Enclosure 3 to E-50936

Replacement Pages and Drawings
for the Standardized NUHOMS® System UFSAR, Revision 17
(Public Version)

NUH-003
Revision *17*
NUH003.0103

UPDATED FINAL SAFETY ANALYSIS REPORT FOR THE STANDARDIZED NUHOMS® HORIZONTAL MODULAR STORAGE SYSTEM FOR IRRADIATED NUCLEAR FUEL

By

TN Americas LLC[1]

Columbia, MD

March 2018

[1] TN Americas LLC, formerly AREVA TN, Transnuclear, Inc. (herein referred to as AREVA TN, Transnuclear, Inc., Transnuclear, or TN)

REVISION LOG
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B.4-1	6	October 2001
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C.1-1	6	October 2001
C.2-1	6	October 2001
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DWG (sh. 3 of 3) NUH-03-1020-SAR	5	Not shown
DWG (sh. 1 of 1) NUH-03-1021-SAR	6	1/8/14
DWG (sh. 1 of 2) NUH-03-1022-SAR	5	1/8/14
DWG (sh. 2 of 2) NUH-03-1022-SAR	5	Not shown
DWG (sh. 1 of 3) NUH-03-1023-SAR	8	1/8/14
DWG (sh. 2 of 3) NUH-03-1023-SAR	8	Not shown
DWG (sh. 3 of 3) NUH-03-1023-SAR	8	Not shown
E.1-3	11	February 2010
DWG (sh. 1 of 1) NUH-03-1029-SAR	6	1/8/14
DWG (sh. 1 of 2) NUH-03-1030-SAR	5	1/8/14
DWG (sh. 2 of 2) NUH-03-1030-SAR	5	Not shown
DWG (sh. 1 of 3) NUH-03-1031-SAR	8	1/8/14
DWG (sh. 2 of 3) NUH-03-1031-SAR	8	Not shown
DWG (sh. 3 of 3) NUH-03-1031-SAR	8	Not shown
DWG (sh. 1 of 3) NUH-03-1032-SAR	7	1/8/14
DWG (sh. 2 of 3) NUH-03-1032-SAR	7	Not shown
DWG (sh. 3 of 3) NUH-03-1032-SAR	7	Not shown
E.1-4	11	February 2010
DWG (sh. 1 of 3) NUH-03-1050-SAR	3	Not shown
DWG (sh. 2 of 3) NUH-03-1050-SAR	3	Not shown
DWG (sh. 3 of 3) NUH-03-1050-SAR	3	Not shown
DWG (sh. 1 of 2) NUH-03-1051-SAR	4	1/8/14
DWG (sh. 2 of 2) NUH-03-1051-SAR	4	Not shown
DWG (sh. 1 of 2) NUH-03-1052-SAR	4	1/8/14
DWG (sh. 2 of 2) NUH-03-1052-SAR	4	Not shown
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DWG (sh. 3 of 3) NUH-03-1053-SAR	5	Not shown
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DWG (sh. 1 of 3) NUH-03-6008-SAR	11	8/26/16
DWG (sh. 2 of 3) NUH-03-6008-SAR	11	Not shown
DWG (sh. 3 of 3) NUH-03-6008-SAR	11	Not shown
DWG (sh. 1 of 2) NUH-03-6009-SAR	9	1/8/14
DWG (sh. 2 of 2) NUH-03-6009-SAR	9	Not shown
DWG (sh. 1 of 2) NUH-03-6010-SAR	5	1/8/14
DWG (sh. 2 of 2) NUH-03-6010-SAR	5	Not shown
DWG (sh. 1 of 3) NUH-03-6014-SAR	9	1/8/14
DWG (sh. 2 of 3) NUH-03-6014-SAR	9	Not shown
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DWG (sh. 1 of 2) NUH-03-6015-SAR	9	7/17/17
DWG (sh. 2 of 2) NUH-03-6015-SAR	9	Not shown
DWG (sh. 1 of 2) NUH-03-6016-SAR	10	1/28/10
DWG (sh. 2 of 2) NUH-03-6016-SAR	10	Not shown
DWG (sh. 1 of 5) NUH-03-6017-01-SAR	7	Not shown
DWG (sh. 2 of 5) NUH-03-6017-01-SAR	7	Not shown
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DWG (sh. 1 of 5) NUH-03-8001-SAR	9	1/8/14
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DWG (sh. 3 of 5) NUH-03-8001-SAR	9	Not shown
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DWG (sh. 5 of 5) NUH-03-8001-SAR	9	Not shown
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H.2	*17*	*March 2018*
H.2a	*17*	*March 2018*
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J.2-1	6	October 2001
J.3-1	6	October 2001
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J.5-6	12	February 2012
J.5-7	6	October 2001
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J.10-1	6	October 2001
J.11-1	13	January 2014
J.12-1	6	October 2001
J.13-1	6	October 2001
J.14-1	6	October 2001
"Appendix K"	14	September 2014
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iv	16	July 2017
v	16	July 2017
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vii	16	July 2017
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DWG (sh. 2 of 2) NUH-61B-1061-SAR	5	Not shown
DWG (sh. 1 of 2) NUH-61B-1062-SAR	6	1/8/14
DWG (sh. 2 of 2) NUH-61B-1062-SAR	6	Not shown
DWG (sh. 1 of 1) NUH-61B-1063-SAR	4	1/8/14
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DWG (sh. 2 of 2) NUH-61B-1064-SAR	7	Not shown
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DWG (sh. 3 of 3) NUH-61B-1066-SAR	7	Not shown
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K.2-3	14	September 2014
K.2-4	14	September 2014
K.2-4a	14	September 2014
K.2-5	8	June 2004
K.2-6	8	June 2004
K.2-7	*17*	*March 2018*
K.2-7a	*17*	*March 2018*
K.2-8	13	January 2014
K.2-9	13	January 2014
K.2-10	*17*	*March 2018*
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K.3.1-3	8	June 2004

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K.9-9 (associated with UFSAR Rev. 11)	11	February 2010
K.9-10 (associated with UFSAR Rev. 11)	11	February 2010
K.9-11 (associated with UFSAR Rev. 11)	11	February 2010
K.9.12 (associated with UFSAR Rev. 11)	11	February 2010
K.9.13 (associated with UFSAR Rev. 11)	11	February 2010
K.9.14 (associated with UFSAR Rev. 11)	11	February 2010
K.9.15 (associated with UFSAR Rev. 11)	11	February 2010
K.9-1 (associated with UFSAR Rev. 12)	8	June 2004
K.9-2 (associated with UFSAR Rev. 12)	11	February 2010
K.9-3 (associated with UFSAR Rev. 12)	11	February 2010
K.9-4 (associated with UFSAR Rev. 12)	11	February 2010
K.9-5 (associated with UFSAR Rev. 12)	11	February 2010
K.9-6 (associated with UFSAR Rev. 12)	11	February 2010
K.9-7 (associated with UFSAR Rev. 12)	11	February 2010
K.9-8 (associated with UFSAR Rev. 12)	11	February 2010
K.9-9 (associated with UFSAR Rev. 12)	11	February 2010
K.9-10 (associated with UFSAR Rev. 12)	11	February 2010
K.9-11 (associated with UFSAR Rev. 12)	11	February 2010
K.9.12 (associated with UFSAR Rev. 12)	11	February 2010
K.9.13 (associated with UFSAR Rev. 12)	11	February 2010
K.9.14 (associated with UFSAR Rev. 12)	11	February 2010
K.9.15 (associated with UFSAR Rev. 12)	12	February 2012
K.9-1 (associated with UFSAR Rev. 13)	13	January 2014
K.9-2 (associated with UFSAR Rev. 13)	13	January 2014
K.9-3 (associated with UFSAR Rev. 13)	13	January 2014
K.9-4 (associated with UFSAR Rev. 13)	13	January 2014
K.9-5 (associated with UFSAR Rev. 13)	13	January 2014
K.9-6 (associated with UFSAR Rev. 13)	13	January 2014
K.9-7 (associated with UFSAR Rev. 13)	13	January 2014
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K.9-13 (associated with UFSAR Rev. 13)	13	January 2014
K.9-14 (associated with UFSAR Rev. 13)	13	January 2014
K.9-15 (associated with UFSAR Rev. 13)	13	January 2014
K.9-1 (associated with UFSAR Rev. 14)	13	January 2014
K.9-2 (associated with UFSAR Rev. 14)	13	January 2014
K.9-3 (associated with UFSAR Rev. 14)	14	September 2014
K.9-4 (associated with UFSAR Rev. 14)	14	September 2014
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K.9-5a (associated with UFSAR Rev. 14)	14	September 2014
K.9-6 (associated with UFSAR Rev. 14)	14	September 2014
K.9-7 (associated with UFSAR Rev. 14)	14	September 2014
K.9-8 (associated with UFSAR Rev. 14)	14	September 2014
K.9-9 (associated with UFSAR Rev. 14)	14	September 2014
K.9-10 (associated with UFSAR Rev. 14)	14	September 2014
K.9-11 (associated with UFSAR Rev. 14)	11	February 2010
K.9-12 (associated with UFSAR Rev. 14)	13	January 2014
K.9-13 (associated with UFSAR Rev. 14)	13	January 2014
K.9-14 (associated with UFSAR Rev. 14)	13	January 2014
K.9-15 (associated with UFSAR Rev. 14)	13	January 2014
K.9-1 (associated with UFSAR Rev. 15)	13	January 2014
K.9-2 (associated with UFSAR Rev. 15)	15	August 2016
K.9-3 (associated with UFSAR Rev. 15)	14	September 2014
K.9-4 (associated with UFSAR Rev. 15)	14	September 2014
K.9-5 (associated with UFSAR Rev. 15)	14	September 2014
K.9-5a (associated with UFSAR Rev. 15)	14	September 2014
K.9-6 (associated with UFSAR Rev. 15)	14	September 2014
K.9-7 (associated with UFSAR Rev. 15)	14	September 2014
K.9-8 (associated with UFSAR Rev. 15)	14	September 2014
K.9-9 (associated with UFSAR Rev. 15)	14	September 2014

