC Sealing Operations

1. *Disconnect the VDS from the DSC. Seal weld the prefabricated covers over the vent and siphon ports, inject helium into the blind space just prior to completing welding, and perform a dye penetrant weld examination.*

2. *Temporary shielding may be installed as necessary to minimize personnel exposure. Install the automated welding machine onto the outer top cover plate and place the outer top cover plate with the automated welding system onto the DSC. Alternately, the welding machine may be mounted onto the cover plate and then placed together on the DSC. Verify proper fit up of the outer top cover plate with the DSC shell.*

3. *Tack weld the outer top cover plate to the DSC shell. Place the outer top cover plate weld root pass.*

4. *Perform helium leakage test of the inner top cover plate and vent/siphon port plate welds using the test port in the outer top cover plate and verify that the "leak-tight" criterion of $\leq 1x10^{-7}$ ref.cm^3/sec as defined in ANSI N14.5 [1] is met. Verify that the personnel performing the leak test are qualified in accordance with SNT-TC-1A [7]. Alternatively, this leak test can be done with a test head following step 1.*

5. *If a leak is found, remove the outer cover plate root pass, the vent and siphon port plugs and repair the inner cover plate welds. Then repeat applicable procedure steps from Section A.7.7.7.2, step 18.*

6. *Perform dye penetrant examination of the root pass weld. Weld out the outer top cover plate to the DSC shell and perform dye penetrant examination on the weld surface.*

7. *Seal weld the prefabricated plug (when applicable) over the outer cover plate test port and perform dye penetrant weld examinations.*

8. *Remove the automated welding machine from the DSC.*

9. *Open the cask drain port valve and drain the water from the cask/DSC annulus.*

The cask/DSC is now ready to be prepared for downending as described in Chapter A.7, Section A.7.1.2.2.

A.7.7.7.4 Unloading the NUHOMS®-61BT DSC to a Fuel Pool

CAUTION: *The process of DSC unloading is similar to that used for DSC loading. DSC opening operations described below are to be carefully controlled in accordance with site procedures. This operation is to be performed under the site's standard health physics guidelines for welding, grinding, and handling of potentially highly contaminated equipment. These are to include the use of prudent housekeeping measures and monitoring or airborne particles. Procedures may require tenting, respirators, supplied air or other measures to contain and minimize the spread of and impact on the health and safety of workers due to contamination.*

1. *Locate the DSC siphon and vent ports using the indications on the DSC outer top cover plate.*
2. *Drill a hole in the DSC outer top cover plate and remove the siphon cover plate to expose the siphon port quick connect.*
3. *Drill a hole in the DSC outer top cover plate and remove the vent cover plate to expose the vent port quick connect.*
4. *Sample the DSC cavity atmosphere. If necessary, flush the DSC cavity gases to the site radwaste systems.*

   CAUTION: *(a) The water fill rate must be regulated during this reflooding operation to ensure that the DSC vent pressure does not exceed 20.0 psig.*

   (b) Provide for continuous hydrogen monitoring of the DSC cavity atmosphere during all subsequent cutting operations to ensure that a safety limit of 2.4% is not exceeded [4] and [5]. Purge with 2-3 psig helium (or any other inert medium) as necessary to maintain the hydrogen concentration safely below this limit.

5. *Fill the DSC with spent fuel pool water (or other plant designated water source) through the siphon port with the vent port open and routed to the plant's off-gas system.*
6. *Install a debris shield over the cask/DSC annulus.*
7. *Use a mechanical cutting system, plasma arc-gouging, or other suitable means to remove the closure weld from the outer top cover plate.*

   CAUTION: *Monitor the hydrogen concentration in the DSC cavity during this step to ensure that it does not exceed 2.4% by volume [4] and [5].*

8. *Remove the DSC outer top cover plate.*
9. *Continue with cutting equipment and remove the DSC inner top cover plate.*
10. *Remove the DSC inner top cover plate.*
11. *NOT USED*

12. *Remove excess material on the DSC inside shell surface which may interfere with top shield plug removal.*
13. *Clean the cask surface of dirt and debris that may have accumulated during transportation or weld removal.*
14. *Engage the cask lifting yoke to the upper trunnions and install the shield plug cables between the yoke and the DSC top shield plug.*
15. *Prior to lowering the cask into the pool, adjust the pool water, if necessary, to accommodate the volume of water which will be displaced by the cask during the operation.*
16. *Lower the cask slowly into the fuel pool while spraying the exterior of the cask with clean water.*
17. *Disengage the lifting yoke from the cask trunnions and remove the top shield plug and hold down ring.*
18. *Remove the fuel assemblies (end caps as applicable for damaged fuel assemblies) from the DSC.*
19. *Engage the lifting yoke to the cask upper trunnions, remove the cask from the pool, and place it in the decon area.*
20. *Remove the water from the DSC cavity and cask/DSC annulus.*
21. *Remove the DSC from the cask and handle in accordance with low-level waste procedures.*
22. *Decontaminate the cask inner and outer surfaces as necessary.*
23. *Inspect the cask hardware (including covers and valves) for damage that may have occurred during transportation. Repair or replace as necessary.*

A.7.7.7.5 References

1. *ANSI N14.5-1997, "American National Standard for Radioactive Materials - Leakage Tests on Packages for Shipment," American National Standards Institute, Inc., New York, 1997.*
2. *Not Used*
3. *Not Used*
4. *U.S. Nuclear Regulatory Commission, Office of the Nuclear Material Safety and Safeguards, "Safety Evaluation of VECTRA Technologies' Response to Nuclear Regulatory Commission Bulletin 96-04 for the NUHOMS®-24P and NUHOMS®-7P."*
5. *U.S. Nuclear Regulatory Commission Bulletin 96-04, "Chemical, Galvanic or Other Reactions in Spent Fuel Storage and Transportation Casks," July 5, 1996.*
6. *U.S. Nuclear Regulatory Commission, Interim Staff Guidance (ISG)-22, "Potential Rod Splitting Due to Exposures to an Oxidizing Atmosphere during Short-term Cask Loading Operations in LWR or Other Uranium Oxide Based Fuel."*
7. *SNT-TC-1A, "American Society for Nondestructive Testing, Personnel Qualification and Certification in Nondestructive Testing."*

APPENDIX A.7.7.8
NUHOMS®-61BTH DSC Wet Loading and Unloading

Appendix A.7.7.8
NUHOMS®-61BTH DSC Wet Loading and Unloading Procedures

NOTE: References in this chapter are shown as [1], [2], etc. and refer to the reference list in Section A.7.7.8.5. The term DSC as used in this appendix refers to the NUHOMS®-61BTH DSC.

A.7.7.8.1 NUHOMS®-61BTH DSC Fuel Loading

The starting condition for the following steps assumes completion of the cask preparation steps in Section A.7.1.2.

1. *Lift the cask/DSC and position it over the cask loading area of the spent fuel pool in accordance with the plant's 10 CFR 50 cask handling procedures.*
2. *Lower the cask into the fuel pool. As the cask is lowered into the pool, spray the exterior surface of the cask and the lifting yoke with clean water.*
3. *Place the cask in the location of the fuel pool designated as the cask loading area.*
4. *Disengage the lifting yoke from the cask lifting trunnions and move the yoke clear of the cask. Spray the lifting yoke with clean water if it is raised out of the fuel pool.*
5. *The potential for fuel misloading is essentially eliminated through the implementation of procedural and administrative controls. The controls instituted to ensure that failed, damaged and/or intact spent fuel assemblies (SFAs) are placed into a known cell location within a DSC, will typically consist of the following:*
    - *A cask/DSC loading plan is developed to verify that the failed, damaged and/or intact SFAs meet the burnup, enrichment and cooling time parameters of the applicable sections as listed in step 13 of Section A.7.1.1, above.*
    - *The loading plan is independently verified and approved before the fuel load.*
    - *A fuel movement schedule is then written, verified and approved based upon the loading plan. All fuel movements from any rack location are performed under strict compliance with the fuel movement schedule.*
    - *If loading damaged fuel assemblies, verify that the required number of bottom end caps are installed in appropriate fuel compartment tube locations before fuel load.*
    - *If loading failed fuel, verify that the required number of failed fuel cans (FFCs) are installed in the appropriate locations, or, once loaded with fuel, are installed in the appropriate locations in the basket.*
6. *Prior to insertion of an SFA into the DSC, the identity of the assembly is to be verified by two individuals using an underwater video camera or other means. Read and record the fuel assembly identification number from the fuel assembly and check this identification number against the DSC loading plan which indicates which fuel assemblies are acceptable for transportation.*
7. *Position the fuel assembly for insertion into the selected DSC storage cell and load the fuel assembly. Repeat steps 6 through 7 for each SFA loaded into the DSC. If loading*

damaged fuel assemblies, place top end caps over each damaged fuel assembly placed into the basket. If loading failed fuel, ensure that the FFC lids are installed. After the DSC has been fully loaded, check and record the identity and location of each fuel assembly in the DSC.

8. *a. After all the SFAs have been placed into the DSC and their identities verified, place the hold-down ring or optional top grid assembly as applicable. Visually verify that the hold-down ring is properly seated. If using the hold down ring, it may be placed on the basket before loading the SFAs.*

   b. Position the lifting yoke and the top shield plug and lower the shield plug into the DSC. Note that separate rigging may be used to install the shield plug prior to engaging the trunnions with the lifting yoke.