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K.9-13 (associated with UFSAR Rev. 15)	13	January 2014
K.9-14 (associated with UFSAR Rev. 15)	13	January 2014
K.9-15 (associated with UFSAR Rev. 15)	13	January 2014
K.9-1 (associated with UFSAR Rev. 16)	13	January 2014
K.9-2 (associated with UFSAR Rev. 16)	15	August 2016
K.9-3 (associated with UFSAR Rev. 16)	14	September 2014
K.9-4 (associated with UFSAR Rev. 16)	14	September 2014
K.9-5 (associated with UFSAR Rev. 16)	16	July 2017
K.9-5a (associated with UFSAR Rev. 16)	16	July 2017
K.9-6 (associated with UFSAR Rev. 16)	14	September 2014
K.9-7 (associated with UFSAR Rev. 16)	16	July 2017
K.9-7a (associated with UFSAR Rev. 16)	16	July 2017
K.9-7b (associated with UFSAR Rev. 16)	16	July 2017
K.9-8 (associated with UFSAR Rev. 16)	14	September 2014
K.9-9 (associated with UFSAR Rev. 16)	16	July 2017
K.9-10 (associated with UFSAR Rev. 16)	14	September 2014
K.9-11 (associated with UFSAR Rev. 16)	11	February 2010
K.9-12 (associated with UFSAR Rev. 16)	13	January 2014
K.9-13 (associated with UFSAR Rev. 16)	13	January 2014
K.9-14 (associated with UFSAR Rev. 16)	13	January 2014
K.9-15 (associated with UFSAR Rev. 16)	13	January 2014
K.9-1 (associated with UFSAR Rev. 17)	*13*	*January 2014*
K.9-2 (associated with UFSAR Rev. 17)	*15*	*August 2016*
K.9-3 (associated with UFSAR Rev. 17)	*14*	*September 2014*
K.9-4 (associated with UFSAR Rev. 17)	*14*	*September 2014*
K.9-5 (associated with UFSAR Rev. 17)	*16*	*July 2017*
K.9-5a (associated with UFSAR Rev. 17)	*16*	*July 2017*
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K.9-10 (associated with UFSAR Rev. 17)	*14*	*September 2014*
K.9-11 (associated with UFSAR Rev. 17)	*11*	*February 2010*
K.9-12 (associated with UFSAR Rev. 17)	*13*	*January 2014*
K.9-13 (associated with UFSAR Rev. 17)	*13*	*January 2014*
K.9-14 (associated with UFSAR Rev. 17)	*13*	*January 2014*
K.9-15 (associated with UFSAR Rev. 17)	*13*	*January 2014*
K.10-1	8	June 2004
K.10-2	8	June 2004
K.10-3	8	June 2004
K.10-4	12	February 2012
K.10-5	8	June 2004
K.10-6	10	February 2008
K.10-7	8	June 2004
K.10.8	8	June 2004
K.10-9	12	February 2012
K.10.10	8	June 2004
K.10.11	8	June 2004
K.10.12	8	June 2004
K.10.13	8	June 2004
K.10.14	8	June 2004
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K.11.16	8	June 2004
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K.13-1	8	June 2004
K.14-1	8	June 2004
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L.1-3	6	October 2001
L.1-4	13	January 2014
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L.1-6	7	November 2003
L.1-7	13	January 2014
L.1-8	7	November 2003
DWG (sh. 1 of 4) NUH-03-1070-SAR	2	01/28/10
DWG (sh. 2 of 4) NUH-03-1070-SAR	2	Not shown
DWG (sh. 3 of 4) NUH-03-1070-SAR	2	Not shown
DWG (sh. 4 of 4) NUH-03-1070-SAR	2	Not shown
DWG (sh. 1 of 4) NUH-03-1071-SAR	1	Not shown
DWG (sh. 2 of 4) NUH-03-1071-SAR	1	Not shown
DWG (sh. 3 of 4) NUH-03-1071-SAR	1	Not shown
DWG (sh. 4 of 4) NUH-03-1071-SAR	1	Not shown
L.1-9	6	October 2001
L.1-10	6	October 2001
L.1-11	6	October 2001
L.2-1	6	October 2001
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L.2-3	13	January 2014
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L.2-5	13	January 2014
L.2-6	13	January 2014
L.2-7	6	October 2001
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L.3-4	9	January 2006
L.3-5	9	January 2006
L.3-6	6	October 2001
L.3-7	6	October 2001
L.3-8	6	October 2001
L.3-9	6	October 2001
L.3-10	6	October 2001
L.3-11	6	October 2001
L.3-12	6	October 2001
L.3-13	13	January 2014
L.3-14	6	October 2001
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L.3-16	6	October 2001
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L.3-23	6	October 2001
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L.3-27	6	October 2001
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L.3-35	6	October 2001
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L.4-9	6	October 2001
L.4-10	6	October 2001
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L.4-20	13	January 2014
L.4-21	6	October 2001
L.4-22	13	January 2014
L.4-23	13	January 2014
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L.4-34	6	October 2001
L.4-35	6	October 2001
L.4-36	13	January 2014
L.4-37	13	January 2014
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L.6-7	6	October 2001
L.6-8	6	October 2001
L.6-9	6	October 2001
L.6-10	6	October 2001
L.6-11	6	October 2001
L.6-12	6	October 2001
L.6-13	6	October 2001
L.6-14	7	November 2003
L.6-15	6	October 2001
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viii	*17*	*March 2018*
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xi	*17*	*March 2018*
xii	*17*	*March 2018*
xiii	*17*	*March 2018*
xiv	*17*	*March 2018*
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DWG (sh. 1 of 3) NUH-32PT-1001-SAR	8	8/26/16
DWG (sh. 2 of 3) NUH-32PT-1001-SAR	8	Not shown
DWG (sh. 3 of 3) NUH-32PT-1001-SAR	8	Not shown
DWG (sh. 1 of 2) NUH-32PT-1002-SAR	5	6/4/14
DWG (sh. 2 of 2) NUH-32PT-1002-SAR	5	Not shown
DWG (sh. 1 of 4) NUH-32PT-1003-SAR	7	8/25/14
DWG (sh. 2 of 4) NUH-32PT-1003-SAR	7	Not shown
DWG (sh. 3 of 4) NUH-32PT-1003-SAR	7	Not shown
DWG (sh. 4 of 4) NUH-32PT-1003-SAR	7	Not shown
DWG (sh. 1 of 4) NUH-32PT-1004-SAR	6	8/25/14
DWG (sh. 2 of 4) NUH-32PT-1004-SAR	6	Not shown
DWG (sh. 3 of 4) NUH-32PT-1004-SAR	6	Not shown
DWG (sh. 4 of 4) NUH-32PT-1004-SAR	6	Not shown
DWG (sh. 1 of 1) NUH-32PT-1006-SAR	3	1/30/06
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M.1-10	9	January 2006
M.1-11	9	January 2006
M.1-12	9	January 2006
M.2-1	14	September 2014
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M.2-3	14	September 2014
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M.2-6	9	January 2006
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M.2-9	13	January 2014
M.2-10	13	January 2014
M.2-11	11	February 2010
M.2-12	14	September 2014
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M.2-29	9	January 2006
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M.2-34	15	August 2016
M.2-35	14	September 2014
M.2-36	14	September 2014
M.2-37	14	September 2014
M.2-38	9	January 2006
M.2-39	9	January 2006
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M.3.6-1a	14	September 2014
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M.3.7-19	8	June 2004
M.3.7-20	8	June 2004
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M.9-2 (associated with UFSAR Rev. 17)	*15*	*August 2016*
M.9-3 (associated with UFSAR Rev. 17	*14*	*September 2014*
M.9-4 (associated with UFSAR Rev. 17)	*14*	*September 2014*
M.9-5 (associated with UFSAR Rev. 17)	*16*	*July 2017*
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M.9-5b (associated with UFSAR Rev. 17)	*16*	*July 2017*

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M.9-11 (associated with UFSAR Rev. 17)	*17*	*March 2018*
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M.9-14 (associated with UFSAR Rev. 17)	*13*	*January 2014*
M.10-1	8	June 2004
M.10-2	8	June 2004
M.10-3	8	June 2004
M.10-4	8	June 2004
M.10-5	8	June 2004
M.10-6	8	June 2004
M.10-7	8	June 2004
M.10-8	13	January 2014
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M.10-10	8	June 2004
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M.11-12	14	September 2014
M.11-13	8	June 2004
M.11-14	8	June 2004
M.11-15	8	June 2004
M.12-1	14	September 2014
M.13-1	8	June 2004
M.14-1	8	June 2004
i	15	August 2016
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vi	15	August 2016
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viii	15	August 2016
ix	15	August 2016

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N.1-4	14	September 2014
N.1-5	8	June 2004
N.1-6	13	January 2014
N.1-7	15	August 2016
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DWG (sh. 3 of 6) NUH-HBU-1000-SAR	3	Not shown
DWG (sh. 4 of 6) NUH-HBU-1000-SAR	3	Not shown
DWG (sh. 5 of 6) NUH-HBU-1000-SAR	3	Not shown
DWG (sh. 6 of 6) NUH-HBU-1000-SAR	3	Not shown
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DWG (sh. 4 of 6) NUH-HBU-1200-SAR	0	Not shown
DWG (sh. 5 of 6) NUH-HBU-1200-SAR	0	Not shown
DWG (sh. 6 of 6) NUH-HBU-1200-SAR	0	Not shown
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N.2-13a	14	September 2014
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N.2-15	9	January 2006
N.2-16	9	January 2006
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N.3-3	8	June 2004
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N.4-14	8	June 2004
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N.5-14	12	February 2012
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N.5-16	12	February 2012
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N.6-28	9	January 2006
N.6-29	9	January 2006
N.6-30	9	January 2006
N.6-31	9	January 2006
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N.8-8	13	January 2014
N.8-9	8	June 2004
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N.8-11	13	January 2014
N.8-12	13	January 2014
N.8-13	13	January 2014

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N.8-17	8	June 2004
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P.1-8	14	September 2014
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P.1-11	14	September 2014
DWG (sh. 1 of 4) NUH24PTH-1001-SAR	6	8/26/16
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DWG (sh. 3 of 4) NUH24PTH-1001-SAR	6	Not shown
DWG (sh. 4 of 4) NUH24PTH-1001-SAR	6	Not shown
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DWG (sh. 2 of 3) NUH24PTH-1002-SAR	2	1/30/06
DWG (sh. 3 of 3) NUH24PTH-1002-SAR	2	1/30/06
DWG (sh. 1 of 7) NUH24PTH-1003-SAR	6	8/26/16
DWG (sh. 2 of 7) NUH24PTH-1003-SAR	6	Not shown
DWG (sh. 3 of 7) NUH24PTH-1003-SAR	6	Not shown
DWG (sh. 4 of 7) NUH24PTH-1003-SAR	6	Not shown
DWG (sh. 5 of 7) NUH24PTH-1003-SAR	6	Not shown
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DWG (sh. 5 of 11) NUH-03-7001-SAR	7	Not shown
DWG (sh. 6 of 11) NUH-03-7001-SAR	7	Not shown
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DWG (sh. 4 of 8) NUH24PTH-72-1009	0	Not shown
DWG (sh. 5 of 8) NUH24PTH-72-1009	0	Not shown
DWG (sh. 6 of 8) NUH24PTH-72-1009	0	Not shown
DWG (sh. 7 of 8) NUH24PTH-72-1009	0	Not shown
DWG (sh. 8 of 8) NUH24PTH-72-1009	0	Not shown
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P.2-28	16	July 2017
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P.9.9 (associated with UFSAR Rev. 11)	11	February 2010
P.9.10 (associated with UFSAR Rev. 11)	11	February 2010
P.9.11 (associated with UFSAR Rev. 11)	11	February 2010
P.9.12 (associated with UFSAR Rev. 11)	11	February 2010
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P.9.9 (associated with UFSAR Rev. 12)	11	February 2010
P.9.10 (associated with UFSAR Rev. 12)	11	February 2010
P.9.11 (associated with UFSAR Rev. 12)	11	February 2010
P.9.12 (associated with UFSAR Rev. 12)	11	February 2010
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DWG (sh. 4 of 6) NUH-61BTH-2002-SAR	3	Not shown
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T.5-151	11	February 2010
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T.9-9 (associated with UFSAR Rev. 11)	11	February 2010
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T.9-13 (associated with UFSAR Rev. 11)	11	February 2010
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T.9-7 (associated with UFSAR Rev. 13)	13	January 2014
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T.9-9 (associated with UFSAR Rev. 13)	13	January 2014
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T.9.14 (associated with UFSAR Rev. 13)	13	January 2014
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T.9-9 (associated with UFSAR Rev. 14)	14	September 2014
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T.9-11 (associated with UFSAR Rev. 14)	14	September 2014
T.9-12 (associated with UFSAR Rev. 14)	11	February 2010
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T.9-12 (associated with UFSAR Rev. 16)	11	February 2010
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U.12-1	11	February 2010
U.13-1	11	February 2010
U.14-1	11	February 2010
i of iv	10	February 2008
ii of iv	10	February 2008
iii of iv	10	February 2008
iv of iv	10	February 2008
V.1-1	*17*	*March 2018*
V.1-1a	*17*	*March 2018*
V.1-2	10	February 2008
V.1-3	13	January 2014
V.1-4	13	January 2014
DWG (sh. 1 of 1) NUH-03-7002-SAR	2	1/8/14
V.1-5	13	January 2014
V.1-6	10	February 2008
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V.2-3	13	January 2014
V.3-1	13	January 2014
V.3-2	13	January 2014
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V.3-4	10	February 2008
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V.3-6	10	February 2008
V.3-7	10	February 2008
V.3-8	10	February 2008
V.3-9	10	February 2008
V.3-10	11	February 2010
V.3-10A	13	January 2014
V.3-11	10	February 2008
V.3-12	13	January 2014
V.3-13	10	February 2008
V.3-14	10	February 2008
V.3-15	10	February 2008

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V.4-5	10	February 2008
V.4-6	10	February 2008
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V.6-1	10	February 2008
V.7-1	10	February 2008
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V.8-3	10	February 2008
V.9-1	13	January 2014
V.9-2	13	January 2014
V.10-1	10	February 2008
V.11-1	10	February 2008
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V.14-1	10	February 2008
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iii	13	January 2014
iv	13	January 2014
v	13	January 2014
vi	13	January 2014
vii	13	January 2014
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W.1-1a	*17*	*March 2018*
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W.1-3	13	January 2014
W.1-4	13	January 2014
W.1-5	13	January 2014
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DWG (sh. 4 of 8) NUH-03-8008-SAR	1	Not shown
DWG (sh. 5 of 8) NUH-03-8008-SAR	1	Not shown
DWG (sh. 6 of 8) NUH-03-8008-SAR	1	Not shown
DWG (sh. 7 of 8) NUH-03-8008-SAR	1	Not shown
DWG (sh. 8 of 8) NUH-03-8008-SAR	1	Not shown
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DWG (sh. 2 of 6) NUH-03-8009-SAR	1	Not shown
DWG (sh. 3 of 6) NUH-03-8009-SAR	1	Not shown
DWG (sh. 4 of 6) NUH-03-8009-SAR	1	Not shown
DWG (sh. 5 of 6) NUH-03-8009-SAR	1	Not shown

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W.1-13	13	January 2014
W.2-1	13	January 2014
W.2-2	14	September 2014
W.2-3	13	January 2014
W.2-4	13	January 2014
W.2-5	13	January 2014
W.2-6	13	January 2014
W.2-7	13	January 2014
W.2-8	14	September 2014
W.2-9	13	January 2014
W.2-10	14	September 2014
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W.4-7	13	January 2014
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W.5-94	13	January 2014
W.5-95	13	January 2014
W.5-96	13	January 2014
W.5-97	13	January 2014
W.6-1	10	February 2008
W.7-1	10	February 2008
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W.8-2	13	January 2014
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W.8-12	13	January 2014
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W.11-1	13	January 2014
W.11-2	13	January 2014
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W.12-1	13	January 2014
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W.14-1	10	February 2008
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xii	14	September 2014
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xv	14	September 2014
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Y.1-6	14	September 2014
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Y.1-9	14	September 2014
Y.1-10	14	September 2014
Y.1-11	14	September 2014