9. *Visually verify that the top shield plug is properly seated in the DSC.*
10. *Position the lifting yoke arms under the cask trunnions and verify that they are properly engaged.*
11. *Raise the cask to the pool surface. Prior to raising the top of the cask above the water surface, stop vertical movement.*
12. *Inspect the top shield plug to verify that it is properly seated within the DSC. If not, lower the cask and reposition the top shield plug. Repeat steps 9 through 12 as necessary.*
13. *Continue to raise the cask from the pool and spray the exposed portion of the cask with demineralized water until the top region of the cask is accessible.*
14. *Drain any excess water from the top of the DSC shield plug back to the fuel pool. Check the radiation levels at the center of the top shield plug and around the perimeter of the cask.*
15. *Drain water as needed from the DSC back into the fuel pool or other suitable location to meet the crane load limits. Use 1-3 psig of helium to backfill the DSC per ISG-22 [6] guidance as water is being removed from the DSC.*
16. *Lift the cask from the fuel pool. As the cask is raised from the pool, continue to spray the cask with clean water.*
17. *Move the cask with loaded DSC to the plant designated preparation area.*
18. *Water removed at step 15 may be replaced with spent fuel pool water or equivalent.*

A.7.7.8.2 NUHOMS®-61BTH DSC Drying and Backfilling

CAUTION: *During performance of steps listed in this section, monitor the cask/DSC annulus water level and replenish as necessary to maintain cooling.*

1. *Check the radiation levels along the perimeter of the cask. The cask exterior surface should be decontaminated as necessary. Temporary shielding may be installed as necessary to minimize personnel exposure.*
2. *Place scaffolding or other suitable work platform(s) around the cask so that the surface of the cask is easily accessible to personnel.*

3. *Disengage the rigging cables from the top shield plug and remove the eyebolts. Disengage the lifting yoke from the trunnions and position it clear of the cask.*

4. *Decontaminate the exposed surfaces of the DSC shell perimeter and remove the annulus seal.*

5. *Connect a drain line to the cask, open the cask drain port and allow water from the annulus to drain out until the water level is approximately twelve inches below the top edge of the DSC shell. Take swipes around the outer top 1 foot surface of the DSC shell and check for smearable contamination as required.*

   ***CAUTION**: Radiation dose rates are expected to be high at the DSC vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

6. *Prior to the start of the welding operations, drain approximately 1100 gallons of water from the DSC to the spent fuel pool or other suitable location using the vacuum drying system (VDS) or an optional liquid pump. Consistent with ISG-22 [6] guidance, use 1-3 psig of helium to backfill the DSC as water is being removed from the DSC.*

7. *Disconnect the hose from the DSC siphon port.*

8. *Install the automated welding machine onto the inner top cover and place the inner top cover with the automated welding machine onto the DSC. Verify proper fit-up of the inner top cover plate with the DSC shell. Alternately, the inner top cover may be placed on the DSC separately or the inner top cover may be part of the shield plug; in these cases the automated welding machine is installed on the inner top cover already installed in the DSC.*

9. *Check radiation levels along the surface of the inner top cover plate. Temporary shielding may be installed as necessary to minimize personnel exposure throughout the subsequent welding operations.*

10. *Insert suitable tubing through the vent port such that it terminates just below the DSC top shield plug. Connect the tubing to a hydrogen monitor to allow continuous monitoring of the hydrogen atmosphere in the DSC cavity during welding of the inner top cover plate. Optionally, other methods may be used for continuous monitoring of the hydrogen atmosphere in the DSC cavity during welding of the inner top cover plate.*

11. *Cover the cask/DSC annulus to prevent debris and weld splatter from entering the annulus.*

12. *Ready the automated welding machine and tack weld the inner top cover plate to the DSC shell. Complete the inner top cover plate weld to the DSC shell and remove the automated welding machine.*

    ***CAUTION**: Continuously monitor the hydrogen concentration in the DSC cavity using the tube arrangement described in step 10 during the inner top cover plate cutting/welding operations. Verify that the measured hydrogen concentration does not exceed a safety limit of 2.4% [4] and [5]. If this limit is exceeded, stop all welding operations and purge the DSC cavity with 2-3* *psig helium to reduce the hydrogen concentration safely below the 2.4% limit.*

13. *Perform dye penetrant examination of the weld surface.*

14. *If loading a Type 2 61BTH DSC skip to step 15; otherwise, place the strongback so that it sits on the inner top cover plate and is oriented such that:*
    - *The DSC siphon and vent ports are accessible*
    - *The strongback stud holes line up with the TC lid bolt holes*

15. *Connect the VDS and/or the water pump to the DSC siphon and vent ports.*

16. *Use a water pump (may be part of VDS or separate pump) connected to the siphon port to remove remaining bulk water from the DSC cavity. Consistent with ISG-22 [6] guidance, use helium to backfill the DSC as water is being removed from the DSC. Alternately, helium (at up to 10.0 psig for Type 1 DSC or 15.0 psig for Type 2 DSC) may be introduced through the vent port to force the water from the DSC cavity through the siphon port.*

17. *Once the water stops flowing from the DSC, close the DSC siphon port and disengage the gas source.*

18. *Connect the hose from the vent port and the siphon port to the intake of the vacuum pump. Connect a hose from the discharge side of the VDS to the plant's radioactive waste system or spent fuel pool. Connect the VDS to a helium source.*

    ***NOTE**: Proceed cautiously when evacuating the DSC to avoid freezing consequences.*

19. *Open the valve on the suction side of the pump, start the VDS and draw a vacuum on the DSC cavity. The cavity pressure should be reduced in steps of approximately 100 mm Hg, 50 mm Hg, 25 mm Hg, 15 mm Hg, 10 mm Hg, 5 mm Hg, and 3 mm Hg (these specific vacuum steps are a guideline only; other stepped vacuum drying processes are acceptable). After pumping down to each level, the pump is valved off and the cavity pressure monitored. The cavity pressure will rise as water and other volatiles in the cavity evaporate. When the cavity pressure stabilizes, the pump is valved in to continue the vacuum drying process. It may be necessary to repeat some steps, depending on the rate and extent of the pressure increase. Vacuum drying is complete when the pressure stabilizes for a minimum of 30 minutes at 3 mm Hg or less.*

    ***NOTE**: The user shall ensure that the vacuum pump is isolated from the canister cavity when demonstrating compliance with <3 mm Hg for 30 minutes. Simply closing the valve between the canister and the vacuum pump is not sufficient, as a faulty valve allows the vacuum pump to continue to draw a vacuum on the canister. Turning off the pump, or opening the suction side of the pump to atmosphere are examples of ways to assure that the pump is not continuing to draw a vacuum on the canister.*

    ***CAUTION**: Radiation dose rates are expected to be high at the vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

20. *Open the valve to the vent port and allow the helium to flow into the DSC cavity.*

21. *If the optional leakage test of step 22 is not to be performed, skip to step 25. Otherwise, pressurize the DSC with helium (up to 10 psig for Type 1 DSC or 15 psig for Type 2 DSC).*

22. *Perform helium leakage test of the inner top cover plate weld for a leakage rate of $\leq 1 \times 10^{-4}$ ref cm^3/sec. This test is optional.*

23. *If a leak is found, repair the weld, repressurize the DSC and repeat the helium leakage test.*

24. *Once no leaks are detected, depressurize the DSC cavity by releasing the helium through the VDS to the plant's spent fuel pool or radioactive waste system, or other appropriate system.*

25. *Re-evacuate the DSC cavity using the VDS. The cavity pressure should be reduced in steps of approximately 10 mm Hg, 5 mm Hg, and 3 mm Hg. After pumping down to each level (these levels are optional), the pump is valved off and the cavity pressure monitored. When the cavity pressure stabilizes, the pump is valved in to continue the vacuum drying process. Vacuum drying is complete when the pressure stabilizes for a minimum of 30 minutes at 3 mm Hg or less.*

    NOTE: *The user shall ensure that the vacuum pump is isolated from the DSC cavity when demonstrating compliance requirements of < 3 mm Hg for 30 minutes. Simply closing the valve between the DSC and the vacuum pump is not sufficient, as a faulty valve allows the vacuum pump to continue to draw a vacuum on the DSC. Turning off the pump, or opening the suction side of the pump to atmosphere are examples of ways to assure that the pump is not continuing to draw a vacuum on the DSC.*

26. *Open the valve on the vent port and allow helium to flow into the DSC cavity to pressurize the DSC between 14.5 to 16.0 psig for 61BTH Type 1 and 18.5 to 20.0 psig for 61BTH Type 2 DSC and hold for 10 minutes. Depressurize the DSC cavity by releasing the helium through the VDS to the plant spent fuel pool or radioactive waste system to 2.5 psig ± 1.0 psig backfill pressure (stable for 30 minutes).*

    CAUTION: *Radiation dose rates are expected to be high at the vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

27. *Close the valves on the helium source.*

28. *If installed, remove the strongback.*

A.7.7.8.3 NUHOMS®-61BTH DSC Sealing Operations

CAUTION: *During performance of steps listed in this section, monitor the cask/DSC annulus water level and replenish as necessary to maintain cooling.*

1. *Disconnect the VDS from the DSC. Seal weld the prefabricated covers over the vent and siphon ports, inject helium into the blind space just prior to completing welding, and perform a dye penetrant weld examination.*

2. *Temporary shielding may be installed as necessary to minimize personnel exposure. Install the automated welding machine onto the outer top cover plate and place the outer top cover plate with the automated welding system onto the DSC. Alternately, the welding machine may be mounted onto the cover plate and then placed together on the DSC. Verify proper fit up of the outer top cover plate with the DSC shell.*
3. *Tack weld the outer top cover plate to the DSC shell. Place the outer top cover plate weld root pass.*
4. *Perform helium leakage test of the inner top cover plate and vent/siphon port plate welds using the test port in the outer top cover plate and verify that the "leak-tight" criterion of $\leq 1x10^{-7}$ ref.cm^3/sec as defined in ANSI N14.5 [1] is met. Verify that the personnel performing the leakage test are qualified in accordance with SNT-TC-1A [7]. Alternatively, this leakage test can be done with a test head following step 1 above.*
5. *If a leak is found, remove the outer cover plate root pass (if not using a test head), the vent and siphon port plugs and repair the inner cover plate welds. Then install the strongback (if used) and repeat procedure steps from A.7.7.8.2, step 18.*
6. *Perform dye penetrant examination of the root pass weld. Weld out the outer top cover plate to the DSC shell and perform dye penetrant examination on the weld surface.*
7. *Install and seal weld the prefabricated plug (when applicable) over the outer cover plate test port and perform dye penetrant weld examinations.*
8. *Remove the automated welding machine from the DSC.*
9. *Open the cask drain port valve and drain the water from the cask/DSC annulus.*

The cask/DSC is now ready to be prepared for downending as described in Chapter A.7, Section A.7.1.2.2.

A.7.7.8.4 Unloading a NUHOMS®-61BTH DSC to a Fuel Pool Using the NUHOMS®-MP197HB Cask

CAUTION: *The process of DSC unloading is similar to that used for DSC loading. DSC opening operations described below are to be carefully controlled in accordance with site procedures. This operation is to be performed under the site's standard health physics guidelines for welding, grinding, and handling of potentially highly contaminated equipment. These are to include the use of prudent housekeeping measures and monitoring of airborne particles. Procedures may require tenting, respirators, supplied air or other measures to contain contamination and minimize the impact on the health and safety of workers.*

1. *Locate the DSC siphon and vent ports using the indications on the DSC outer top cover plate.*
2. *Drill a hole in the DSC outer top cover plate and remove the siphon cover plate to expose the siphon port quick connect.*

3. *Drill a hole in the DSC outer top cover plate and remove the vent cover plate to expose the vent port quick connect.*

4. *Sample the DSC cavity atmosphere. If necessary, flush the DSC cavity gases to the site radwaste systems.*

   CAUTION: *(a) The water fill rate must be regulated during this reflooding operation to ensure that the DSC vent pressure does not exceed 20.0 psig.*

   (b) Provide for continuous hydrogen monitoring of the DSC cavity atmosphere during all subsequent cutting operations to ensure that a safety limit of 2.4% is not exceeded [4] and [5]. Purge with 2-3 psig helium as necessary to maintain the hydrogen concentration safely below this limit.

5. *Fill the DSC with spent fuel pool water (or other plant-designated water source) through the siphon port with the vent port open and routed to the plant's off-gas system.*

6. *Install a debris shield over the cask/DSC annulus.*

7. *Use a mechanical cutting system, plasma arc-gouging, or other suitable means to remove the closure weld from the outer top cover plate. The exhaust system should be operating at all times.*

   CAUTION: *Monitor the hydrogen concentration in the DSC cavity during this step to ensure that it does not exceed 2.4% by volume [4] and [5].*

8. *Remove the DSC outer top cover plate.*

9. *Continue with cutting equipment and remove the closure weld from the DSC inner top cover plate.*

10. *Remove the DSC inner top cover plate.*

11. *NOT USED*

12. *Remove excess material on the DSC inside shell surface which may interfere with top shield plug removal.*

13. *Clean the cask surface of dirt and debris that may have accumulated during transportation or weld removal.*

14. *Engage the cask lifting yoke to the upper trunnions and install the shield plug cables between the yoke and the DSC top shield plug.*

15. *Prior to lowering the cask into the pool, adjust the pool water, if necessary, to accommodate the volume of water which will be displaced by the cask during the operation.*

16. *Lower the cask slowly into the fuel pool while spraying the exterior of the cask with clean water.*

17. *Disengage the lifting yoke from the cask trunnions and remove the top shield plug.*

18. *Remove the holddown ring (if not integral to the basket).*

19. *Remove the fuel assemblies (or fuel cans/end caps as applicable for failed/damaged fuel assemblies) from the DSC.*

20. *Engage the lifting yoke to the cask upper trunnions, remove the cask from the pool, and place it in the decon area.*
21. *Remove the water from the DSC cavity and cask/DSC annulus.*
22. *Remove the DSC from the cask and handle in accordance with low-level waste procedures.*
23. *Decontaminate the cask inner and outer surfaces as necessary.*
24. *Inspect the cask hardware (including covers and valves) for damage that may have occurred during transportation. Repair or replace as necessary.*

A.7.7.8.5 References

1. *ANSI N14.5-1997, "American National Standard for Radioactive Materials - Leakage Tests on Packages for Shipment," American National Standards Institute, Inc., New York, 1997.*
2. *Not Used*
3. *Not Used*
4. *U.S. Nuclear Regulatory Commission, Office of the Nuclear Material Safety and Safeguards, "Safety Evaluation of VECTRA Technologies' Response to Nuclear Regulatory Commission Bulletin 96-04 for the NUHOMS®-24P and NUHOMS®-7P."*
5. *U.S. Nuclear Regulatory Commission Bulletin 96-04, "Chemical, Galvanic or Other Reactions in Spent Fuel Storage and Transportation Casks," July 5, 1996.*
6. *U.S. Nuclear Regulatory Commission, Interim Staff Guidance (ISG)-22, "Potential Rod Splitting Due to Exposures to an Oxidizing Atmosphere during Short-term Cask Loading Operations in LWR or Other Uranium Oxide Based Fuel."*
7. *SNT-TC-1A, "American Society for Nondestructive Testing, Personnel Qualification and Certification in Nondestructive Testing."*

APPENDIX A.7.7.9
NUHOMS®-69BTH DSC Wet Loading and Unloading

Appendix A.7.7.9
NUHOMS®-69BTH DSC Wet Loading and Unloading Procedures

NOTE: References in this chapter are shown as [1], [2], etc., and refer to the reference list in Section A.7.7.9.5. The term DSC as used in this appendix refers to the NUHOMS®-69BTH DSC.

A.7.7.9.1 NUHOMS®-69BTH DSC Fuel Loading

The starting condition for the following steps assumes completion of the cask preparation steps in Section A.7.1.2.

1. *Lift the cask/DSC and position it over the cask loading area of the spent fuel pool in accordance with the plant's 10CFR50 cask handling procedures.*
2. *Lower the cask into the fuel pool. As the cask is lowered into the pool, spray the exterior surface of the cask and the lifting yoke with clean water.*
3. *Place the cask in the location of the fuel pool designated as the cask loading area.*
4. *Disengage the lifting yoke from the cask lifting trunnions and move the yoke clear of the cask. Spray the lifting yoke with clean water if it is raised out of the fuel pool.*
5. *The potential for fuel misloading is essentially eliminated through the implementation of procedural and administrative controls. The controls instituted to ensure that damaged and/or intact spent fuel assemblies (SFAs) are placed into a known cell location within a DSC will typically consist of the following:*
   - *A cask/DSC loading plan is developed to verify that the intact and damaged fuel assemblies meet the burnup, enrichment and cooling time parameters of the applicable sections as listed in step 13 of Section A.7.1.1 above.*
   - *The loading plan is independently verified and approved before the fuel load.*
   - *A fuel movement schedule is then written, verified and approved based upon the loading plan. All fuel movements from any rack location are performed under strict compliance with the fuel movement schedule.*
   - *If loading damaged fuel assemblies, verify that the required number of bottom end caps are installed in appropriate locations in the basket.*
6. *Prior to loading of an SFA into the DSC, the identity of the assembly is to be verified by two individuals using an underwater video camera or other means. Read and record the identification number from the SFA and check this identification number against the DSC loading plan which indicates which SFAs are acceptable for transport.*
7. *Position the fuel assembly for insertion into the selected DSC fuel compartment and load the fuel assembly. Repeat steps 6 through 7 for each SFA loaded into the DSC. If loading damaged fuel assemblies, place top end caps over each damaged fuel assembly placed into the basket. After the DSC has been fully loaded, check and record the identity and location of each fuel assembly in the DSC.*
8. *After all the SFAs have been placed into the DSC and their identities verified, install the hold down ring. Alternately, the hold down ring may be placed before loading the SFAs.*

Position the lifting yoke and the top shield plug (shield plug assembly) and lower the shield plug into the DSC. Optionally the shield plug may be installed using alternate rigging in lieu of the yoke.

9. *Visually verify that the top shield plug is properly seated in the DSC.*
10. *Position the lifting yoke arms under the cask trunnions and verify that they are properly engaged.*
11. *Raise the cask to the pool surface. Prior to raising the top of the cask above the water surface, stop vertical movement.*
12. *Inspect the top shield plug to verify that it is properly seated within the DSC. If not, lower the cask and reposition the top shield plug. Repeat steps 9 through 12 as necessary.*
13. *Continue to raise the cask from the pool and spray the exposed portion of the cask with demineralized water until the top region of the cask is accessible.*
14. *Drain any excess water from the top of the DSC shield plug back to the fuel pool.*
15. *Check the radiation levels at the center of the top shield plug and around the perimeter of the cask.*
16. *As required for crane load limitations, drain water from the DSC. Use 1 to 3 psig of helium to backfill the DSC per ISG-22[6] guidance as water is being removed from the DSC cavity.*
17. *Lift the cask from the fuel pool. As the cask is raised from the pool, continue to spray the cask with clean water.*
18. *Move the cask with loaded DSC to the plant designated preparation area.*
19. *Water removed at step 16 may be replaced with spent fuel pool water or equivalent.*

A.7.7.9.2 NUHOMS®-69BTH DSC Drying and Backfilling

CAUTION: *During performance of steps listed in this section, monitor the cask/DSC annulus water level and replenish as necessary to maintain cooling.*

1. *Check the radiation levels along the perimeter of the cask. The cask exterior surface should be decontaminated as necessary. Temporary shielding may be installed as necessary to minimize personnel exposure.*
2. *Place scaffolding or other suitable work platform(s) around the cask so that the surface of the cask is easily accessible to personnel.*
3. *Disengage the rigging cables from the top shield plug and remove the eyebolts. Disengage the lifting yoke from the trunnions and position it clear of the cask.*
4. *Decontaminate the exposed surfaces of the DSC shell perimeter and remove the annulus seal.*
5. *Connect a drain line to the cask, open the cask drain port and allow water from the annulus to drain out until the water level is approximately twelve inches below the top*

edge of the DSC shell. Take swipes around the outer top 1 foot surface of the DSC shell and check for smearable contamination as required.