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DWG (sh. 3 of 4) NUH69BTH-72-1001	0	Not shown
DWG (sh. 4 of 4) NUH69BTH-72-1001	0	Not shown
DWG (sh. 1 of 4) NUH69BTH-72-1002	0	8/25/14
DWG (sh. 2 of 4) NUH69BTH-72-1002	0	Not shown
DWG (sh. 3 of 4) NUH69BTH-72-1002	0	Not shown
DWG (sh. 4 of 4) NUH69BTH-72-1002	0	Not shown
DWG (sh. 1 of 4) NUH69BTH-72-1003	0	8/25/14
DWG (sh. 2 of 4) NUH69BTH-72-1003	0	Not shown
DWG (sh. 3 of 4) NUH69BTH-72-1003	0	Not shown
DWG (sh. 4 of 4) NUH69BTH-72-1003	0	Not shown
DWG (sh. 1 of 6) NUH69BTH-72-1004	0	8/25/14
DWG (sh. 2 of 6) NUH69BTH-72-1004	0	Not shown
DWG (sh. 3 of 6) NUH69BTH-72-1004	0	Not shown
DWG (sh. 4 of 6) NUH69BTH-72-1004	0	Not shown
DWG (sh. 5 of 6) NUH69BTH-72-1004	0	Not shown
DWG (sh. 6 of 6) NUH69BTH-72-1004	0	Not shown
DWG (sh. 1 of 5) NUH69BTH-72-1011	0	8/25/14
DWG (sh. 2 of 5) NUH69BTH-72-1011	0	Not shown
DWG (sh. 3 of 5) NUH69BTH-72-1011	0	Not shown
DWG (sh. 4 of 5) NUH69BTH-72-1011	0	Not shown
DWG (sh. 5 of 5) NUH69BTH-72-1011	0	Not shown
DWG (sh. 1 of 6) NUH69BTH-72-1012	0	8/25/14
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DWG (sh. 3 of 6) NUH69BTH-72-1012	0	Not shown
DWG (sh. 4 of 6) NUH69BTH-72-1012	0	Not shown
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Y.2-3	16	July 2017
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Y.2-6	14	September 2014
Y.2-7	14	September 2014
Y.2-8	14	September 2014
Y.2-9	*17*	*March 2018*
Y.2-9a	*17*	*March 2018*
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Y.2-11	14	September 2014
Y.2-12	16	July 2017
Y.2-13	16	July 2017
Y.2-14	16	July 2017
Y.2-15	16	July 2017
Y.2-16	14	September 2014
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Y.9-4 (associated with UFSAR Rev. 14)	14	September 2014
Y.9-5 (associated with UFSAR Rev. 14)	14	September 2014
Y.9-6 (associated with UFSAR Rev. 14)	14	September 2014
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Y.9-8 (associated with UFSAR Rev. 14)	14	September 2014
Y.9-9 (associated with UFSAR Rev. 14)	14	September 2014
Y.9-10 (associated with UFSAR Rev. 14)	14	September 2014
Y.9-11 (associated with UFSAR Rev. 14)	14	September 2014
Y.9-12 (associated with UFSAR Rev. 14)	14	September 2014
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Y.9-6 (associated with UFSAR Rev. 15)	14	September 2014
Y.9-7 (associated with UFSAR Rev. 15)	14	September 2014
Y.9-8 (associated with UFSAR Rev. 15)	14	September 2014
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Y.9-13 (associated with UFSAR Rev. 15)	14	September 2014
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Y.9-5 (associated with UFSAR Rev. 16)	14	September 2014
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Y.9-7 (associated with UFSAR Rev. 16)	14	September 2014
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Y.9-8a (associated with UFSAR Rev. 16)	16	July 2017
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Y.9-12 (associated with UFSAR Rev. 16)	14	September 2014
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Y.9-14 (associated with UFSAR Rev. 16)	14	September 2014
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Y.9-5 (associated with UFSAR Rev. 17)	*14*	*September 2014*
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Y.9-8a (associated with UFSAR Rev. 17)	*16*	*July 2017*
Y.9-9 (associated with UFSAR Rev. 17)	*14*	*September 2014*
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Y.9-11 (associated with UFSAR Rev. 17)	*14*	*September 2014*
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xviii	16	July 2017
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Z.1-12	14	September 2014
Z.1-13	16	July 2017
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EXECUTIVE SUMMARY

This Updated Final Safety Analysis Report (No. NUH-003, Revision *17*, NRC Docket No. 72-1004) provides the generic safety analysis for the standardized NUHOMS®[1] system for storage of light water reactor spent nuclear fuel assemblies. This system provides for the safe dry storage of spent fuel in a passive Independent Spent Fuel Storage Installation (ISFSI) which fully complies with the requirements of 10 CFR 72 and ANSI 57.9. The related NUHOMS®-24P Topical Report (No. NUH-002, Revision 1A, NRC Project No. M-49) was approved by the U.S. Nuclear Regulatory Commission on April 21, 1989. The original NUHOMS®-07P Topical Report (No. NUH-001, Revision 1A, NRC Project No. M-39) was approved by the U.S. Nuclear Regulatory Commission on March 28, 1986.

This Updated Final Safety Analysis Report (UFSAR) formed the basis for generic NRC certification of the standardized NUHOMS® system and will be used by 10 CFR 50/10 CFR 72 general license holders in accordance with 10CFR72 Subparts K and L. It is also suitable for reference in 10 CFR 72 site specific license applications. In January 1995, the US NRC issued a generic Certificate of Compliance to VECTRA for the standardized NUHOMS® canister/module horizontal cask storage system. The Nuclear Regulatory Commission staff does not intend to repeat the review in order to authorize the use of a standardized NUHOMS® ISFSI by a general license holder. *The US NRC approved the renewal of the generic Certificate of Compliance for an additional 40 years, effective December 11, 2017.*

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

1. A free-standing prefabricated horizontal storage module founded on an ISFSI basemat which is not important to safety.
2. A standardized dry shielded canister for on-site dry storage and eventual off-site shipment of spent PWR or BWR fuel assemblies.
3. Removal of site specific dependencies to allow direct implementation by 10CFR72 general license holders.
4. Design qualification for five-year cooled PWR and BWR spent fuel.

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

Revision 12 of this UFSAR incorporates design modifications implemented per 10 CFR 72.48 since the issuance of UFSAR Revision 11.

Revision 13 of this UFSAR incorporates design modifications implemented per 72.48 since the issuance of UFSAR Revision 12, including FCN 721004-951 that was approved prior to the issuance of Revision 12. It also incorporates changes implemented due to approval of Amendment 11 to CoC 1004.

Revision 14 of this UFSAR incorporates design modifications implemented per 72.48 since the issuance of UFSAR Revision 13. It also incorporates changes implemented due to approval of Amendment 13 to CoC 1004.

Revision 15 of this UFSAR incorporates design modifications implemented per 10 CFR 72.48 since the issuance of UFSAR Revision 14.

Revision 16 of this UFSAR incorporates design modifications implemented per 72.48 since the issuance of UFSAR Revision 15. It also incorporates changes implemented due to approval of Amendment 14 to CoC 1004.

Revision 17 of this UFSAR incorporates design modifications implemented per 10 CFR 72.48 since the issuance of UFSAR Revision 16. It also incorporates changes and CoC holder commitments resulting from the review and approval of the renewal of CoC 1004 (i.e., incorporation of aging management-related items).

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LIST OF ABBREVIATIONS

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

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

1. INTRODUCTION AND GENERAL DESCRIPTION OF INSTALLATION

This Updated Final Safety Analysis Report (the terms, UFSAR, FSAR or SAR, are used interchangeably in this document) describes the design and forms the generic licensing basis for 10CFR72 Subpart L (1.1) certification of the standardized NUHOMS® horizontal cask system for dry storage of PWR or BWR spent nuclear fuel assemblies. The NUHOMS® system provides for the horizontal storage of spent fuel in a dry shielded canister (DSC) which is placed in a concrete horizontal storage module (HSM). The NUHOMS® system is designed to be installed at any reactor site or any new site where an independent spent fuel storage installation (ISFSI) is required.

The original NUHOMS® Topical Report (NUH-001, Revision 1A, NRC Project No. M-39) was approved by the United States Nuclear Regulatory Commission (NRC) on March 28, 1986 for storage of seven spent PWR fuel assemblies per DSC and HSM (NUHOMS®-07P) (1.12, 1.13). The NUHOMS®-07P system is designed to be compatible with the IF-300 shipping cask. The DSC internal basket incorporates borated guide sleeves to ensure criticality safety during wet loading operations without credit for burnup or soluble boron.

The NUHOMS® Topical Report was revised (NUH-002, Revision 0, NRC Docket No. M-49) to provide the generic design criteria and safety analysis for the larger 24 spent PWR fuel assembly design (NUHOMS®-24P) and its associated on-site transfer cask. NRC approval of the NUHOMS®-24P Topical Report was granted on April 26 1989 (1.10, 1.11). Unlike the NUHOMS®-07P design, no borated neutron absorbing material is used in the internal basket design of the NUHOMS®-24P DSC for criticality safety. Credit for soluble boron is used as the approval basis. Credit for burnup is also evaluated as an alternative design acceptance basis for the NUHOMS®-24P DSC design pending future generic acceptance by the NRC. The approved NUHOMS®-24P Topical Report forms the principal basis for the standardized NUHOMS® system presented in this FSAR. The NRC has issued Certificate of Compliance (CoC) 1004, dated January 23, 1995, for the standardized NUHOMS® system.

This FSAR also includes the NUHOMS®-52B DSC, which is designed to store 52 BWR fuel assemblies with the fuel assembly flow channels intact. The NUHOMS®-52B utilizes the same HSM as does the standardized NUHOMS®-24P DSC. New criticality, thermal and structural analyses for the 52B basket are included as are the specifications of spent fuel assemblies to be stored. The 52B basket includes fixed neutron absorbing plates for criticality safety, similar to that of the NUHOMS®-07P DSC. Unborated plates may be used pending a burnup credit analysis to be submitted when burnup credit is generically accepted by the NRC.

NOTE: CoC 1004 was originally licensed for 20 years. On December 11, 2017, the NRC approved renewal of CoC 1004 for an additional 40 years. The aging management activities associated with this renewal apply to the previously approved amendments, and future amendments will include an aging management review (AMR) and any resultant, required aging management activities. The current aging management results are detailed in Chapter 12.

Renewal

Renewal
(Grey shading indicates 72.48 change)

These original UFSAR chapters, plus the appendices, which report the analysis of additional DSCs, HSMs, and transfer casks (TCs), indicate design life and service life values of 40 years or 50 years. With NRC approval of the renewal application, the license has been extended to 60 years. Time-limited aging-analyses (TLAAs) associated with original analyses, which involved time limited assumptions defined by the original operating term, are detailed in Chapter 12, Section 12.2. TLAAs identified as #1, #4, and #5 in Section 12.2 performed for the renewal of this design conservatively used a service life of 100 years.

Analysis discussion and details in these original UFSAR chapters and appendices are not revised as a result of renewal, but notes discussing renewal and referencing Chapter 12 are included for clarity throughout this UFSAR.

The NRC approved Amendment No. 1 to CoC 1004 on April 2000. This amendment reflects the transfer of the CoC from VECTRA Technologies, Inc. to Transnuclear West Inc.

Amendment No. 2 to CoC 1004, approved on September 5, 2000, adds fuel qualification tables and updates Fuel Specification 1.2.1 to reflect additional fuel parameters for both the PWR and BWR fuels. The fuel qualification tables provide a simplified approach for users of the

Table 1.2-2
Key Design Parameters[4] for the Standardized NUHOMS®-24P and 52B System
(continued)

Category	Criteria or Parameter	Value
Dry Shielded Canister: (Concluded)	Maximum Design Pressure	Conservatively Based on 100% Release of Fill Gas and 30% Release of Fission Gas from fuel assemblies and BPRAs (if applicable) as follows: • 1% of Rods and BPRAs (normal) • 10% of Rods and BPRAs (off-normal) • 100% of Rods and BPRAs (accident)
	Equivalent Cask Drop Deceleration	75g Vertical (End) and Horizontal (Side), 25g Oblique (Corner)
	Materials of Construction	Carbon and Stainless Steel Basket Components, Carbon Steel or Steel Encased Lead Shield Plugs, and Stainless Steel Shell Assembly
	Service Life	50 years[(1)(2)]
On-Site TC:	Payload Capacity	36,300 kg (80,000 lbs.) (dry) 40,900 kg (90,000 lbs.) (wet)
	Gross Weight	90,700 kg (200,000 lbs.) (handling) 86,200 kg (190,000 lbs.) (transfer)
	Surface Dose Rate	ALARA
	Equivalent Cask Drop Deceleration	75g Vertical (End) and Horizontal (Side) 25g Oblique (Corner)
	Materials of Construction	Carbon Steel, Stainless Steel, Lead, and Neutron Absorbing Material
	Service Life	50 years[(2)]

Renewal

Renewal

(1) Expected life is much longer (hundreds of years); however, for the purpose of this generic FSAR, the service life is taken as 50 years. [(2)]

(2) *With NRC approval of the CoC 1004 renewal application, the license is extended to a total of 60 years. The TLAAs identified as #1, #4, and #5 in Section 12.2 performed for the renewal of this design conservatively used a service life of 100 years.* 72.48

Table 1.2-2
Key Design Parameters for the Standardized NUHOMS® -24P and 52B System
(concluded)

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

Renewal

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

(2) With NRC approval of the CoC 1004 renewal application, the license is extended to a total of 60 years. The TLAAs identified as #1, #4, and #5 in Section 12.2 performed for the renewal of this design conservatively used a service life of 100 years. 72.48

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

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

The design details for the 24PTH, 61BTH and 32PTH1 69BTH and 37PTH baskets are provided in Appendices P, T, U, Y, and Z, respectively.

Aging Management Program Requirements

Aging management program (AMP) requirements for use of the 24P and 52B DSC during the period of extended storage operations are contained in Section 12.3. Applicable TLAAs performed for the initial CoC 1004 renewal application are provided in Section 12.2.

Renewal

1.3.1.2 Horizontal Storage Module Model 80 and Model 102

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

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

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

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

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

The NUHOMS® system HSMs provide an independent, passive system with substantial structural capacity to ensure the safe dry storage of spent fuel assemblies. To this end, the HSMs are designed to ensure that normal transfer operations and postulated accidents or natural phenomena do not impair the DSC or pose a hazard to plant personnel.

The HSMs are constructed on a load bearing foundation which consists of a reinforced concrete basemat on compacted engineered fill. The HSMs are located in a fenced, secured location with

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

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

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

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

Aging Management Program Requirements

AMP requirements for use of the HSM during the period of extended storage operations are contained in Section 12.3. Applicable TLAAs performed for the initial CoC 1004 renewal application are provided in Section 12.2.

Renewal

1.3.2 Transfer Systems Descriptions

1.3.2.1 On-Site TC

The transfer cask used in the NUHOMS® system provides shielding and protection from potential hazards during the DSC closure operations and transfer to the HSM. Five alternate configurations of the transfer cask are available for the licensees' use. The basic configuration, where the cask is provided with a solid neutron shield, is described herein as the "Standardized Cask." An alternate transfer cask configuration, where a liquid neutron shield is provided instead, is described in this SAR as the "OS197, OS197H, OS197L, or OS200 Cask."