CAUTION: *Radiation dose rates are expected to be high at the DSC vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

6. *Prior to the start of the welding operations, drain a minimum of 100 gallons of water from the DSC using the vacuum drying system (VDS) or an optional liquid pump. Consistent with ISG-22 [6] guidance, use 1-3 psig helium to backfill the DSC as water is being removed from the DSC.*
7. *Disconnect the hose from the DSC siphon port.*
8. *Install the automated welding machine onto the inner top cover and place the inner top cover with the automated welding machine onto the DSC. Verify proper fit-up of the inner top cover plate with the DSC shell. Alternately, the inner top cover may be placed on the DSC separately or the inner top cover may be part of the shield plug; in these cases the automated welding machine is installed on the inner top cover already installed in the DSC.*
9. *Check radiation levels along the surface of the inner top cover plate. Temporary shielding may be installed as necessary to minimize personnel exposure throughout the subsequent welding operations.*
10. *Insert suitable tubing through the vent port such that it terminates just below the DSC top shield plug. Connect the tubing to a hydrogen monitor to allow continuous monitoring of the hydrogen atmosphere in the DSC cavity during welding of the inner top cover plate. Optionally, other methods may be used for continuous monitoring of the hydrogen atmosphere in the DSC cavity during welding of the inner top cover plate.*
11. *Cover the cask/DSC annulus to prevent debris and weld splatter from entering the annulus.*
12. *Ready the automated welding machine and tack weld the inner top cover plate to the DSC shell. Complete the inner top cover plate weld to the DSC shell and remove the automated welding machine.*

CAUTION: *Continuously monitor the hydrogen concentration in the DSC cavity using the tube arrangement described in step 10 during the inner top cover plate cutting/welding operations. Verify that the measured hydrogen concentration does not exceed a safety limit of 2.4% [4] and [5]. If this limit is exceeded, stop all welding operations and purge the DSC cavity with 2-3 psig helium to reduce the hydrogen concentration safely below the 2.4% limit.*

13. *Perform dye penetrant examination of the weld surface.*
14. *Connect the VDS and/or water pump to the DSC siphon and vent ports.*
15. *Use a water pump (may be part of VDS or separate pump) connected to the siphon port to remove remaining bulk water from the DSC cavity. Consistent with ISG-22 [6]*

guidance, use helium to backfill the DSC as water is being removed from the DSC. Alternately, helium at up to 15.0 psig may be introduced through the vent port to force the water from the DSC cavity through the siphon port.

16. *Once the water stops flowing from the DSC, close the DSC siphon port and disengage the gas source.*

17. *Connect the hose from the vent port and the siphon port to the intake of the vacuum pump. Connect a hose from the discharge side of the VDS to the plant's radioactive waste system or spent fuel pool. Connect the VDS to a helium source.*

    ***NOTE**: Proceed cautiously when evacuating the DSC to avoid freezing consequences.*

18. *Open the valve on the suction side of the pump, start the VDS and draw a vacuum on the DSC cavity. The cavity pressure should be reduced in steps of approximately 100 mm Hg, 50 mm Hg, 25 mm Hg, 15 mm Hg, 10 mm Hg, 5 mm Hg, and 3 mm Hg (these specific vacuum steps are a guideline only; other stepped vacuum drying processes are acceptable). After pumping down to each level, the pump is valved off and the cavity pressure monitored. The cavity pressure will rise as water and other volatiles in the cavity evaporate. When the cavity pressure stabilizes, the pump is valved in to continue the vacuum drying process. It may be necessary to repeat some steps, depending on the rate and extent of the pressure increase. Vacuum drying is complete when the pressure stabilizes for a minimum of 30 minutes at 3 mm Hg or less.*

    ***NOTE**: The user shall ensure that the vacuum pump is isolated from the canister cavity when demonstrating compliance with <3 mm Hg for 30 minutes. Simply closing the valve between the canister and the vacuum pump is not sufficient, as a faulty valve allows the vacuum pump to continue to draw a vacuum on the canister. Turning off the pump, or opening the suction side of the pump to atmosphere are examples of ways to assure that the pump is not continuing to draw a vacuum on the canister.*

    ***CAUTION**: Radiation dose rates are expected to be high at the vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

19. *Open the valve to the vent port and allow the helium to flow into the DSC cavity.*

20. *If the optional leakage test of step 21 is not to be performed, skip to step24. Otherwise, pressurize the DSC with helium up to 15.0 psig.*

21. *Perform helium leakage test of the inner top cover plate weld for a leakage rate of* $\leq 1 \times 10^{-4}$ *ref.cm*^{3}*/sec. This test is optional.*

22. *If a leak is found, repair the weld, repressurize the DSC and repeat the helium leakage test.*

23. *Once no leaks are detected, depressurize the DSC cavity by releasing the helium through the VDS to the plant's spent fuel pool or radioactive waste system, or other appropriate system.*

24. *Re-evacuate the DSC cavity using the VDS. The cavity pressure should be reduced in steps of approximately 10 mm Hg, 5 mm Hg, and 3 mm Hg. After pumping down to each*

level, the pump is valved off and the cavity pressure monitored. When the cavity pressure stabilizes, the pump is valved in to continue the vacuum drying process. Vacuum drying is complete when the pressure stabilizes for a minimum of 30 minutes at 3 mm Hg.

25. *Open the valve on the vent port and allow helium to flow into the DSC cavity to pressurize the DSC between 16.5 and 18.0 psig and hold for 10 minutes. Depressurize the DSC cavity to 2.5 ± 1.0 psig (stable for 30 minutes).*

    ***CAUTION**: Radiation dose rates are expected to be high at the vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

26. *Close the valves on the helium source.*

A.7.7.9.3 NUHOMS®-69BTH DSC Sealing Operations

***CAUTION:** During performance of steps listed in this section, monitor the cask/DSC annulus water level and replenish as necessary to maintain cooling.*

1. *Disconnect the VDS from the DSC. Seal weld the prefabricated covers over the vent and siphon ports, inject helium into the blind space just prior to completing welding, and perform a dye penetrant weld examination.*
2. *Temporary shielding may be installed as necessary to minimize personnel exposure. Install the automated welding machine onto the outer top cover plate and place the outer top cover plate with the automated welding system onto the DSC. Alternately, the welding machine may be mounted onto the cover plate and then placed together on the DSC. Verify proper fit up of the outer top cover plate with the DSC shell.*
3. *Tack weld the outer top cover plate to the DSC shell. Place the outer top cover plate weld root pass.*
4. *Perform a helium leakage test of the inner top cover plate and vent/siphon port plate welds using the test port in the outer top cover plate and verify that the "leak-tight" criterion of $\leq 1x10^{-7}$ ref.cm^3/sec as defined in ANSI N14.5 [1] is met. Verify that the personnel performing the leakage test are qualified in accordance with SNT-TC-1A [7]. Alternatively, this leakage test can be done with a test head following Step 1 above.*
5. *If a leak is found, remove the outer cover plate root pass (if not using a test head), the vent and siphon port plugs and repair the inner cover plate welds. Then repeat applicable procedure steps from Section A.7.7.9.2, step 17.*
6. *Perform dye penetrant examination of the root pass weld. Weld out the outer top cover plate to the DSC shell and perform dye penetrant examination on the weld surface.*
7. *Seal weld the prefabricated plug (when applicable) over the outer cover plate test port and perform dye penetrant weld examinations.*
8. *Remove the automated welding machine from the DSC.*
9. *Open the cask drain port valve and drain the water from the cask/DSC annulus.*

The cask/DSC is now ready to be prepared for downending as described in Chapter A.7, Section A.7.1.2.2.

A.7.7.9.4 Unloading a NUHOMS®-69BTH DSC to a Fuel Pool

CAUTION: *The process of DSC unloading is similar to that used for DSC loading. DSC opening operations described below are to be carefully controlled in accordance with site procedures. This operation is to be performed under the site's standard health physics guidelines for welding, grinding, and handling of potentially highly contaminated equipment. These are to include the use of prudent housekeeping measures and monitoring of airborne particles. Procedures may require tenting, respirators, supplied air or other measures to contain contamination and minimize the impact on the health and safety of workers.*

1. *Locate the DSC siphon and vent ports using the indications on the DSC outer top cover plate.*
2. *Drill a hole in the DSC outer top cover plate and remove the siphon cover plate to expose the siphon port quick connect.*
3. *Drill a hole in the DSC outer top cover plate and remove the vent cover plate to expose the vent port quick connect.*
4. *Sample the DSC cavity atmosphere. If necessary, flush the DSC cavity gases to the site radwaste systems.*

CAUTION: *(a) The water fill rate must be regulated during this reflooding operation to ensure that the DSC vent pressure does not exceed 20.0 psig.*

(b) Provide for continuous hydrogen monitoring of the DSC cavity atmosphere during all subsequent cutting operations to ensure that a safety limit of 2.4% is not exceeded [4] and [5]. Purge with 2-3 psig helium (or any other inert medium) as necessary to maintain the hydrogen concentration safely below this limit.

5. *Fill the DSC with spent fuel pool water (or other plant-designated water source) through the siphon port with the vent port open and routed to the plant's off-gas system.*
6. *Install a debris shield over the cask/DSC annulus.*
7. *Use a mechanical cutting system, plasma arc-gouging, or other suitable means to remove the closure weld from the outer top cover plate.*

CAUTION: *Monitor the hydrogen concentration in the DSC cavity during this step to ensure that it does not exceed 2.4% by volume [4] and [5].*

8. *Remove the DSC outer top cover plate.*
9. *Continue with cutting equipment and remove the closure weld from the DSC inner top cover plate.*
10. *Remove the DSC inner top cover plate.*
11. *NOT USED*
12. *Remove excess material on the DSC inside shell surface which may interfere with top shield plug removal.*

13. Clean the cask surface of dirt and debris that may have accumulated during transportation or weld removal.

14. Engage the cask lifting yoke to the upper trunnions and install the shield plug cables between the yoke and the DSC top shield plug.

15. Prior to lowering the cask into the pool, adjust the pool water, if necessary, to accommodate the volume of water which will be displaced by the cask during the operation.

16. Lower the cask slowly into the fuel pool while spraying the exterior of the cask with clean water.

17. Disengage the lifting yoke from the cask trunnions and remove the top shield plug and hold-down ring, as applicable.

18. Remove the fuel assemblies (or end caps as applicable for damaged assemblies) from the DSC.

19. Engage the lifting yoke to the cask upper trunnions, remove the cask from the pool, and place it in the decon area.

20. Remove the water from the DSC cavity and cask/DSC annulus.

21. Remove the DSC from the cask and handle in accordance with low-level waste procedures.

22. Decontaminate the cask inner and outer surfaces as necessary.

23. Inspect the cask hardware (including covers and valves) for damage that may have occurred during transportation. Repair or replace as necessary.

A.7.7.9.5 References

1. *ANSI N14.5-1997, "American National Standard for Radioactive Materials - Leakage Tests on Packages for Shipment," American National Standards Institute, Inc., New York, 1997.*
2. *Not Used*
3. *Not Used*
4. *U.S. Nuclear Regulatory Commission, Office of the Nuclear Material Safety and Safeguards, "Safety Evaluation of VECTRA Technologies' Response to Nuclear Regulatory Commission Bulletin 96-04 for the NUHOMS®-24P and NUHOMS®-7P."*
5. *U.S. Nuclear Regulatory Commission Bulletin 96-04, "Chemical, Galvanic or Other Reactions in Spent Fuel Storage and Transportation Casks," July 5, 1996.*
6. *U.S. Nuclear Regulatory Commission, Interim Staff Guidance (ISG)-22, "Potential Rod Splitting Due to Exposures to an Oxidizing Atmosphere during Short-term Cask Loading Operations in LWR or Other Uranium Oxide Based Fuel."*
7. *SNT-TC-1A, "American Society for Nondestructive Testing, Personnel Qualification and Certification in Nondestructive Testing."*

APPENDIX A.7.7.10
Radioactive Waste Canister (RWC) Wet Loading Procedures

Appendix A.7.7.10
Radioactive Waste Canister (RWC) Wet Loading Procedures

Note: The procedure outlined below applies to the final loading of either the RWC-W or the RWC-B prior to release for shipment. Both versions of the RWC have a top shield plug (which also serves as a bolt-on lid for the RWC-B) and an outer top cover plate. Both the plug and the plate are welded in place prior to transport.

A.7.7.10.1 Wet Loading of the RWC

The starting condition for the following steps assumes completion of the cask preparation steps in Section A.7.1.2.

1. *Lift the cask and position it over the cask loading area of the spent fuel pool in accordance with the plant's 10CFR50 cask handling procedures.*
2. *Lower the cask into the fuel pool until the bottom of the cask is at the height of the fuel pool surface. As the cask is lowered into the pool, spray the exterior surface of the cask with clean water.*
3. *Place the cask in the location of the fuel pool designated as the cask loading area.*
4. *Disengage the lifting yoke from the cask lifting trunnions and move the yoke clear of the cask. Spray the lifting yoke with clean water if it is raised out of the fuel pool.*
5. *Using the appropriate handling tool and/or suitable hoist, load the RWC cavity. Verify that the cask is full or install appropriate component spacers to restrain the contents during transport. Record contents and location on the cask loading report to the extent practical.*
6. *Install the liner shield plug (RWC-W), as applicable, and then install the RWC top shield plug.*
7. *Position the lifting yoke with the cask trunnions and verify that it is properly engaged.*
8. *Raise the cask to the pool surface. Prior to raising the top of the cask above the water surface, stop vertical movement.*
9. *Inspect the shield plug/lid to verify that it is properly seated within the RWC. If not, lower the cask and reposition. Repeat steps 6 through 8 as necessary.*
10. *Continue to raise the cask from the pool and spray the exposed portion of the cask with clean or demineralized water until the top region of the cask is accessible.*
11. *Drain any excess water from the top of the RWC back to the fuel pool.*
12. *Check the radiation levels at the center of the top shield plug and around the perimeter of the cask.*
13. *As required for crane load limitations, drain water from the RWC.*
14. *Lift the cask from the fuel pool. As the cask is raised from the pool, continue to spray the cask with clean water.*
15. *Move the cask to the plant designated preparation area.*

A.7.7.10.2 RWC Drying and Backfilling

1. Check the radiation levels along the perimeter of the cask. The cask exterior surface should be decontaminated as necessary. Temporary shielding may be installed as necessary to minimize personnel exposure.

2. Place scaffolding or other suitable work platform(s) around the cask so that the surface of the cask is easily accessible to personnel.

3. Disengage the rigging cables from the top shield plug and remove the eyebolts as applicable. Disengage the lifting yoke from the trunnions and position it clear of the cask.

4. Decontaminate the exposed surfaces of the RWC shell perimeter and remove the annulus seal.

5. Connect a drain line to the cask, open the cask drain port and allow water from the annulus to drain out until the water level is approximately twelve inches below the top edge of the RWC shell. Take swipes around the outer top 1 foot surface of the RWC shell and check for smearable contamination as required.

CAUTION: *Radiation dose rates are expected to be high at the RWC vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

6. Prior to the start of welding operations drain approximately 100 gallons of water from the RWC using the vacuum drying system (VDS) or an optional liquid pump.

7. Disconnect the hose from the RWC siphon port.

8. Install the automated welding machine onto the top shield plug already installed in the RWC.

9. Check radiation levels along the surface of the top shield plug. Temporary shielding may be installed as necessary to minimize personnel exposure throughout the subsequent welding operations.

10. Cover the cask/RWC annulus to prevent debris and weld splatter from entering the annulus.

11. Ready the automated welding machine and tack weld the top shield to the RWC shell. Complete the top shield plug weld to the RWC shell and remove the automated welding machine.

12. Perform dye penetrant examination of the weld surface.

13. Connect the VDS and/or water pump to the RWC siphon and vent ports.

14. Use a water pump (may be part of VDS or separate pump) connected to the siphon port to remove remaining bulk water from the RWC cavity. Alternately, air or helium (up to 10 psig) may also be used on the vent port and allow the gas to force the water from the RWC cavity through the siphon port.

15. *Once the water stops flowing from the RWC, close the RWC siphon port and disengage the gas source.*

16. *Connect the hose from the vent port and the siphon port to the intake of the vacuum pump. Connect a hose from the discharge side of the VDS to the plant's radioactive waste system or spent fuel pool. Connect the VDS to a helium source, as appropriate.*

17. *Open the valve on the suction side of the pump, start the VDS and draw a vacuum on the RWC cavity until dry. That is, until a vacuum of approximately 10 mbar can be maintained for 10 minutes.*

18. *Open the valve on the vent port and allow air or helium to flow into the RWC cavity to pressurize the RWC to 2.5 ± 1.0 psig backfill pressure (stable for 30 minutes).*

    CAUTION: *Radiation dose rates are expected to be high at the vent and siphon port locations. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.*

19. *Close the line connected to the vent port.*

A.7.7.10.3 RWC Sealing Operations

1. *Disconnect the VDS from the RWC. Seal weld the prefabricated covers over the vent and siphon ports and perform a dye penetrant weld examination.*

2. *Temporary shielding may be installed as necessary to minimize personnel exposure. Install the automated welding machine onto the outer top cover plate and place the outer top cover plate with the automated welding system onto the RWC. Alternately, the welding machine may be mounted onto the cover plate and then placed together on the RWC. Verify proper fit up of the outer top cover plate with the RWC shell.*

3. *Tack weld the outer top cover plate to the RWC shell. Place the outer top cover plate weld root pass.*

4. *Perform dye penetrant examination of the root pass weld. Weld out the outer top cover plate to the RWC shell and perform dye penetrant examination on the weld surface.*

5. *Remove the automated welding machine from the RWC.*

6. *Open the cask drain port valve and drain the water from the cask/RWC annulus.*

The cask/RWC is now ready to be prepared for downending as described in Chapter A.7, Section A.7.1.2.2.

Chapter A.8
Acceptance Tests and Maintenance Program

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A.8.1.3 Structural and Pressure Tests

A.8.1.3.1 Load Tests

Two sets of trunnions are provided for the NUHOMS®-MP197HB transport package lifting. One set of trunnions has double shoulders (non-single failure proof). The other set of trunnions has a single shoulder (single failure proof). Only one set of trunnions is used depending on site and transfer operation requirements. The trunnions are fabricated and tested in accordance with ANSI N14.6 [3]. A load test of 3.0 times the design lift load (for single failure proof trunnions) or 1.5 times the design lift load (for non-single failure proof trunnions) is applied to the trunnions for a period of ten minutes, to ensure that the trunnions can perform satisfactorily.

A force equal to 1.5 times the impact limiter weight will be applied to the hoist rings of each *impact* limiter for a period of ten (10) minutes. At the conclusion of the test, the impact limiter hoist rings will be visually examined for defects and permanent deformation.

A.8.1.3.2 Pressure Tests

A pressure test is performed on the NUHOMS®-MP197HB packaging assembly at a pressure between 40.0 and 45.0 psig. This is well above 1.5 times the maximum normal operating pressure of 12.7 psig (Chapter A.3, Table A.3-20). The test pressure is held for a minimum of 10 minutes. The test is performed in accordance with ASME B&PV Code, Section III, Subsection NB, Paragraph NB-6200 or NB-6300. All visible joints/surfaces are visually examined for possible leakage after application of the pressure.

In addition, a bubble leak*age* test is performed on the resin enclosure. The purpose of this test is to identify any potential leak*age* passages in the enclosure welds.

A.8.1.4 Containment Boundary Leakage Tests

A.8.1.4.1 MP197HB Cask Leakage Tests

Leakage tests are performed on the MP197HB cask containment boundary prior to first use, typically at the fabricator's facility. The fabrication verification leak*age* test can be separated into the following five tests: 1) cask leakage integrity, 2) cask vent port closure bolt seal integrity, 3) cask drain port closure bolt seal integrity, 4) cask *lid* seal integrity, and 5) ram access closure plate seal integrity. These tests are usually performed using the helium mass spectrometer method. Alternative methods are acceptable, provided that the required sensitivity is achieved. The leak*age* test is performed in accordance with ANSI N14.5 [4] or ISO-12807 [11]. The personnel performing the leakage test are qualified in accordance with SNT-TC-1A [2].

Cask Leakage Integrity Test

Prior to lead pour and final machining of the inner shell, the cylindrical portion of the containment boundary, including the bottom end closure, will be leak*age* tested in accordance with the requirements of ANSI N14.5 *[4]* or ISO-12807 *[11]*, using temporary closures and seals for the ram access cover plate and lid. Because the inner shell will not be accessible for leak*age* testing after lead is poured, leak*age* testing will be performed during the fabrication process, as permitted by ANSI N14.5 Table 1 *[4]*. As one means of performing this test, the interior of the cask cavity may be flooded with a helium atmosphere while vacuum is drawn on the lead cavity to determine the leak*age* rate. If a leak*age* is discovered, the source will be determined, repaired, and the shells retested to ensure that the measured leak*age* rate is less than 1×10^{-7} ref cm^3/s.

The test will be performed in conjunction with the non-destructive examination of the inner shell welds in accordance with ASME B&PVC Code, Section III, Subsection NB. *An MT or* PT examination of every weld layer in the shell-to-top-forging closure weld and a*n MT or* PT examination of all final machined weld surfaces of the inner shell *will be performed* per the Code.