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

The third configuration of the transfer cask, designated as OS197FC/OS197H FC, or OS197FC-B/OS197HFC-B is a modified version of OS197/OS197H equipped with a modified lid to allow air circulation through the TC/DSC annulus, and is described in Appendix P and Appendix T. The fourth configuration of the transfer cask, designated as OS197L TC, is a version of the OS197 TC designed for heat loads of 13 kW maximum. It is described in Appendix W.

The fifth configuration is designated as OS200TC/OS200FC. This is a larger diameter transfer cask designed to accommodate the 32PTH1, 69BTH, and 37PTH DSCs. The OS200TC is described in Appendix U. The OS200/OS200FC TC is provided with an aluminum internal sleeve to accommodate onsite transfer of the smaller diameter NUHOMS®-61BT, 32PT, 24PTH and 61BTH DSCs described in UFSAR Appendix K, M, P and T respectively.

The standardized transfer cask for the NUHOMS® system, has a 4.75m (186.75 inches) long inner cavity, a 1.73 m (68 inches) inside diameter and a maximum payload capacity of 44,430 kg (97,950

pounds) wet and 42,321 kg (93,300 pounds) dry. These maximum payload capacities are based on standardized transfer cask weights of 102,050 (without top lid) and 106,700 pounds (with top lid), respectively. A cask collar is used to extend the transfer cask cavity length by .25 m (10 inches) for use with the longer DSCs for BWR fuel. The OS197 and OS197H transfer casks with a longer cavity length of 196.75 inches (no cask collar) may be used for DSCs with BWR fuel and when combined with a cask spacer may also be used to load DSCs with PWR fuel. The transfer cask is designed to meet the requirements of 10CFR72 for on-site transfer of the DSC from the plant's fuel pool to the HSM. As shown in Figure 1.3-6, the transfer cask is constructed from two concentric cylindrical steel shells with a bolted top cover plate and a welded bottom end assembly. The annulus formed by these two shells is filled with cast lead to provide gamma shielding. The transfer cask also includes an outer steel jacket which is filled with a hydrogen rich solid material or water for neutron shielding. The top and bottom end assemblies also incorporate a solid neutron shield material.

The transfer cask is designed to provide sufficient shielding to ensure that dose rates are ALARA. Two lifting trunnions are provided for handling the transfer cask in the plant's fuel/reactor building using a lifting yoke and an overhead crane. Lower support trunnions are provided on the cask for pivoting the transfer cask from/to the vertical and horizontal positions on the support skid/transfer trailer. A cover plate is provided to seal the bottom hydraulic ram access penetration of the cask during fuel loading.

Table 1.3-2 provides a listing of known fabricated NUHOMS® transfer casks that have design compatibility with the TC design basis models indicated on this table.

Aging Management Program Requirements

AMP requirements for use of the Onsite TC during the period of extended storage operations are contained in Section 12.3. Applicable TLAAs performed for the initial CoC 1004 renewal application are provided in Section 12.2.

Renewal

1.3.2.2 Transfer Equipment

Note: For transfer of the OS197L TC listed in Section 1.3.2.1 above, a modified version of the transfer equipment described in the following paragraphs is provided. See Appendix W.1 for a brief description of the details.

Transfer Trailer: The NUHOMS® transfer trailer consists of a heavy industrial trailer with a payload capacity of 113.4 Te (125 tons). The trailer transfers the cask support skid and the loaded transfer cask between the plant's fuel/reactor building and the ISFSI. The trailer is designed to ride as low to the ground as possible to minimize the HSM height and the transfer cask height during transfer operations. Figure 1.3-7 shows the heavy haul industrial trailer used with the standardized NUHOMS® system. The trailer is equipped with four hydraulic leveling jacks to provide vertical travel for alignment of the cask with the HSM. The trailer is towed by a conventional heavy haul truck tractor or other suitable prime mover. The nominal trailer bed height during canister transfer to the HSM is such that the transfer cask is typically not elevated more than 1.68 m (5'-6") above grade as measured from the lowest point on the cask. This is well below the 2.0 m (80 inch) drop height used as the accident drop design basis of the cask and canister.

Cask Support Skid: The NUHOMS® system cask support skid is similar in design and operation to other transfer cask skids used for shipment of fuel. The key differences are:

1. There is no ancillary equipment mounted on the skid, except as described on pages P.1-3 and P.1-4.

2. The skid is mounted on a surface with sliding support bearings and hydraulic positioners to provide alignment of the cask with the HSM. Brackets with locking bolts are provided to prevent movement during trailer towing.

water must be borated to the specified minimum concentration. For BWR fuel, demineralized water may be used. Fill liquid neutron shield *with demineralized water*, if applicable.

10. Using the fuel/reactor building main hook and the cask lifting yoke, position the cask lifting yoke above the DSC top shield plug and attach the four designated cable assemblies between the yoke and the DSC top shield plug. Adjust the turnbuckles on the cable assemblies as necessary to level the shield plug. If not already done, test fit the DSC top shield plug onto the DSC.

11. Place the DSC top shield plug, with the cable assemblies attached and disconnect from the yoke. Position the cask lifting yoke above the transfer cask and engage the cask lifting trunnions.

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

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

14. 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.

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

16. Prior to the cask being lifted into the fuel pool, 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.

5.1.1.2 <u>DSC Fuel Loading</u>

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 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 demineralized water.

3. Place the cask in the location of the fuel pool designated as the cask loading area.

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

16. Move the transfer cask with loaded DSC to the cask decon area.

17. Install TC seismic restraints if required by Technical Specification 4.3.3.7 (required only on plant-specific basis).

18. Verify that the transfer cask dose rates are compliant with limits specified in Technical Specification 5.2.4.e.

5.1.1.3 DSC Drying and Backfilling

1. Check the radiation levels along the perimeter of the cask. The cask exterior surface should be decontaminated as necessary in accordance with the limits specified in Technical Specification 5.2.4.d. Temporary shielding may be installed as necessary to minimize personnel exposure. Fill neutron shield *with demineralized water,* if empty.

2. Place scaffolding 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 move it clear of the cask.

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

4a. In accordance with Technical Specification 5.2.4.a, verify that the neutron shield (NS) is filled before the draining operation in Step 5 is initiated and continually monitored during the first five minutes of the draining evolution to ensure the NS remains filled.

5. Connect the cask drain line to the cask, open the cask cavity 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 surface of the DSC shell and check for smearable contamination in accordance with the Technical Specification 5.2.4.d limits.

6. Install the automated welding machine onto the inner top cover plate and place the inner top cover plate with the automated welding machine onto the DSC. Verify proper fit-up of the inner top cover plate with the DSC shell.

14. Recheck all alignment marks in accordance with the Technical Specification 5.3.3 limits and ready all systems for DSC transfer.

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

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

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

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

19. The trailer may be moved as necessary to install the HSM door. Install the HSM door and secure it in place. Verify that the HSM dose rates are compliant with the limits specified in Technical Specifications 5.4.1 and 5.4.2.

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

21. *If this is the final loading, fully drain the liquid neutron shield.*

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

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

5.1.1.7 Monitoring Operations

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

Note: Perform one of the two alternate surveillance activities listed below.

2a. Perform a daily visual surveillance of the HSM air inlets and outlets (end wall and roof birdscreens) to insure that no debris is obstructing the HSM vents in accordance with Technical Specification 5.2.5.a requirements.

2b. Perform a temperature measurement of the thermal performance, for each HSM, on a daily basis in accordance with Technical Specification 5.2.5.b requirements.

5.1.1.8 DSC Retrieval from the HSM

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

7.2.3 Fuel Qualification Tables *and Equations*

Fuel qualification descriptions for the DSC systems listed below are in the locations identified.

- *DSCs 24P and 52B, Chapter 7, Section 7.2.3.1.*
- *DSC 24PHB, Appendix N, Section N.2.1.*
- *DSC 61BT, Appendix K, Section K.2.1.*
- *DSC 32PT, Chapter 7, Section 7.2.3.2.*
- *DSC 24PTH, Chapter 7, Section 7.2.3.2.*
- *DSC 61BTH, Chapter 7, Section 7.2.3.2.*
- *DSC 32PTH1, Appendix U, Section U.2.1.*
- *DSC 69BTH, Chapter 7, Section 7.2.3.2.*
- *DSC 37PTH, Chapter 7, Section 7.2.3.2.*

7.2.3.1 Fuel Qualifications for the 24P and 52B Systems

The purpose of this section is to document the methodology used to determine the cooling times required for PWR and BWR fuel assemblies, with various burnups and initial enrichments, for storage in the standardized NUHOMS® 24P and 52B systems. An acceptable fuel assembly meets the cladding temperature limits, overall heat generation limit, and design basis HSM and Transfer Cask (TC) surface dose rates presented in the Section 7.3.2. The methodology is based on preserving the following parameters for design basis fuel: the cladding temperature, the total dose rate on the exterior of the HSM and the TC radial surface thereby, assuring that the temperatures and dose rates calculated on and around the HSM and TC, using the design basis fuel source terms, remain bounding. The HSM roof surface dose rate is chosen for this evaluation because it represents the largest contribution to the exposure received by members of the public, both offsite and onsite. The TC radial surface is chosen because it represents the greatest surface area and dose rate on the TC surface to which workers are exposed during fuel loading operations.

For a wide range of assembly burnups and initial enrichments, the OCRWM Characteristics Database (CDB) [7.14] is used to determine the required cooling time to meet the decay heat and surface dose rate criteria described above for this evaluation. The results of this evaluation are provided in Fuel Qualification Table 3.1-8a and Table 3.1-8b.

Methodology

The standard NUHOMS® design basis fuel assemblies have a decay heat of 1.0 kW/assy for a PWR assembly and 0.37 kW/assy for a BWR assembly. A fuel assembly with a decay heat less than these design basis values results in maximum HSM, TC and DSC component temperatures less than those listed in Section 8.1.3. The maximum allowable fuel cladding temperature is a function of both the post irradiation cooling time and the fuel burnup. Allowable decay heats as a function of cooling time and burnups are based on the criteria in Reference [7.15]. These decay heats result in maximum fuel cladding temperatures that are less than the corresponding cladding temperature limit.

Surface neutron dose rates are assumed to be directly proportional to the total neutron sources in the assemblies. The primary neutron source in LWR spent fuel is the spontaneous fission of 244Cm. For the ranges of burnups, initial enrichments, and cooling times in the fuel qualification tables, 244Cm represents more than 85% of the total neutron source. The neutron spectrum is, therefore, relatively constant for the fuel parameters addressed herein. To account for the fact that the original analyses used a different neutron spectrum, the variation in the spectrum is accounted for by applying a

7.2.3.2 Determining Fuel Assembly Minimum Required Cooling Times Using Fitting Equations for the 32PT, 24PTH, 37PTH, 61BTH, and 69BTH DSCs

Fuel qualification tables (FQTs) are developed to provide the minimum required cooling times needed for the authorized fuel assemblies for a given decay heat limit and/or radiological sources (combined total dose rates). As described in Chapter M.5, Section M.5.1, the FQTs are developed for the 32PT DSC for two heavy metal loadings – 400 KgU and 475 KgU. As described in Chapter P.5 and Z.5, the FQTs are developed for the 24PTH and 37PTH DSCs, respectively, for two heavy metal loadings – 400 KgU and 492 KgU. As described in Chapter T.5 and Y.5, the FQTs are developed for the 61BTH and 69BTH DSCs, respectively, for two heavy metal loadings – 175 KgU and 198 KgU.

This section provides a method for calculating the minimum required cooling time for a given fuel assembly, with an intermediate heavy metal loading that is in between the two discrete heavy metal load values mentioned above. It is demonstrated that the minimum required cooling times can be calculated by using a simple fitting equation. Section 7.2.3.2.1 *provides details on the fitting equation and how to determine the various terms of the equations. Section* 7.2.3.2.2 *provides several examples on how to use the fitting equation. Section* 7.2.3.2.3 *provides verification and validation information concerning the accuracy of the fitting equation results.*

7.2.3.2.1 Fitting Equations for Determining Minimum Required FA Cooling Times

Determining the minimum required cooling time for a given FA using this method is a two-step process. Step one involves clearly identifying the variable value inputs needed for the fitting equation for the applicable system, some of which are user inputs and others are looked up in FQTs. Step two involves determining the minimum required cooling time for the FA in question in the applicable system by using the looked up variable value inputs with the applicable fitting equation.

First, it is necessary to clearly identifying the variable value inputs needed for the fitting equation. These values are listed in Table 7.2-12 below.

Table 7.2-12
Input Parameters Needed for Fitting Equation

	Low kgU/FA Data	Unknown Cool Time Intermediate value kgU/FA Data	High kgU/FA Data
Metal Loading (kgU)	400 for PWR 170 for BWR (kgU_{low})	$400 < kgU_{new} < 475$ (32PT) $400 < kgU_{new} < 490$ (Other PWR Systems) $170 < kgU_{new} < 198$ (BWR Systems)	475 for 32PT 490 for other PWR Systems 198 for BWR Systems (kgU_{high})
Burnup (GWD/MTU)	BU (user input) **(This value must be identical for all three FAs)**		
Wt. % U235 (%)	w/o (user input) **(This value must be identical for all three FAs)**		
Decay Heat (kWt/FA)	DH (user input) **(This value must be identical for all three FAs)**		
Min. Cooling Time (years)	CT_{low} (Find in FQT using Bu, wt. %, and decay heat)	CT_{new} (Determined by fitting equation)	CT_{high} (Find in FQT using Bu, wt. %, and decay heat)

Next, the generic form of the fitting equation is defined. This equation determines the intermediate metal loading FA cooling time.

Generic Fitting Equation 1

$$CT_{new} = \frac{CT_{high} * \ln(kgU_{new}/kgU_{low}) + CT_{low} * [\ln(kgU_{high}/kgU_{low}) - \ln(kgU_{new}/kgU_{low})]}{\ln(kgU_{high}/kgU_{low})}$$

7.2.3.2.2 Fitting Equation Examples

This fitting equation methodology is currently applicable to the 32PT, 24PTH, 37PTH, 61BTH, and 69BTH systems only. Although this Appendix describes the 32PT system, this section contains examples on how to apply this method to each of the above mentioned systems. These examples will be referenced in the technical specifications for utility user guidance.