Fabrication Verification Leak*age* Tests

The fabrication verification leak*age* tests include the following:

- Cask vent port closure *bolt* seal integrity
- Cask drain port closure *bolt* seal integrity
- Cask lid seal integrity
- Cask ram access closure plate seal integrity

The tests will be performed as described in Chapter A.7, Section A.7.4.1, in accordance with the ANSI N 14.5 *[4]* or ISO-12807 *[11]*. The acceptance criterion requires each component to be individually leaktight, that is, the leak*age* rate must be less than 1×10^{-7} *ref* cm^3/s.

A.8.1.4.2 NUHOMS® DSCs Leakage Test

The containment boundary of a NUHOMS® DSC is leak*age* tested to verify it is leaktight in accordance with ANSI N14.5 *[4]* or ISO-12807 *[11]*. The leak*age* tests are typically performed using the helium mass spectrometer method. Alternative methods are acceptable, provided that the required sensitivity is achieved. Following completion of the welding of the DSC inner top cover plate and siphon and vent cover plates, these welds are leak*age* tested to $\leq 1.0 \times 10^{-7}$ *ref* cm^3/s.

If the leak*age* rate exceeds this criteria, the inner top cover plate seal weld *and* siphon and vent cover plate welds *will be inspected and repaired where necessary.*

For the 24PT4 DSC, the leakage test requirements outlined in CoC 1029 are used to demonstrate leaktightness in lieu of the above criteria.

A.8.1.5 MP197HB Cask Component and Material Tests

A.8.1.5.1 Valves, Rupture Discs, and Fluid Transport Devices

There are no valves, *rupture discs,* or couplings in the *containment of the* NUHOMS®-MP197HB packaging.

A.8.1.5.2 Gaskets

The lid and all the other containment penetrations are sealed using O-ring seals. Leak*age* testing of the seals is described in *Section* A.8.1.4.1.

A.8.1.5.3 Impact Limiter Leakage Test

Prior to initial use, the following test will be performed, after all the seal welds have been completed on the impact limiter to verify that the impact limiter wood is completely enclosed, thereby preventing any moisture exchange with the ambient environment.

Each impact limiter container is pressurized to a pressure between 2.0 and 3.0 psig. Test all the weld seams and penetrations for leakage using a soap bubble test.

A.8.1.5.4 Functional Tests

The following functional tests will be performed prior to *the* first use of the cask. Generally these tests will be performed at the fabrication facility.

a. Installation and removal of the lid, ram access cover plates, port plugs, and other fittings will be observed. Each component will be checked for difficulties in installation and removal. After removal, each component will be visually examined for damage. Any defects will be corrected prior to *the* acceptance of the cask.
b. After installation of the fuel basket into the DSC, each basket compartment will be checked by gauge to demonstrate that the fuel assemblies will fit in the basket.

A.8.1.6 Shielding Tests

Chapter A.5 presents the analyses performed to ensure that the NUHOMS®-MP197HB package shielding integrity is adequate.

A.8.1.6.1 Gamma Shield Test

The integrity of the NUHOMS®-MP197HB cask poured lead shielding will be confirmed via gamma scanning prior to installation of the neutron shield.

The outer cask surface is gridded and a *gamma scan* chart is made to reflect the gridded surface. The gamma scan *is* performed using a detector with a detection area enveloping the grid minimum area (e.g., for a 6” × 6” grid, the detector will encompass a 6” × 6” square).

The acceptance criterion for the gamma scan is based on the results of dose rate measurements of mockup test block constructed to replicate the MP197HB cask through-wall configuration. The test block consists of the inner wall, layer of lead, and the outer wall. The test uses nominal thicknesses of steel walls (provided in SAR drawings given in Chapter A.1, Appendix A.1.4.10) and nominal less 5% thickness of lead layer. The dose rate measured *using the* test block *configuration* is used as the maximum acceptable reading for the inspected *cask.*

The source/detector distance used in the *cask* inspection shall be the same as that used in establishing the *maximum* dose rate *limit.*

A.8.1.6.2 Neutron Shield

The radial neutron shield is protected from damage or loss by the aluminum and steel enclosure. The neutron shield material, VYAL B, is a proprietary vinyl ester resin mixed with alumina hydrate and zi*n*c borate which are added for their fire retardant properties.

The primary function of the resin is to shield against neutrons, which is performed primarily by the hydrogen content in the resin. The sole function of the boron is to suppress n-γ reactions with hydrogen. The resin also provides some gamma shielding, which is a function of the overall resin density, and is not sensitive to composition.

Proprietary information withheld pursuant to 10 CFR 2.390

The following are acceptance values for density and chemical composition for the resin. The values used in the shielding calculations of Chapter A.5 are included for comparison.

Chapter A.5 values		Acceptance Testing Values		
Element	Nominal wt %	Element	Wt %	Acceptance range (wt %)
H	4.54	H	5.0	± 8
B	0.82	B	0.9	± 10

The minimum resin density in acceptance testing is 1.75 g/cm^3. Resin composition or density test results which fall outside of this range will be evaluated to ensure that the shielding regulatory dose limits are not exceeded.

Proprietary information withheld pursuant to 10 CFR 2.390

The individual aluminum tubes containing the resin are then installed around the outside of the cask as shown in SAR drawing MP197HB-71-1005. The installation of the tubes into the annulus between the cask outer shell and the neutron shield shell is controlled to maximize the tube-to-tube contact, thus minimizing gaps between adjacent tubes.

Tests are performed at loading to ensure that the radiation dose limits are not exceeded for each cask.

A.8.1.7 Neutron Absorber Tests

CAUTION
Sections A.8.1.7.1 through A.8.1.7.4 below are incorporated by reference into the CoC 9302 Conditions (paragraph 7.(d)) and shall not be deleted or altered in any way without a CoC revision approval from the NRC. The text of these sections is shown in bold type to distinguish them from other sections.

The neutron absorber used for criticality control in the DSC baskets may consist of any of the following types of material. Depending on the DSC model, these neutron absorber materials may be used alone or be paired with aluminum:

(a) Boron-aluminum alloy (borated aluminum)

(b) Boron carbide/Aluminum metal matrix composite (MMC)

(c) Boral®

These materials only serve as neutron absorber for criticality control and as heat conduction paths. The MP197HB packaging safety analyses do not rely upon their mechanical strength. The radiation and temperature environment in the cask is not sufficiently severe to damage these metallic/ceramic materials. To assure performance of the neutron absorber's design function only the presence of B10 and the uniformity of its distribution need to be verified, with testing requirements specific to each material. The boron content of these materials is given in the Appendices A.1.4 for each DSC type.

References to metal matrix composites throughout this chapter are not intended to refer to Boral®, which is described later in this section.

A.8.1.7.1 Boron Aluminum Alloy (Borated Aluminum)

See the Caution in Section A.8.1.7 before deletion or modification to this section.

The material is produced by direct chill (DC) or permanent mold casting with boron precipitating as a uniform fine dispersion of discrete AlB_2 or TiB_2 particles in the matrix of aluminum or aluminum alloy. For extruded products, the TiB_2 form of the alloy shall be used. For rolled products, either the AlB_2, the TiB_2, or a hybrid may be used.

Boron is added to the aluminum in the quantity necessary to provide the specified minimum B10 areal density in the final product, with sufficient margin to minimize rejection, typically 10 % excess. The amount required to achieve the specified minimum B10 areal density will depend on whether boron with the natural isotopic distribution of the isotopes B10 and B11, or boron enriched in B10 is used. In no case shall the boron content in the aluminum or aluminum alloy exceed 5% by weight.

The criticality calculations take credit for 90% of the minimum specified B10 areal density of borated aluminum. The basis for this credit is the B10 areal density acceptance testing, which shall be as specified in Section A.8.1.7.6. The specified acceptance testing assures that at any location in the material, the minimum specified areal density of B10 will be found with 95% probability and 95% confidence.

A.8.1.7.2 Boron Carbide/Aluminum Metal Matrix Composites (MMC)

See the Caution in Section A.8.1.7 before deletion or modification to this section.

The material is a composite of fine boron carbide particles in an aluminum or aluminum alloy matrix. The material shall be produced by either direct chill casting, permanent mold casting, powder metallurgy, or thermal spray techniques. It is a low-porosity product, with a metallurgically bonded matrix. The boron carbide content shall not exceed 40% by volume. The boron carbide content for MMCs with an integral aluminum cladding shall not exceed 50% by volume.

The final MMC product shall have density greater than 98% of theoretical density demonstrated by qualification testing, with no more than 0.5 volume % interconnected porosity. For MMC with an integral cladding, the final density of the core shall be greater than 97% of theoretical density demonstrated by qualification testing, with no more than 0.5 volume % interconnected porosity of the core and cladding as a unit of the final product.

Boron carbide particles for the products considered here typically have an average size no greater than 40 microns, although the actual specification may be by mesh size, rather than by average particle size. No more than 10% of the particles shall be over 60 microns.

Prior to use in the DSC, MMCs shall pass the qualification testing specified in Section A.8.1.7.7, and shall subsequently be subject to the process controls specified in Section A.8.1.7.8.

The criticality calculations take credit for 90% of the minimum specified B10 areal density of MMCs. The basis for this credit is the B10 areal density acceptance testing, which is specified in Section A.8.1.7.6. The specified acceptance testing assures that at any location in the final product, the minimum specified areal density of B10 will be found with 95% probability and 95% confidence.

A.8.1.7.3 Boral®

See the Caution in Section A.8.1.7 before deletion or modification to this section.

This material consists of a core of aluminum and boron carbide powders between two outer layers of aluminum, mechanically bonded by hot-rolling an "ingot" consisting of an aluminum box filled with blended boron carbide and aluminum powders. The core, which is exposed at the edges of the sheet, is slightly porous. The nominal boron carbide content shall be limited to 65% (+ 2% tolerance limit) of the core by weight.

The criticality calculations take credit for 75% of the minimum specified B10 areal density of Boral®. B10 areal density will be verified by chemical analysis and by certification of the B10 isotopic fraction for the boron carbide powder, or by neutron transmission testing. Areal density testing is performed on a coupon taken from the sheet produced from each ingot. If the measured areal density is below that specified, all the material produced from that ingot will be either rejected, or accepted only on the basis of alternate verification of B10 areal density for each of the final pieces produced from that ingot.

A.8.1.7.4 Visual Inspections of Neutron Absorbers

Neutron absorbers shall be 100% visually inspected in accordance with the Certificate Holder's QA procedures. Material that does not meet the following acceptance criteria shall be reworked, repaired, or scrapped. Blisters shall be treated as non-conforming. Inspection of MMCs with an integral aluminum cladding shall also include verification that the matrix is not exposed through the faces of the aluminum cladding and that solid aluminum is not present at the edges. For Boral, visual inspection shall verify that there are no cracks through the cladding, exposed core on the face of the sheet, or solid aluminum at the edge of the sheet.

A.8.1.7.5 Other Visual Inspections Criteria (non-CoC Conditions)

For borated aluminum and MMCs, visual inspections shall follow the recommendations in Aluminum Standards and Data, Chapter 4 "Quality Control, Visual Inspection of Aluminum Mill Products and Castings" [12]. Local or cosmetic conditions such as scratches, nicks, die lines, inclusions, abrasion, isolated pores, or discoloration are acceptable.

A.8.1.7.6 Specification for Acceptance Testing of Neutron Absorbers by Neutron Transmission

CAUTION
Section A.8.1.7.6a and portions of A.8.1.7.6b are incorporated by reference into the CoC 9302 Conditions (paragraph 7.(d)) and shall not be deleted or altered in any way without a CoC revision approval from the NRC. The text of information incorporated by reference in these sections is shown in bold type to distinguish it from other sections.

A.8.1.7.6a Neutron Transmission acceptance testing procedures shall be subject to approval by the Certificate Holder. Test coupons shall be removed from the rolled or extruded production material at locations that are systematically or probabilistically distributed throughout the lot. Test coupons shall not exhibit physical defects that would not be acceptable in the finished product, or that would preclude an accurate measurement of the coupon's physical thickness.

A lot is defined as all the pieces produced from a single ingot or heat or from a group of billets from the same heat. If this definition results in lot size too small to provide a meaningful statistical analysis of results, an alternate larger lot definition may be used, so long as it results in accumulating material that is uniform for sampling purposes.

The sampling rate for neutron transmission measurements shall be such that there is at least one neutron transmission measurement for each 2000 square inches of final product in each lot.

The B10 areal density is measured using a collimated thermal neutron beam of no more than 1 inch diameter.

The neutron transmission through the test coupons is converted to B10 areal density by comparison with transmission through calibrated standards. These standards are composed of a homogeneous boron compound without other significant neutron absorbers. For example, boron carbide, zirconium diboride or titanium diboride sheets are acceptable standards. These standards are paired with aluminum shims sized to match the effect of neutron scattering by aluminum in the test coupons. Uniform but non-homogeneous materials such as metal matrix composites may be used for standards, provided that testing shows them to provide neutron attenuation equivalent to a homogeneous standard. Standards will be calibrated, traceable to nationally recognized standards, or by attenuation of a monoenergetic neutron beam correlated to the known cross section of boron 10 at that energy.

Alternatively, digital image analysis may be used to compare neutron radioscopic images of the test coupon to images of the standards. The area of image analysis shall be no more than 0.75 sq. inch.

The minimum areal density specified shall be verified for each lot at the 95% probability, 95% confidence level or better. If a goodness-of-fit test demonstrates that the sample comes from a normal population, the one-sided tolerance limit for a normal distribution may be used for this purpose. Otherwise, a non-parametric (distribution-free) method of determining the one-sided tolerance limit may be used. Demonstration of the one-sided tolerance limit shall be evaluated for acceptance in accordance with the Certificate Holder's QA procedures.

A.8.1.7.6b The following illustrates one acceptable method and is intended to be utilized as an example. Therefore, the following text is not part of the CoC 9302 Conditions.

The acceptance criterion for individual plates is determined from a statistical analysis of the test results for their lot. The B10 areal densities determined by neutron transmission are converted to volume density, i.e., the B10 areal density is divided by the thickness at the location of the neutron transmission measurement or the maximum thickness of the coupon. The lower tolerance limit of B10 volume density is then determined, defined as the mean value of B10 volume density for the sample, less K times the standard deviation, where K is the one-sided tolerance limit factor with 95% probability and 95% confidence [13].

Finally, the minimum specified value of B10 areal density is divided by the lower tolerance limit of B10 volume density to arrive at the minimum plate thickness which provides the specified B10 areal density.

Any plate which is thinner than the statistically derived minimum thickness from Section A.8.1.7.6a or the minimum design thickness, whichever is greater, shall be treated as non-conforming, with the following exception. Local depressions are acceptable, so long as they total no more than 0.5% of the area on any given plate, and the thickness at their location is not less than 90% of the minimum design thickness.

Non-conforming material shall be evaluated for acceptance in accordance with the Certificate Holder's QA procedures.

A.8.1.7.7 Specification for Qualification Testing of Metal Matrix Composites

CAUTION

Section A.8.1.7.7.3.1, Section A.8.1.7.7.4, and Section A.8.1.7.7.5 are incorporated by reference into the CoC 9302 Conditions (paragraph 7.(d)) and shall not be deleted or altered in any way without a CoC revision approval from the NRC. The text of these sections is shown in bold type to distinguish them from other sections.

A.8.1.7.7.1 Applicability and Scope

Metal matrix composites (MMCs) acceptable for use in the DSCs are described in Section A.8.1.7.2.

Prior to initial use in a spent fuel transport system, such MMCs shall be subjected to qualification testing that will verify that the product satisfies the design function. Key process controls shall be identified per Section A.8.1.7.8 so that the production material is equivalent to or better than the qualification test material. Changes to key processes shall be subject to qualification before use of such material in a spent fuel dry storage or transport system.

ASTM test methods and practices are referenced below for guidance. Alternative methods may be used with the approval of the certificate holder.

A.8.1.7.7.2 Design Requirements

In order to perform its design functions the product must have at a minimum sufficient strength and ductility for manufacturing and for the normal and accident conditions of the transport system. This is demonstrated by the tests in Section A.8.1.7.7.4. It must have a uniform distribution of boron carbide. This is demonstrated by the tests in Section A.8.1.7.7.5.

A.8.1.7.7.3 Durability

There is no need to include accelerated radiation damage testing in the qualification. Such testing has already been performed on MMCs, and the results confirm what would be expected of materials that fall within the limits of applicability cited above. Metals and ceramics do not experience measurable changes in mechanical properties due to fast neutron fluences typical over the lifetime of spent fuel transport, about 10^{15} neutrons/cm^2.

The need for thermal damage and corrosion (hydrogen generation) testing shall be evaluated case-by-case based on comparison of the material composition and environmental conditions with previous thermal or corrosion testing of MMCs.

Thermal damage testing is not required for unclad MMCs consisting only of boron carbide in an aluminum 1100 matrix, because there is no reaction between aluminum and boron carbide below 842 °F, well above the basket temperature under normal conditions of transport[1].

Corrosion testing is not required for MMCs (clad or unclad) consisting only of boron carbide in an aluminum 1100 matrix, because testing on one such material has already been performed by Transnuclear[2].

A.8.1.7.7.3.1 Delamination Testing of Clad MMC

Clad MMCs shall be subjected to thermal damage testing following water immersion to ensure that delamination does not occur under normal conditions of transport.

A.8.1.7.7.4 Required Qualification Tests and Examinations to Demonstrate Mechanical Integrity

At least three samples, one each from approximately the two ends and middle of the qualification material run shall be subject to:

a) room temperature tensile testing (ASTM- B557[3]) demonstrating that the material has the following tensile properties:

- ***Minimum yield strength, 0.2% offset: 1.5 ksi***
- ***Minimum ultimate strength: 5 ksi***
- ***Minimum elongation in 2 inches: 0.5%***

As an alternative to the elongation requirement, ductility may be demonstrated by bend testing per ASTM E290[4]. The radius of the pin or mandrel shall be no greater than three times the material thickness, and the material shall be bent at least 90 degrees without complete fracture,

b) Testing to verify more than 98% of theoretical density for non-clad MMCs and 97% for the matrix of clad MMCs. Testing or examination for interconnected porosity on the faces and edges of unclad MMC, and on the edges of clad MMC shall be performed by a means to be approved by the Certificate Holder. The maximum interconnected porosity is 0.5 volume %, and for at least one sample,

c) For MMCs with an integral aluminum cladding, thermal durability testing demonstrating that after a minimum 24 hour soak in either pure or borated water, then

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1 *Sung, C., "Microstructural Observation of Thermally Aged and Irradiated Aluminum/Boron Carbide (B_4C) Metal Matrix Composite by Transmission and Scanning Electron Microscope," 1998.*

2 *Boralyn testing submitted to the NRC under docket 71-1027, 1998.*

3 *ASTM B557 Standard Test Methods of Tension Testing Wrought and Cast Aluminum and Magnesium-Alloy Products*

4 *ASTM E290, Standard Methods for Bend Testing of Materials for Ductility.*

insertion into a preheated oven at approximately 825°F for a minimum of 24 hours, the specimens are free of blisters and delamination and pass the mechanical testing requirements described in test 'a' of this section.

A.8.1.7.7.5 Required Tests and Examinations to Demonstrate B10 Uniformity

Uniformity of the boron distribution shall be verified either by:

a) Neutron radioscopy of material from the ends and middle of the test material production run, verifying no more than 10% difference between the minimum and maximum B10 areal density, or
b) Quantitative testing for the B10 areal density, B10 density, or the boron carbide weight fraction, on locations distributed over the test material production run, verifying that one standard deviation in the sample is less than 10% of the sample mean. Testing may be performed by a neutron transmission method similar to that specified in Section A.8.1.7.6, or by chemical analysis for boron carbide content in the composite.

A.8.1.7.7.6 Approval of Procedures

Qualification procedures shall be subject to approval by the Certificate Holder.

A.8.1.7.8 Specification for Process Controls for Metal Matrix Composites

This section provides process controls to ensure that the material delivered for use is equivalent to the qualification test material.

CAUTION
Sections A.8.1.7.8.1 and A.8.1.7.8.2 are incorporated by reference into the CoC 9302 Conditions (paragraph 7.(d)) and shall not be deleted or altered in any way without a CoC revision approval from the NRC. The text of these sections is shown in bold type to distinguish them from other sections.

A.8.1.7.8.1 Applicability and Scope

Key processing changes shall be subject to qualification prior to use of the material produced by the revised process. The Certificate Holder shall determine whether a complete or partial re-qualification program per Section A.8.1.7.7 is required, depending on the characteristics of the material that could be affected by the process change.