7.2.3.2.2.1 32PT

For the 32PT example, a 3.2 without FA with 430 kgU of metal loading at 55 GWD/MTU of burnup is used. The FA needs to be loaded into a heat loading zone, which cannot exceed 0.87 kWt/FA. The minimum required cooling times for PWR FAs in 32PT DSC are tabulated in FQTs shown in Appendix Chapter M.2. Using these FQTs, the known values are identified in Table 7.2-13.

Table 7.2-13
Input Parameters Needed for 32PT Example

	Low kgU/FA Data	Unknown Cool Time Intermediate value kgU/FA Data	High kgU/FA Data
Metal Loading (kgU)	400 (kgU_{low})	430 (kgU_{new})	475 (kgU_{high})
Burnup (GWD/MTU)	55		
Wt. % U235 (%)	3.2		
Decay Heat (kWt/FA)	0.87		
Min. Cooling Time (years)	CT_{low} (12.3)	CT_{new} (TBD)	CT_{high} (18.5)

Generic Fitting Equation 1 may be simplified by substituting the known low and high kgU/FA values of 400 and 475 into it. This simplification results in Fitting Equation 2, which can be used to determine the intermediate FA MTU cooling time for the 32PT system.

Fitting Equation 2 for 32PT

$$CT_{new} = 5.82 * [(ln(kgU_{new}) - 5.99] * CT_{high} - [ln(kgU_{new}) - 6.16] * CT_{low}$$

Substituting the known input values into Equation 2, the value of minimum cooling time for the 430 kgU FA is found.

Equation 2 Example Solution

$$CT_{new} = 5.82 * [(ln(430) - 4] * 18.5 - [ln(430) - 6.16] * 12.3 = 14.91 \text{ years}$$

The minimum required cooling time determined for the 430 kgU FA is 15.0 years. The result of the fitting equation shall be rounded up to the next highest single decimal place. Fitting Equation 2 will be used in the notes and examples of the FQTs for the 32PT system for calculating minimum required cooling times for FAs with an intermediate heavy metal loading.

7.2.3.2.2.2 24PTH and 37PTH

For the 24PTH and 37PTH examples, a 2.7 without FA with 450 kgU of metal loading at 48 GWD/MTU of burnup is used. The FA needs to be loaded into a heat loading zone, which cannot exceed 1.2 kWt/FA, and the assembly contains no CCs. The minimum required cooling times for PWR FAs in the 24PTH DSC are tabulated in FQTs shown in Appendix Chapter P.2. The minimum required cooling times for PWR FAs in the 37PTH DSC are tabulated in FQTs shown in Appendix Chapter Z.2. Using the 37PTH FQTs, the known values are identified in Table 7.2-14.

Table 7.2-14
Input Parameters Needed for 37PTH Example

	Low kgU/FA Data	Unknown Cool Time Intermediate value kgU/FA Data	High kgU/FA Data
Metal Loading (kgU)	400 (kgU_{low})	450 (kgU_{new})	490 (kgU_{high})
Burnup (GWD/MTU)		48	
Wt. % U235 (%)		2.7	
Decay Heat (kWt/FA)		1.2	
Min. Cooling Time (years)	CT_{low} (5.7)	CT_{new} (TBD)	CT_{high} (7.0)

Generic Fitting Equation 1 may be simplified by substituting the known low and high kgU/FA values of 400 and 490 into it. This simplification results in Fitting Equation 3, which can be used to determine the intermediate FA MTU cooling time for the 24PTH or 37PTH systems.

Fitting Equation 3 for 24PTH and 37PTH

$$CT_{new} = 4.93 * [(ln(kgU_{new}) - 5.99] * CT_{high} - [ln(kgU_{new}) - 6.19] * CT_{low}$$

Substituting the known input values into Equation 3, the value of minimum cooling time for the 450 kgU FA is found.

Equation 3 Example Solution

$$CT_{new} = 4.93 * [(ln(450) - 5.99] * 7.0 - [ln(450) - 6.19] * 5.7 = 6.44 \text{ years}$$

The minimum required cooling time determined for the 450 kgU FA is 6.5 years. The result of the fitting equation shall be rounded up to the next highest single decimal place. Equation 3 will be used in the notes and examples of the FQTs for the 24PTH and 37PTH systems for calculating minimum required cooling times for FAs with an intermediate heavy metal loading.

7.2.3.2.2.3 61BTH and 69BTH

For the 61BTH and 69BTH examples, a 3.4 without FA with 180 kgU of metal loading at 62 GWD/MTU of burnup is used. The FA needs to be loaded into a heat loading zone, which cannot exceed 0.9 kWt/FA. The minimum required cooling times for BWR FAs in the 61BTH DSC are tabulated in FQTs shown in Appendix Chapter T.2. The minimum required cooling times for BWR FAs in the 69BTH DSC are tabulated in FQTs shown in Appendix Chapter Y.2. Using the 61BTH FQTs, the known values are identified in Table 7.2-15.

Table 7.2-15
Input Parameters Needed for 61BTH Example

	Low kgU/FA Data	Unknown Cool Time Intermediate value kgU/FA Data	High kgU/FA Data
Metal Loading (kgU)	170 (kgU_{low})	180 (kgU_{new})	198 (kgU_{high})
Burnup (GWD/MTU)	62		
Wt. % U235 (%)	3.4		
Decay Heat (kWt/FA)	0.9		
Min. Cooling Time (years)	CT_{low} (4.5)	CT_{new} (TBD)	CT_{high} (5.0)

Generic Fitting Equation 1 may be simplified by substituting the known low and high kgU/FA values of 170 and 198 into it. This simplification results in Fitting Equation 4, which can be used to determine the intermediate FA MTU cooling time for the 61BTH or 69BTH systems.

Fitting Equation 4 for 61BTH and 69BTH

$$CT_{new} = 6.56 * [(ln(kgU_{new}) - 5.14] * CT_{high} - [ln(kgU_{new}) -5.29] * CT_{low}$$

Substituting the known input values into Equation 4, the value of minimum cooling time for the 180 kgU FA is found.

Equation 4 Example Solution

$$CT_{new} = 6.56 * [(ln(180) - 5.14] * 5.0 - [ln(180) - 5.29] * 4.5 = 4.69 \text{ years}$$

The minimum required cooling time determined for the 180 kgU FA is 4.7 years. The result of the fitting equation shall be rounded up to the next highest single decimal place. Fitting Equation 4 will be used in the notes and examples of the FQTs for the 61BTH and 69BTH systems for calculating minimum required cooling times for FAs with an intermediate heavy metal loading.

7.2.3.2.3 Verification of Fitting Equation Methodology

7.2.3.2.3.1 PWR Fuel in 24PTH and 37PTH

Table M.5-45 provides examples of cooling time determinations for various kgU and burnup/enrichment using the fitting equation and the linear interpolation using cooling times determined in FQTs explicitly generated at 400 kgU and 490 kgU.

As shown in Table M.5-45, the predicted cooling times obtained using Fitting Equation 3 for 24PTH and 37PTH are in agreement with those obtained by the linear interpolation approach. For certain cases, the predicted cooling times by the fitting equations are slightly higher.

Table M.5-46 shows examples of decay heats and dose rates calculated using the linear interpolation approach to predict the cooling times for given KgU and burnup/enrichment. Explicit SAS2H/ORIGENS calculations are performed to calculate the decay heats and 37PTH response functions are utilized to calculate the dose rate for various MTUs between 400 kgU and 490 kGU and the following heat load zone:

- *Zone 1 and Zone 2, 0.4 kW, 40 GWd/MTU, 1.5 wt. %,*
- *Zone 3, 0.7 kW, 41 GWd/MTU, 1.5 wt. %,*
- *Zone 4, 1.2 kW, 62 GWd/MTU, 3.4 wt. %.*

The results show that the decay heats and dose rates meet all the requirements. Similar results are expected for the 24PTH and 32PT systems.

7.2.3.2.3.2 BWR Fuel in 61BTH and 69BTH

Table M.5-47 provides examples of cooling time determinations for various kgU and burnup/enrichment using the fitting equations and the linear interpolation using cooling times determined in FQTs explicitly generated at 170 kgU and 190 kGU.

As shown in Table M.5-47, the predicted cooling times obtained using the fitting equations are in agreement with those obtained by the linear interpolation approach. For certain cases, the predicted cooling times by the fitting equations are slightly higher.

Table M.5-48 shows examples of decay heats and dose rates calculated using the linear interpolation approach to predict the cooling times for given KgU and burnup/enrichment. Explicit SAS2H/ORIGENS calculations are performed to calculate the decay heats and 69BTH response functions are utilized to calculate the dose rate for various MTUs between 170 KgU and 190 KgU and the following heat load zone:

- *Zone 1 through Zone 3, 0.49 kW,*
- *Zone 4 and Zone 5, 0.7 kW.*

The results show that the decay heats and dose rates meet all the requirements.

C. Design Basis Thermal Loads

The NUHOMS® transfer cask, DSC, and HSM are subjected to the thermal expansion loads associated with normal operating conditions. The range of average daily ambient temperatures used for the design of the transfer cask, DSC, and HSM for normal operating conditions is 0°F to 100°F. The normal operating seasonal average daily ambient temperature fluctuates from 0°F minimum (winter) to 100°F maximum (summer) and is conservatively assumed to occur for a sufficient duration to establish steady state conditions for the transfer cask, DSC and HSM. These minimum and maximum steady-state long-term ambient design temperatures, envelop the 24 hour average seasonal ambient temperature at any location within the contiguous United States (8.46).

The long-term average normal ambient temperature for the 50-year design life[(1)] of the system is assumed to be 70°F. This base case average ambient temperature bounds practically all reactor sites within the United States (8.27). Exceptions should be addressed on site specific basis by the licensee as necessary. Renewal

The range of ambient temperature cases analyzed are further defined in Section 8.1.3. The resulting temperature distributions in the HSM, DSC and transfer cask are determined by performing thermal analyses for these ambient conditions. The thermal analyses, described in Section 8.1.3, provide temperature distributions for the HSM, DSC, and transfer cask such as those shown in Table 8.1-17, Table 8.1-22b through Table 8.1-29a and Figure 8.1-1 through Figure 8.1-12. These temperature distributions are developed for the range of normal ambient temperatures specified above and are applicable to any size HSM array. The corresponding HSM structural analysis results for thermal loads are applicable to HSM arrays ranging in size from a single stand-alone module to a single row of side-by-side modules or a double row of back-to-back side-by-side modules of unrestricted length.

Figure 8.1-1 and Figure 8.1-3 show the temperature distribution around the circumference of the DSC (when in storage in an HSM) for the base case 70°F lifetime average ambient temperature. The maximum temperatures of the centermost fuel rods for each fuel assembly for the DSC are also shown. The analysis and HEATING7 (8.5) results for the 70°F ambient temperature base case are discussed in Section 8.1.3. The DSC and fuel assembly temperature distributions during storage in an HSM are also evaluated for the minimum average daily (winter) and maximum average daily (summer) ambient conditions. The resulting temperature distribution for the 100°F ambient temperature case are shown in Figure 8.1-2 and Figure 8.1-4. The fuel assembly temperatures for the minimum average daily (winter) conditions are enveloped by this case and are, therefore, not evaluated further.

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[1] *With NRC approval of the CoC 1004 renewal application, the license is extended to a total of 60 years. The TLAAs identified as #1, #4, and #5 in Section 12.2 performed for the renewal of this design conservatively used a service life of 100 years.* 72.48

Figure 8.1-5 and Figure 8.1-6 show the temperature distribution in a spacer disk located mid-length along the axis of the DSC for the 100°F ambient temperature case. This temperature distribution is determined by averaging the temperatures from a two-dimensional HEATING7 calculation of the heat transfer across a spacer disk (steel assumed to be between the guide sleeves and DSC shell) and the higher temperatures of the helium on either side of the spacer

Table 8.1-24 shows that the maximum HSM temperature for the life time average ambient temperature of 70°F does not exceed the ACI limit of 200°F for local area temperatures. The average HSM temperature for this condition does not exceed 150°F. As discussed above no reduction in concrete strength results from a short term temperature rise such as would occur for maximum and extreme ambient temperature conditions, or blockage of the HSM vents. Even for a sustained temperature increase of up to 250°F, the resulting reduction in concrete strength is minimal. As can be seen from Table 8.1-24, the HSM concrete temperatures are less than or equal to 250°F for all cases but the enveloping blocked vent case, which is postulated to occur for a period of 5 days or less.

Coupled with the conservative reductions in concrete material strength used in the HSM design calculations for the 125°F off-normal and accident conditions, the design criteria utilized is adequate to ensure that the NUHOMS® HSM will perform its intended safety function for all design conditions.

D. Radiation Effects on HSM Concrete

The accumulated neutron flux over the 50-year service life[1] of the HSM is estimated to be 1.7E14 neutrons/cm^2. From the study by Hilsdorf, Kropp, and Koch (8.25), the compressive strength and modulus of elasticity of concrete is not affected by a neutron flux of this magnitude. Renewal

The gamma energy flux deposited in the HSM concrete is 1.7E9 MeV/cm^2-sec. or 3.0E-4 watt/cm^2. According to ANSI/ANS-6.4-1977 (8.26), the temperature rise in concrete due to this level of radiation is negligible. Thus, radiation effects on concrete strength are not evaluated further for the HSM design.

E. HSM Design Analysis

For comparison with the normal operating condition loads factored to include the ACI Codes strength reduction factors the flexural and shear strength capacities for the various HSM concrete sections are calculated using the ultimate strength method of ACI 349-85.

[1] *With NRC approval of the CoC 1004 renewal application, the license is extended to a total of 60 years. The TLAAs identified as #1, #4, and #5 in Section 12.2 performed for the renewal of this design conservatively used a service life of 100 years.* 72.48

Conservatively ignoring the contribution of the compression reinforcing, the ultimate moment capacity of a typical 12 inch wide section of the HSM wall, roof, or floor for normal operating load combinations is:

$$M_u = \phi A_s f_y \left(d - \frac{A_s f_y}{1.7 f_c' b} \right) \tag{8.1-6}$$

Where:

M_u = Ultimate moment capacity k-in./ft.

b = 12 in., Width of section

The NUHOMS® components are evaluated for a range of design basis ambient temperatures as follows:

A. Normal Operating Conditions: The system components are evaluated for average ambient temperatures in the range of 0 °F minimum (winter) to 100 °F maximum (summer). Ambient temperatures within this range are assumed to occur for a sufficient duration to cause a steady-state temperature distribution in the NUHOMS® system components. For the evaluation of thermal cycling and material properties, fluctuations in the ambient temperature from winter to summer conditions are assumed to occur once per year for the HSM, and six times per year for the transfer cask. The lifetime average ambient temperature for the 50-year service life[1] is taken as 70 °F. The "stress-free" temperature for material properties is also assumed to be 70 °F.

Renewal

B. Off Normal and Accident Conditions: The system components are evaluated for the extreme ambient temperatures of -40 °F (winter) and 125 °F (summer). Should these extreme conditions ever occur, they would be expected to last for a very short duration of time. Nevertheless, these ambient temperatures are conservatively assumed to occur for a sufficient duration to cause a steady-state temperature distribution in the NUHOMS® system components (a few hours for the transfer cask, several days for the HSM). In addition, for postulated accident conditions the HSM ventilation inlet and outlet openings are assumed to be completely blocked for a five day period concurrent with the extreme ambient conditions (125 °F) as described in Section 8.2.7.

8.1.3.1 Thermal Hydraulics of the HSM

A. Principles of HSM Cooling System

The HSM is cooled by a natural draft of air entering through the air inlet openings located in the lower side walls of the HSM, and exiting through air outlet openings located in the upper side walls of the HSM. Cooler air at the prevailing ambient conditions is drawn into the HSM. The cooler air flows from the bottom of the HSM along the outer DSC surface where it is warmed by the decay heat of the spent fuel inside the DSC. The warmed air flows along the ceiling of the HSM and exits through the air outlet openings. The HSM vent geometries and flow paths for ventilation air are illustrated in Figure 8.1-34 and Figure 8.1-35 and on the drawings contained in Appendix E.

[1] With NRC approval of the CoC 1004 renewal application, the license is extended to a total of 60 years. The TLAAs identified as #1, #4, and #5 in Section 12.2 performed for the renewal of this design conservatively used a service life of 100 years. 72.48

The HSM roof and side walls are the primary concrete surface conducting heat to the outside environment. For analytical purposes, an HSM centered in a group of HSMs, each loaded with a DSC, is assumed. For the thermal analysis of an interior HSM with no DSC present in the adjacent HSMs, the outer surface of the wall is assumed to be exposed to the prevailing ambient conditions. For the thermal analyses of a single free-standing HSM, or an HSM at the end of a multiple module array, a shield wall is modeled, the outer surface of which is assumed to be exposed to the prevailing ambient conditions. The ISFSI basemat is in contact with soil, which is assumed to be at a constant temperature at a combined depth of eleven feet. Air infiltration and heat radiation from the HSM access opening door is conservatively neglected.

Fatigue effects need not be specifically evaluated provided the six criteria contained in NB-3222.4(a) are met. As demonstrated in Appendix C.4.1, an evaluation using these six criteria is performed to show that the ASME Code fatigue requirements are satisfied for the DSC.

8.2.10.3 Transfer Cask Load Combination Evaluation

As described in Section 3.2, the transfer cask calculated stresses due to normal operating loads are combined with the appropriate calculated stresses from postulated accident conditions at critical stress locations. It is assumed that only one postulated accident can occur at a time. Also, since the postulated drop accidents produce the highest calculated stresses, the load combination of dead load plus drop accident envelopes the stresses induced by other postulated accident scenarios. The maximum calculated stress intensities for the transfer cask normal operating, off-normal, and accident load combinations are tabulated in Table 8.2-21 through Table 8.2-23b.

Fatigue effects on the transfer cask are addressed using the criteria provided in NC-3219.2 of the ASME Code (Reference 8.3). As described in Appendix C.4.2, the code specified criteria given in this section are evaluated relative to the transfer cask to demonstrate that fatigue requirements are satisfied.

8.2.10.4 HSM Load Combination Evaluation

The maximum bending moments and shear forces induced in the HSM for the individual normal and off-normal loads are listed in Table 8.1-19. Similarly, the maximum moments and shears induced in the HSM for the individual accident loads are listed in Table 8.2-3. As described in Section 3.2.5.l, the load combination procedure of Section 6.17.3.1 of ANSI 57.9 (8.2) is used to combine the factored normal operation, off normal, and postulated accident loadings imposed on the reinforced concrete HSM. Many of the general event combinations, shown in Table 3.2-5, are enveloped by others that contain the same load factors with additional applied load cases.

The governing calculated bending moments and shears for each load combination are tabulated in Table 8.2-18. The tabulated results represent the bounding shears and moments for either the single free-standing HSM or an array of HSMs. For comparison, the ultimate moment and shear capacity of the HSM for the controlling load combinations are also shown in Table 8.2-18. Comparison of the reported bending moment and shear for each load combination with the corresponding ultimate capacity shows that the design strength of the HSM is greater than the strength required for the most critical load combination.

8.2.10.5 Thermal Cycling of the HSM

NOTE: The discussion that follows is for the HSM thermal cycling for the period of initial licensing. The TLAA that includes HSM thermal fatigue performed for the initial CoC 1004 renewal application is provided in Section 12.2.3.

As stated earlier, the largest mean daily change of temperature in the United States of 45°F occurs in Reno, Nevada. Because of the massive concrete sections used in the HSM

B 10.4.3.3.7 Seismic Restraints

BASES

For the Provision of TC Seismic Restraint Inside the Spent Fuel Pool Building as a Function of Horizontal Acceleration and Loaded Cask Weight, the basis is the calculation of overturning and restoring moments.

B 10.5.2.4 RADIATION PROTECTION PROGRAM

B 10.5.2.4.a ALARA Assessment

BASES

The basis for the ALARA assessment is 10 CFR 72.212 (b)(2)(i)(C).

B 10.5.2.4.b DSC Dye Penetrant Test of Closure Welds

BASES

Article NB-5000 Examination, ASME Boiler and Pressure Vessel Code, Section III, Division 1, Sub-Section NB.

B 10.5.2.4.c Leak Test

BASES

If the DSC leaked at the maximum acceptable rate of 1.0×10^{-4} atm cm^3/s for a period of 60 years, about 189,600 cc of helium would escape from the DSC. This is about 3.25% of the 5.83×10^6 cm^3 of helium initially introduced in the DSC. This conservatively assumes no reduction of internal gas temperature and pressure. Considering reduction of internal gas temperature and pressure the total helium loss over the period of extended operation (60 years) is calculated as 59,800 cm^3 or 1.03% of the initial helium inventory.

The 61BT, 32PT, 24PHB, 24PTH, 61BTH, 32PTH1, 69BTH and 37PTH DSC will maintain an inert atmosphere around the fuel and radiological consequences will be negligible, since it is designed and tested to be leak tight.

11. QUALITY ASSURANCE

The Quality Assurance Program to be applied to the "important-to-safety" and " safety related" activities associated with the standardized NUHOMS® system is as described in the *TN Americas LLC* (TN) Quality Assurance Program Description *Manual For 10 CFR Part 71, subpart H And 10 CFR Part 72, Subpart G* unless noted otherwise.

11.1 Introduction

This section provides a brief summary of the quality assurance controls which apply to activities affecting the quality of NUHOMS® parts, components, and systems designated as "important to safety" and "safety related.". System components which are "important to safety" are defined herein. Activities affecting quality are defined by site-specific contract and may include any or all of the following: design, procurement, fabrication, handling, shipping, storage, cleaning, erection, inspection, test, repair, or modification. These activities shall be performed in accordance with a quality assurance program which meets the requirements specified herein.

TN's Quality Assurance Program shall be applied to the important-to-safety activities within TN's scope of responsibility as defined herein. The TN Quality Assurance Program complies with the criteria and requirements of 10 CFR 72, Subpart G. The complete description and specific commitments of the TN Quality Assurance Program are contained in the TN Quality Assurance Program Description *Manual*. The Nuclear Regulatory Commission (NRC) has approved the TN QA Program Description *Manual* for 10 CFR 72, Subpart G. Changes to the TN QA program description *manual* shall be submitted to the NRC for approval within thirty (30) days of implementation. Changes to the TN QA program which decrease or delete previously approved quality assurance commitments shall be submitted to the NRC for approval prior to implementation.

A matrix comparing 10 CFR 72, Subpart G criteria with the TN QA Program Description *Manual* is provided in Table 11.1-1.

Table 11.1-1
Quality Assurance Criteria Matrix

10CFR72, Subpart G	TN QA Program Description *Manual*	
.142	1.0	Organization
.144	2.0	*Quality Assurance* Program
.146	3.0	Design Control
.148	4.0	Procurement Document Control
.150	5.0	Instructions, *Procedures,* and Drawings
.152	6.0	Document Control
.154	7.0	Control of Purchased *Material, Equipment* and Services
.156	8.0	Identification and Control of Materials, Parts, and Components
.158	9.0	Control of Special Processes
.160	10.0	Inspection
.162	11.0	Test Control
.164	12.0	Control of Measuring and Test Equipment
.166	13.0	Handling, Storage, and Shipping
.168	14.0	Inspection*, Test and Operating* Status
.170	15.0	*Nonconforming Material, Parts or Components*
.172	16.0	Corrective Action
.174	17.0	*Quality Assurance* Records
.176	18.0	Audits

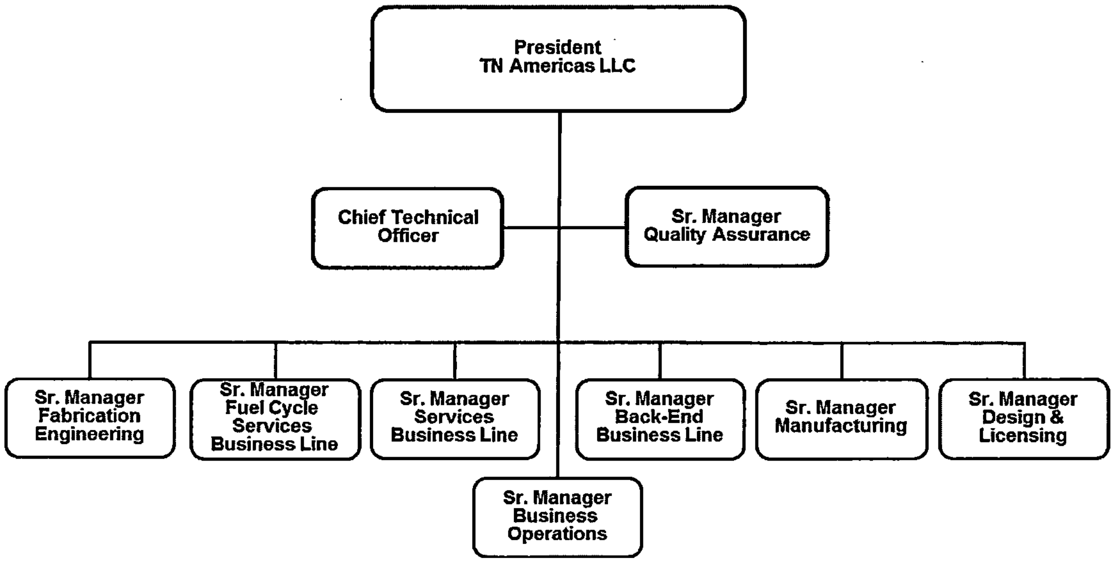

Figure 11.1-1
TN Americas LLC Functional Organization for Quality Assurance Program Activities

11.2 “Important-to-Safety” and “Safety Related” NUHOMS® System Components

TN will apply the TN Quality Assurance Program to those NUHOMS® components for which TN has responsibility and which are "important to safety" and "safety related" as delineated in Section 3.4. These include the DSC with closure weld filler metal, the HSM, and the transfer cask. The lifting yoke is classified as “safety related”.

Each item is first identified as "important to safety," "safety related" or "not important to safety." Items that are considered "important to safety" are further categorized using a graded quality approach. When the graded quality approach is used, a list shall be developed for each "important to safety" item which includes an assigned quality category consistent with the item's importance to safety. Quality categories shall be determined based on the guidance from Regulatory Guide 7.10:

Category A items are critical to safe operation. These items include structures, components, and systems whose failure or malfunction could result directly in a condition adversely affecting (1) safe spent fuel storage, (2) integrity of the spent fuel, or (3) public health and safety. This would include conditions as loss of primary containment with subsequent release of radioactive material, loss of shielding or an unsafe geometry compromising criticality control.

Category B items have a major impact on safety. These items include structures, components, and systems whose failure or malfunction could indirectly result in a condition adversely affecting (1) safe spent fuel storage, (2) integrity of the spent fuel, or (3) public health and safety. An unsafe operation could result only if a primary event occurs in conjunction with a secondary event or other failure or environmental occurrence.

Category C items have a minor impact on safety. These items include structures, components, and systems whose failure or malfunction would not significantly reduce the packaging effectiveness and would be unlikely to create a condition adversely affecting (1) safe spent fuel storage, (2) integrity of the spent fuel, or (3) public health and safety.