A.8.1.7.8.2 Definition of Key Process Changes

Key process changes are those which could adversely affect the uniform distribution of the boron carbide in the aluminum, reduce density, reduce corrosion resistance, or reduce the mechanical strength or ductility of the MMC.

A.8.1.7.8.3 Identification and Control of Key Process Changes

The manufacturer shall provide the Certificate Holder with a description of materials and process controls used in producing the MMC. The Certificate Holder and manufacturer shall identify key process changes as defined in Section A.8.1.7.8.2.

An increase in nominal boron carbide content over that previously qualified shall always be regarded as a key process change. The following are examples of other changes that are established as key process changes, as determined by the Certificate Holder's review of the specific applications and production processes:

a) *Changes in the boron carbide particle size specification that increase the average particle size by more than 5 microns or that increase the amount of particles larger than 60 microns from the previously qualified material by more than 5% of the total distribution but less than the 10% limit,*

b) *Change of the billet production process, e.g., from vacuum hot pressing to cold isostatic pressing followed by vacuum sintering,*

c) *Change in the nominal matrix alloy,*

d) *Changes in mechanical processing that could result in reduced density of the final product, e.g., for PM or thermal spray MMCs that were qualified with extruded material, a change to direct rolling from the billet,*

e) *For MMCs using a magnesium-alloyed aluminum matrix, changes in the billet formation process that could increase the likelihood of magnesium reaction with the boron carbide, such as an increase in the maximum temperature or time at maximum temperature,*

f) *Changes in powder blending or melt stirring processes that could result in less uniform distribution of boron carbide, e.g., change in duration of powder blending, and*

g) *For MMCs with an integral aluminum cladding, a change greater than 25% in the ratio of the nominal aluminum cladding thickness (sum of two sides of cladding) and the nominal matrix thickness could result in changes in the mechanical properties of the final product.*

In no case shall process changes be accepted if they result in a product outside the limits in Sections A.8.1.7.7.1 and A.8.1.7.7.4.

A.8.1.7.9 ***Neutron Absorber for DSCs Already Loaded and DSCs Under Fabrication***

> ***CAUTION***
>
> *Section A.8.1.7.9 is incorporated by reference into the CoC 9302 Conditions (paragraph 7.(d)) and shall not be deleted or altered in any way without a CoC revision approval from the NRC. The text of this section is shown in bold type to distinguish it from other sections.*

The neutron absorber tests and acceptance criteria as described in Section A.8.1.7.1 through Section A.8.1.7.8 are only applicable to all the canister types that will be loaded in the spent fuel pool using the MP197HB cask. However, for canister types which are already in service under 10CFR Part72, the neutron absorber material acceptance requirements for each specific canister type as described in the applicable 10CFR Part72 approved certificate of compliance are applicable.

A.8.1.8 Thermal Tests

The thermal evaluation of the MP197HB cask described in Chapter A.3 is performed using very conservative and bounding assumptions. Gaps between the components are modeled in the thermal analysis to account for possible gaps expected during fabrication. Gaps are assumed to be present during NCT and HAC post fire cases when calculating heat flow out of the cask and gaps are assumed closed when calculating heat flow into the cask (i.e., during the HAC fire). The calculated cladding temperatures are much lower than the cladding temperature limit, assuring large margins to the limits. The cladding temperatures reported for the DSCs are very conservative because the allowed heat loads for a given DSC are reduced until the calculated DSC shell temperature in the MP197HB cask is below that calculated for storage conditions in the applicable 10 CFR Part 72 license. The reported cladding temperature is that of the higher heat load allowed under storage conditions with the same or higher DSC shell temperature.

However, to provide additional assurance that the thermal performance of the fabricated cask is equal to or exceeds the theoretical performance reported in the SAR, a thermal test is performed after fabrication of MP197HB cask.

Heat dissipation for the MP197HB cask to the ambient occurs three-dimensionally with a significant portion of the design heat load being radially dissipated through the neutron shield region of the cask body. The cask top and bottom ends beyond the neutron shield region are covered by the impact limiters. Due to limited contact between the thermal shields and the cask end plates (cask bottom plate and cask lid) and the insulating properties of wood within the impact limiters, the heat dissipation in the axial direction is largely restricted and is insignificant in comparison to the radial heat dissipation.

The thermal test measures the effective thermal conductivity of a cask in the radial direction over an approximately 10-ft exposed length within the neutron shield region. These measured thermal conductivities will be used as thermal input into the ANSYS model described in the SAR, Chapter A.3, Section A.3.3.1.1 for the NCT thermal analysis. The temperature distribution computed with the measured conductivity of the cask is then compared against the corresponding values in the

SAR, Chapter A.3, Table A.3-8, and A.3-10 to demonstrate the thermal performance of the fabricated cask is equal to or exceeds the theoretical performance reported in the SAR.

A.8.2 Maintenance Program

A.8.2.1 Structural and Pressure Tests

Within 14 months prior to any lift of a NUHOMS®-MP197HB transport package, the front trunnions shall be subject to either of the following:

- A test load equal to 300% of the maximum service load per ANSI N14.6 [3], paragraph 7.3.1(a) for single failure proof trunnions or a test load equal to 150% of the maximum service load per ANSI N14.6 *[3]*, paragraph 7.3.1(b) for non-single failure proof trunnions. After sustaining the test load for a period of not less than 10 minutes, *accessible* critical areas shall be subjected to visual inspection for defects, and all components shall be inspected for permanent deformation.
- Dimensional testing, visual inspection and nondestructive examination of *accessible* critical areas of the trunnions including the bearing surfaces in accordance with Paragraph 6.3.1 of ANSI N14.6 *[3]*.

A.8.2.2 Leakage Tests

The following containment boundary components shall be subject to periodic maintenance, and preshipment leak*age* testing in accordance with ANSI N14.5 *[4]* or ISO-12807 *[11]*:

- Lid
- Ram Access Closure Plate
- Vent Port
- Drain Port

Test	**Frequency**	**Acceptance Criteria**	**Typical Method (ANSI N14.5 TABLE A-1, *[4]*)**
Periodic	Within 12 months prior to shipment	Each component individually ≤ 1×10^{-7} ref cm^3/s	(He) A.5.3 A.5.4
Pre-shipment	Before each shipment, after the contents are loaded and the package is closed	No detected leakage, sensitivity of 10^{-3} ref cm^3/s or better, unless seal is replaced.	A.5.1 A.5.2 A.5.8 A.5.9
Maintenance	After maintenance, repair, or replacement of containment components, including inner seals	Each component individually ≤ 1×10^{-7} ref cm^3/s	(He) A.5.3 A.5.4

No leak*age* tests are required prior to shipment of an empty NUHOMS®-MP197HB packaging.

A.8.2.3 Component and Material Tests

A.8.2.3.1 Fasteners

All threaded fasteners and port plugs shall be inspected whenever removed, and annually, for deformed or stripped threads. Damaged parts shall be evaluated for continued use and replaced as required.

At a minimum, the MP197HB cask lid bolts shall be replaced at least every 250 shipments (round trip) to ensure adequate fatigue strength is maintained.

A.8.2.3.2 Impact Limiters

A visual examination of the impact limiters before each shipment will be performed to ensure that the impact limiters have not been degraded between leak*age* test intervals. If there is no evidence of weld cracking or other damage which could result in water in-leakage, the wood will not be degraded. If there is visual damage, the impact limiter will be removed from service, repaired, if possible, and inspected for degradation of the wood. Impact limiters will be leak*age* tested once every five years to ensure that water has not entered the impact limiters. If the leak*age* test indicates that the impact limiters have a leak, a humidity test will be performed to verify that there is no free water in the impact limiters.

A.8.2.3.3 Valves, Rupture Discs, and Gaskets on Containment Vessel

If the ram access cover plate or the lid is removed, the seals are replaced prior to transport of a loaded DSC or *RWC*. The seals will be leak tested after retorquing the bolts in accordance with Chapter A.7, Section A.7.4.

O-ring seals may be reused for transport of an empty NUHOMS®-MP197HB packaging.

There are no valves, rupture discs, *or couplings* on the *containment of the* NUHOMS®-MP197HB packaging.

A.8.2.3.4 Shielding

There are no periodic tests or inspections required for the NUHOMS®-MP197HB shielding. As described in Chapter A.7, radiation surveys will be performed on the package exterior to ensure that the limits specified in 10 CFR 71.47 are met prior to each shipment.

The material composition of the VYAL-B neutron shielding resin employed in the shielding calculations are based on minimum guaranteed values that are determined as a result of extensive tests under various (including extreme) environmental conditions. These tests indicate that the neutron shielding resin does not degrade under normal conditions and is durable over extended periods of time. The shielding calculations employed are based on conservative models and design basis source terms and demonstrate that the dose rate criteria are satisfied with sufficient margin. The comparisons of calculated and measured dose rate have indicated that the calculated dose rates are highly conservative. The 10CFR 71 dose rate compliance measurements serve to indicate the shielding effectiveness of the package. Therefore, periodic tests for the neutron shielding resin are not necessary.

A.8.2.4 *Periodic* Thermal Tests

There are no periodic tests or inspections required for the NUHOMS®-MP197HB package heat transfer components for the reasons explained in Section A.8.1.8.

A.8.2.5 Miscellaneous Tests

There are no additional maintenance tests required for the MP197HB package.

A.8.3 References

1. ASME Boiler and Pressure Vessel Code, Section III, 2004 Edition including 2006 addenda. (For the MP197HB; various editions apply to specific DSCs. See Chapter A.2 for specific applications).
2. SNT-TC-1A, "American Society for Nondestructive Testing, Personnel Qualification and Certification in Nondestructive Testing."
3. ANSI N14.6-1993, "American National Standard for Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds or More for Nuclear Materials," New York.
4. ANSI N14.5-1997, "American National Standard for Leakage Tests on Packages for Shipment of Radioactive Materials."
5. Not Used.
6. *Not Used.*
7. *Not Used.*
8. *Not Used.*
9. *Not Used.*
10. *Not Used.*
11. ISO-12807, "Safe transport of radioactive material - Leakage testing on packages," First Edition, 1996.
12. *"Aluminum Standards and Data, 2003," The Aluminum Association.*
13. *Natrella, "Experimental Statistics," Dover, 2005.*