The Quality Assurance Program as described in paragraph 11.3 is applicable to each “important to safety” graded category and is limited as follows: For “safety related” items the program is applied as described in Category A items. Appendix K provides clarification for the procurement of Category A items for the NUHOMS®-61BT DSC. Appendix L provides clarification for the procurement of Category A items for the NUHOMS®-24PT2 DSC. Appendix M provides clarification for the procurement of Category A items for the NUHOMS®-32PT DSC. *Appendix P provides clarification for the procurement of Category A items for the NUHOMS®-24PTH DSC. Appendix T provides clarification for the procurement of Category A items for the NUHOMS®-61BTH DSC. Appendix U provides clarification for the procurement of Category A items for the NUHOMS®-32PTH1 DSC. Appendix Y provides clarification for the procurement of Category A items for the NUHOMS®-69BTH DSC. Appendix Z provides clarification for the procurement of Category A items for the NUHOMS®-37PTH DSC.*

11.3 Description of TN 10 CFR 72 Subpart G Quality Assurance Program

11.3.1 Organization

The organization structure for *quality assurance program activities* is presented in Figure 11.1-1. A description of TN's organizational structure, functional responsibilities, levels of authority, and lines of internal and external (client and supplier) communication may *also* be found in the TN Quality Assurance Program Description.

The Senior Manager, Quality Assurance is responsible for developing, maintaining and verifying execution of the Quality Assurance Program.

Personnel who perform quality-affecting activities related to items and services classified as important-to-safety or safety-related are indoctrinated, trained, and qualified in accordance with the TN QA Program.

11.3.2 Quality Assurance Program

TN has established and implemented a QA program for the control of quality in the design, purchase, fabrication, handling, shipping, storing, cleaning, assembly, inspection, testing, operation, maintenance, repair and modification of shipping containers for nuclear products. Training and/or evaluation of personnel qualifications are required for all QA functions in accordance with written procedures. The QA program assures that all quality requirements, engineering specifications and specific provisions of any package design approval are met. Those characteristics critical to safety are emphasized.

The *Senior Manager, Quality Assurance* regularly evaluates the TN QA program for adherence to the 18 point criteria in scope, implementation and effectiveness. Further, the TN President requires that the Quality Assurance Program, including the QA Program Description Policies and Procedures, be implemented and enforced on all applicable projects at TN.

11.3.3 Design Control

Important-to-safety and safety related NUHOMS® design activities including the performance of design verifications shall be implemented in accordance with the TN Quality Assurance Program.

Errors and deficiencies in the design, including the design process, are documented in the form of Corrective Action Reports.

Typically, valid industry standards and specifications are used for the selection of suitable materials, parts, equipment and processes for important-to-safety and safety related structures, systems, or components. Standard, or off-the-shelf items, and items previously approved for a different application are reviewed for suitability prior to selection.

11.3.4 Procurement Document Control

Procurement documents are prepared in accordance with the TN Quality Assurance Program which delineates the actions to be accomplished in the preparation, review, approval, and control of procurement documents. Review and approval of procurement documents by the *Senior Manager, Quality Assurance* are documented on the procurement documents prior to release to assure the adequacy of quality requirements stated therein. This review determines that quality requirements are correctly stated, inspectable, and controllable; that there are adequate acceptance and rejection criteria; and that the procurement document has been prepared, reviewed, and approved in accordance with QA program requirements.

The procurement documents shall identify the documentation required to be submitted for information, review, or approval by TN or TN's client. The time of submittal shall also be established. When TN requires the supplier to maintain specific quality assurance records, the retention times and disposition requirements shall be prescribed.

11.3.5 Instructions, *Procedures,* and Drawings

Activities affecting quality are prescribed and accomplished in accordance with approved, written instructions, *procedures, and* drawings as required by the TN QA Program.

11.3.6 Document Control

The issuance, distribution, and receipt of documents, which prescribe activities affecting quality, are controlled in accordance with the TN Quality Assurance Program. Controlled documents include, but are not limited to, the TN design specifications and criteria documents, drawings, instructions, and test procedures.

The individuals or groups responsible for reviewing, approving, and issuing documents and revisions thereto are identified in the "Responsibilities" sections of the TN QA Program.

11.3.7 Control of Purchased *Material, Equipment* and Services

The control of purchased *material, equipment,* and services shall be implemented in accordance with the TN Quality Assurance Program.

Surveillance of subcontracted activities is planned and performed in accordance with written procedures to assure conformance to the purchase order. These procedures provide for instructions that specify the characteristics to be witnessed, inspected or verified, and accepted; the method of surveillance and the extent of documentation required; and those responsible for implementing these instructions.

TN suppliers shall furnish documentation that identifies any procurement requirements which have not been met, together with a description of those nonconformances dispositioned as "use-as-is" or "repair."

Documentation from TN suppliers which demonstrates compliance with procurement requirements (such as material test reports, NDE results, performance test results, etc.) is periodically evaluated by audits, independent inspections, or tests as necessary to assure its validity.

11.3.8 Identification and Control of Materials, Parts, and Components

Materials, parts, and components shall be identified and controlled in accordance with the TN Quality Assurance Program. Hardware identification requirements are determined during generation of design drawings and specifications such that the location and method of identification do not affect the form, fit, function, or quality of the item being identified.

11.3.9 Control of Special Processes

The control of special processes, such as nondestructive examination, chemical cleaning, welding, and heat treating shall be performed in accordance with the TN Quality Assurance Program.

11.3.10 Inspection

Receipt inspections, in-process and final inspections of TN fabricated, constructed, or erected items, systems, components, or structures shall be performed in accordance with the TN Quality Assurance Program.

11.3.11 Test Control

Test control shall be accomplished in accordance with the TN Quality Assurance Program.

11.3.12 Control of Measuring and Test Equipment

The TN QA Program defines the requirements for calibration of measuring and testing equipment. Calibration is against certified measurement standards which have known relationships to national standards, where such standards exist. Where such standards do not exist, the basis for calibration shall be documented.

11.3.13 Handling, Storage and Shipping

Handling, storage, and shipping shall be conducted in accordance with the TN Quality Assurance Program. Special handling, preservation, storage, cleaning, packaging, and shipping requirements are established and accomplished by qualified individuals in accordance with predetermined work and inspection instructions.

11.3.14 Inspection, *Test, and Operating* Status

The use of inspection, test, *and operating* status tags shall be accomplished in accordance with the TN Quality Assurance Program.

11.3.15 *Nonconforming Material, Parts or Components*

The TN Quality Assurance Program defines the requirements and assigns the responsibilities for the control, identification, segregation, documentation, and close-out of nonconforming *material, parts or components* to prevent their inadvertent installation or use in fabrication, construction, or erection.

Nonconformance reports identify the item description and quantity, the disposition of the nonconformance, the inspection requirements, and signature approval of the disposition. They are retained in the Project files and are periodically analyzed to show quality trends and help identify root causes of nonconformances. Significant results are reported to responsible management for review and assessment.

Nonconforming items are segregated from acceptable items and tagged to prevent inadvertent use until properly dispositioned and closed out.

Nonconforming items dispositioned "use-as-is" or "repair" are reported to the client.

11.3.16 Corrective Action

Corrective action for significant conditions adverse to quality shall be taken in accordance with the TN Quality Assurance Program.

11.3.17 *Quality Assurance* Records

The TN Quality Assurance Program defines the scope of the records program such that sufficient records are maintained to provide documentary evidence of the quality of items and the activities affecting quality.

11.3.18 Audits

A comprehensive system of planned and documented audits, including audits of suppliers and site construction activities, verifies compliance with all aspects of the TN Quality Assurance Program and determines the effectiveness of the program.

Audits are performed by certified lead auditors and are planned, performed, and documented in accordance with the TN Quality Assurance Program.

Unannounced QA surveillances may be performed on activities affecting quality by the TN *Senior Manager, Quality Assurance*, or his designee, on an as-needed basis to further assure compliance with QA requirements.

11.4 Conditions of Approval Records

As required by 10 CFR 72, Subpart L, TN will establish and maintain records for each storage component fabricated under a certificate of compliance as required by §72.234(d). The records will be available for inspection as required by §72.234(e). Written procedures and appropriate tests will be established prior to use of the storage components, which will be provided to each system user as required by §72.234(f).

12. AGING MANAGEMENT

12.1 Aging Management Review

The AMR of the Standardized NUHOMS® System contained in the application for initial CoC renewal provides an assessment of aging effects that could adversely affect the ability of in-scope SSC to perform their intended functions during the extended storage period. Aging effects, and the mechanisms that cause them, are evaluated for the combinations of materials and environments identified for the subcomponent of the in-scope structures, systems, and components (SSCs) based on a review of relevant technical literature, available industry operating experience (OE), and AREVA Inc. OE. Aging effects that could adversely affect the ability of the in-scope SSC to perform their safety function(s) require additional aging management activity to address potential degradation that may occur during the extended storage period. The TLAAs and AMPs that are credited with managing aging effects during the extended storage period are discussed in Sections 12.2 and 12.3, respectively.

12.2 Time-Limited Aging Analyses and Other Supporting Evaluations

A comprehensive review to identify the TLAAs for the in-scope SSCs of the Standardized NUHOMS® System was performed to determine the analyses that could be credited with managing aging effects over the extended storage period. The TLAAs identified involved the in-scope SSCs, considered the effects of aging, involved explicit time-limited assumptions, provided conclusions regarding the capability of the SSC to perform its intended function through the operating term, and were contained or incorporated in the licensing basis. The TLAAs identified and other supporting evaluations include:

1. Fatigue Evaluation of the Dry Shielded Canister
2. Fatigue Evaluation of the Transfer Casks
3. Horizontal Storage Module Concrete and Dry Shielded Canister Steel Support Structure Thermal Fatigue, Corrosion, and Temperature Effects Evaluation
4. Dry Shielded Canister Poison Plates Boron Depletion Evaluation
5. Evaluation of Neutron Fluence and Gamma Radiation on Storage System Structural Materials
6. Confinement Evaluation of 24P and 52B Non-Leaktight Dry Shielded Canisters
7. Thermal Performance of Horizontal Storage Modules for the Period of Extended Operation
8. Evaluation of Additional Cladding Oxidation and Additional Hydride Formation Assuming Breach of Dry Shielded Canister Confinement Boundary
9. Evaluation of Cladding Gross Rupture during Period of Extended Operation
10. Structural Assessment of High Burnup Cladding Performance during Period of Extended Operation 72.48
11. Defense-in-Depth Thermal Evaluation of Dry Shielded Canister Internal Pressures Assuming High Burnup Fuel Cladding Failure during Period of Extended Operation
12. Defense-in-Depth Structural Evaluation of Dry Shielded Canister Confinement and Retrievability Assuming High Burnup Fuel Cladding Failure during Period of Extended Operation
13. Bounding Evaluation of Dry Shielded Canister with Reduced Shell Thickness Due to Chloride-Induced Stress Corrosion Cracking under Normal and Off-Normal Conditions of Storage during Renewal Period

Sections 12.2.1 through 12.2.13 provide a summary description and the conclusions for each TLAA.

12.2.1 Fatigue Evaluation of the Dry Shielded Canister.

12.2.1.1 Summary Description

This time-limited aging analysis (TLAA) evaluates the effects of cyclic loading (fatigue) on the mechanical properties of dry shielded canister (DSC) materials of the Standardized NUHOMS® System.

The evaluation is performed in accordance with the provisions of NB 3222.4(d) of the applicable ASME Code: "Rules to Determine Need for Fatigue Analysis of Integral Parts of Vessels." As provided by the American Society of Mechanical Engineers (ASME) Code, fatigue effects need not be specifically evaluated provided the six criteria contained in NB 3222.4(d) are met. An evaluation using these six criteria is performed to show that the ASME Code fatigue exemption requirements are satisfied for the DSCs. The following DSCs are included: 24P, 24PTH, 24PT2, 24PHB, 32PT, 32PTH1, 37PTH, 52B, 61BT, 61BTH, and 69BTH.

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12.2.1.2 Conclusions

The evaluation for the NUHOMS® DSCs shows that fatigue analysis exemption criteria given in ASME Code Section NB 3222.4(d) are met for a 100-year service life for the following NUHOMS® DSCs: 24P, 24PTH, 24PT2, 24PHB, 32PT, 32PTH1, 37PTH, 52B, 61BT, 61BTH, and 69BTH. No additional fatigue evaluations are required for the DSCs.

12.2.2 Fatigue Evaluation of the Transfer Casks

12.2.2.1 Summary Description

This time-limited aging analysis (TLAA) evaluates the effects of cyclic loading (fatigue) on the mechanical properties of transfer cask (TC) materials of the Standardized NUHOMS® System.

The evaluation is performed in accordance with the provisions of NC-3219.2 of the applicable American Society of Mechanical Engineers (ASME) Code: "Rules to Determine Need for Fatigue Analysis of Integral Parts of Vessels." The evaluation includes the OS197 Type and

OS200 TCs, as well as the Standardized TC. Throughout this evaluation, the OS197 Type TC is used to refer to all of the variations of the OS197 TC design. The OS197 Type TCs include the following: OS197, OS197H, OS197FC, OS197H FC, OS197FC-B, OS197HFC-B, and OS197L.

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Material properties used in determining the need for a fatigue evaluation are based on a maximum temperature of [ ] anywhere in the TC. A review of all of the structural calculations associated with any of the TCs shows that this is a bounding temperature for TC operational temperatures of the TC. In addition, the controlling (or largest) product of E times α (product of modulus of elasticity times instantaneous coefficient of thermal expansion taken at the mean temperature of the adjacent points) is taken at this temperature, and is conservative because it gives a larger resulting product of E times α than that at lower temperatures. Therefore, bounding conservative products of E and α are used in the evaluation. The material properties are based on ASME Code 1998 through 2000 Addenda [12.1] for the OS200 TC and on ASME Code 1983 through 1985 Addenda [12.2] for the Standardized TC and OS197 Type TCs.

12.2.2.2 Conclusions

The evaluation demonstrates that the six criteria (a) through (f) contained in NC-3219.2 are satisfied for all components of the TCs, as listed in Table 12.2-1 and Table 12.2-2. ASME Code criteria listed in NC-3219.2 were evaluated, based on [ ] TC use cycles (over a period of [ ] years), to demonstrate that there is no need for a fatigue analysis of the OS197 Type TCs, OS200 TC and the Standardized TC.

12.2.3 Horizontal Storage Module Concrete and Dry Shielded Canister Steel Support Structure Thermal Fatigue, Corrosion, and Temperature Effects Evaluation

12.2.3.1 Summary Description

This TLAA evaluates time-dependent aging mechanisms associated with potential degradation of the HSM component. The HSMs subject to these evaluations are the HSM Models 80 and 102, HSM Model 152, and HSM-H (HSM-HS and HSM Model 202). The HSM-HS and HSM Model 202 are the same as the HSM-H for purposes of these evaluations. The evaluations presented herein are bounding for the six HSM types. All the storage modules are identified as HSM in these evaluations unless the specific HSM type is noted.

The effect of radiation on the HSM materials is evaluated in Section 12.2.5 for a service life of [ ]. The evaluation concludes that there are no adverse effects on the HSM structure due to neutron fluence or gamma radiation over the period of extended operation.

The HSM is evaluated for sustained elevated temperature effects, thermal fatigue, and corrosion of the reinforcing steel.

The DSC support structure is evaluated for the effects of corrosion and thermal fatigue. The sliding surfaces of the DSC support structure are fabricated from NITRONIC® 60 austenitic stainless steel, which is coated with a dry film lubricant to minimize friction during insertion and retrieval of the DSC. The effect of radiation is evaluated for the lubricant.

The heat shields are designed to limit concrete temperature to within acceptable limits. The heat shields are evaluated for corrosion effects.

12.2.3.2 Conclusions

This time-limited aging analysis evaluated the effects of temperature, thermal cycling fatigue, and corrosion on the HSM components. The evaluation conclusions are as follows:

- Degradation due to elevated temperature is not an aging effect requiring management for the HSM concrete. The long-term temperatures corresponding to maximum design basis heat loads trend toward the allowed long-term temperature limits of the ACI 349 Code.
- Thermal fatigue is not an aging effect requiring management for the HSM concrete. A fatigue usage factor of 0.25 due to daily and seasonal temperature fluctuations is conservatively calculated. Thermal cycling fatigue is not considered an aging effect requiring management.
- Even though environmental degradation of the HSM concrete due to rebar corrosion is not expected to occur, corrosion of rebar is considered an aging effect requiring management for the HSM concrete.
- Loss of material due to general corrosion of carbon steel and crevice and pitting corrosion of stainless steel DSC steel support structure is considered an aging effect requiring management for the HSM DSC steel support structure.

- Loss of material due to general corrosion of the carbon steel heat shield and crevice and pitting corrosion of stainless steel and aluminum heat shields is an aging effect requiring management.

12.2.4 Dry Shielded Canister Poison Plates Boron Depletion Evaluation

12.2.4.1 Summary Description

This analysis is performed to document the time-limited aging analysis (TLAA) in support of the aging management review (AMR) on poison plates. Although the proposed renewal period for Certificate of Compliance (CoC) 1004 is 40 years, the TLAA is defined over the 20-year initial license and additional [ ] The analysis determines the total B-10 depletion incurred by the poison plates over the course of [ ] of storage.

12.2.4.2 Conclusions

The TLAA determines the amount of B-10 depleted in the poison plates due to neutron irradiation during [ ] of storage. Although the license renewal period is 40 years, this evaluation takes into account the initial 20 years and an additional [ ] of storage for a total of [ ]. The evaluation considers a bounding neutron irradiation rate with the least amount of B-10 content available in poison plates and computes the reaction rate density. Compared to the initial amount of B-10 available, analyses indicate that more than 99.999% of B-10 remains in the poison plates after [ ] of irradiation. This TLAA demonstrates the ability of the poison plates and PRAs to maintain sub-criticality over the desired duration of storage.

12.2.5 Evaluation of Neutron Fluence and Gamma Radiation on Storage System Structural Materials

12.2.5.1 Summary Description

This time-limited aging analysis (TLAA) evaluates the effects of neutron fluence and gamma radiation on the mechanical properties of dry shielded canister (DSC) and horizontal storage module (HSM) materials of the Standardized NUHOMS® System.

Irradiation embrittlement can lead to a decrease in fracture toughness of steel materials. Available data indicate that the effects on the mechanical properties of steel are discernable at fluence levels above $1x10^{18}$ neutrons/cm^2 [12.3, 12.5]. Irradiation in the form of neutrons or gamma rays can affect the concrete and reinforcing steel properties. Based on the experimental data presented in ACI SP 55-10 [12.4] concrete experiences a reduction in compressive and tensile strength at neutron fluence exposure levels greater than 10^{19} neutrons/cm^2. A threshold value for gamma radiation levels at which a reduction in compressive and tensile strength was observed is on the order of 10^{10} rads. A threshold level of neutron fluence of 1×10^{18} neutrons/cm^2 has been cited as criteria for alteration of reinforcing steel mechanical properties per [12.3].

Aluminum 6061 material is used for the transition rails of certain DSCs (e.g., 24PTH). These rails form the transition between the rectangular geometry of the basket and the cylindrically shaped shell and, structurally, are typically under compression. Aluminum alloys such as 6061 have minimum neutron absorption rate and their low density results in minimum gamma heating and thus, they are capable of withstanding very high neutron exposures in plant reactor environments (e.g., spent fuel storage racks). Threshold levels for aluminum 6061 are expected to be higher than those for steel.

This TLAA presents the accumulated neutron flux and gamma energy deposition over a period of extended operation of **[ ]** (for a total service life of **[ ]**).

The gamma radiolysis of any water present on the DSC outer surface has been considered.

12.2.5.2 Conclusions

The neutron fluence and gamma dose after **[ ]** of storage has been calculated for the DSC basket, shell, and HSM concrete using bounding source terms and a conservative model of the DSC and HSM. **[ ]**. These are well below the 10^{18} n/cm^2 threshold for embrittlement of the basket structure, the DSC shell, or the reinforcing steel in the concrete. The maximum gamma dose at the inside surface of the concrete is **[ ]**, below the 10^{10} rad threshold for damage to the concrete.

Therefore, radiation damage is not an aging mechanism that requires an aging management program.

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12.2.6 Confinement Evaluation of 24P and 52B Non-Leaktight Dry Shielded Canisters

12.2.6.1 Summary Description

The purpose of this appendix is to compute the dose commitments from the 24P and 52B dry storage canisters (DSCs) during normal, off-normal, and accident conditions from the airborne release of radioactive nuclides after 20 years of storage.

This appendix updates the analysis of Section 8.2.8. The updated analysis uses leakage rates related to the confinement leak test acceptance criterion rather than assuming an instantaneous non-mechanistic failure and follows the Standard Review Plan (SRP) [12.6] in evaluating dispersion factors and organ doses. Normal, off-normal, and accident conditions correspond to the evaluations of UFSAR Section 8.1.

The SRP [12.6] exempts storage casks that are designed and tested to be leak-tight, as defined in the American National Standards Institute (ANSI) standard for Leakage Tests on Packages for Shipment of Radioactive Materials [12.7]. All DSCs under Certificate of Compliance (CoC) 1004, other than the 24P (standard and long), the 24PT2, and 52B have been leak tested to the 10^{-7} ref cm^3/s leak-tight standard and are, therefore, not considered in this analysis. Because the 24P and the 24PT2 have the same fuel qualification table, (Table 3.1-8a [12.8]), the analysis of the 24P applies to both models. The addition of burnable poison rod assemblies (BPRAs) (Table 3.1-8c [12.8]) to the 24P long model or the 24PT2 requires the same or slightly longer cooling times, so it is bounded by the 24P standard analysis.

This analysis presents the total dose commitments from a single 24P or 52B at a distance of 100 m from the DSC after 20 years of storage. The original analyses (Section 7.2) were performed using the ORIGEN2 [12.9] computer code. The new analyses are performed using the SCALE 5.0 ORIGEN-S/SAS2H [12.10] computer code sequence to more accurately track the amount of radioactive nuclides that could be available for release in any of the operational modes considered.

12.2.6.2 Conclusion

Compliance to 10 CFR 72.104 and 10 CFR 72.106 is demonstrated for both the 24P and 52B DSCs at 100 m distances after 20 years of storage. A comparison of the doses to the applicable regulations is found in Table 12.2-3 and Table 12.2-4.

The least margin occurs for the 24P under off-normal conditions for the critical organ dose and is only 3.22% of the limit. The consequences of leakage continue to decline during the 20 to 60 year CoC extension period as the source decays and the internal pressure declines.

The methodology, source terms, and dose rates presented in this appendix are developed to be reasonably bounding for general licensee implementation of the ISFSI. These results may be

used in lieu of the confinement evaluation by the general licensee, although the inputs utilized in this appendix should be evaluated for applicability by each site. A site-specific confinement evaluation may be performed by the general licensee to modify key input parameters in order to meet the dose limits specified in 10 CFR 72.104(a) and 10 CFR 72.106(b).

12.2.7 Thermal Performance of Horizontal Storage Modules for the Period of Extended Operation

12.2.7.1 Summary Description

This appendix evaluates the confinement weld temperatures on the outer surface of the NUHOMS® dry shielded canisters (DSCs) and the concrete temperatures over the extended period of storage as input to aging management reviews (AMRs) and time limited aging analyses (TLAAs) for the DSC and the horizontal storage module (HSM). The DSCs subject to this evaluation are stored in one of the three storage module types; Standardized HSM (HSM Models 80 or 102), HSM-H (HSM Model 202 and HSM-HS), or HSM Model 152. All storage modules are identified as HSM in this evaluation unless the specific type of the HSM is noted. Studies of chloride-induced stress corrosion cracking (CISCC) show that stainless steel welds are susceptible to CISSC when the weld temperature is in the range of 30 °C to 80 °C.

To evaluate the confinement weld temperatures various heat loads at steady state condition and average annual temperature of 70 °F are considered in the models. The evaluated heat loads are in the range of 2 kW to 22 kW for DSCs loaded in the Standardized HSM (HSM Model 80 or 102) or HSM Model 152 and in the range of 2 kW to 32 kW for DSCs loaded in the HSM-H.

[

]

For these evaluations, half symmetric, three-dimensional computational fluid dynamics (CFD) models generated in ANSYS FLUENT [12.11] are used to simulate the air flow and heat transfer within the each HSM type separately. These evaluations also provide the DSC confinement weld temperature as a function of the heat load and storage time for a DSC during long-term storage time.

12.2.7.2 Conclusions

This TLAA provides the canister and concrete temperature ranges during extended storage, to be used as input for the stress corrosion cracking AMR [12.19, Appendix 5B] and the concrete TLAA (Section 12.2.3).

12.2.8 Evaluation of Additional Cladding Oxidation and Additional Hydride Formation Assuming Breach of Dry Shielded Canister Confinement Boundary

12.2.8.1 Summary Description

This time-limited aging analysis (TLAA) evaluates the potential effects of additional cladding oxidation and concurrent hydride formation on the cladding integrity when dry shielded canister (DSC) confinement is hypothetically breached after 40 and 60 years of storage. Using a temperature dependent oxidation model for cladding, the additional oxide thickness formed on the cladding surface when exposed to the ambient air and corresponding clad thinning is calculated as a function of storage time. The calculated clad thinning is compared with the cladding oxide thickness (maximum 120 μm) assumed for structural analysis in the Updated Final Safety Analysis Report (UFSAR). The effects of alloy composition and fuel burnup on the cladding oxidation are also evaluated. Assuming absorption of hydrogen released as a result of cladding oxidation in humid air, the additional amount of hydrogen content and corresponding hydride formation is estimated. The cladding materials evaluated in this TLAA include Zircaloy-2, Zircaloy-4, ZIRLO™, and M5®.

Background Information

The UFSAR uses the following cladding thickness reductions for evaluation of fuel integrity under drop accident accelerations:

- 61BT (Section K.3.6.3) 200 μm
- 24PTH (Section P.3.6.3) 120 μm
- 61BTH (Section T.3.5.2) 0.0027 inch (68.6 μm), based on 120 μm oxide thickness
- 32PTH1 (Section U.3.5.1) 0.0027 inch (68.6 μm), based on 120 μm oxide thickness

[12.19, Appendix 5A] evaluates the potential for breaching of the DSC confinement boundary due to stress corrosion cracking for canisters that are stored in locations with significant chloride aerosols. The analysis estimates that, barring aging management, such a breach could occur between 40 and 60 years after the beginning of storage.

[ ].

The following analysis will evaluate storage from [ ] under a hypothetical breached DSC condition, which is conservative compared to a [ ] scenario, in terms of both duration and temperature of cladding exposure to air. The [ ] results are included in the tables and figures, but are not discussed in the text.

12.2.8.2 Conclusions

Clad Thinning

The calculation results show that the additional oxide formation for Zircaloy-2 and Zircaloy-4 will be very small: an average oxide thickness of [ ] formed during the exposure time of [ ] in air following breaching of the DSC confinement. The corresponding clad thinning averages [ ]. Compared to the cladding thinning of 68.6 μm in the UFSAR, the added thinning of [ ] corresponds to only [ ], and does not change the UFSAR assumption within two significant digits. Because of high corrosion resistance of the new alloys such as ZIRLO™ and M5® compared to Zircaloy-2 and Zircaloy-4, it is expected that the percentage of cladding thickness oxidized will be lower than that of the traditional zirconium based alloys. High burnup has no effect on oxidation and additional clad thinning due to air exposure during dry storage, and the amount of oxidation, 120 μm, originally assumed in the UFSAR already bounds the typical limit of 100 μm expected for fuel burnup in the 60-65 GWd/MTU range. Thus, there is no adverse impact of the postulated air exposure on cladding thinning, including the effects of temperature, alloy composition, and burnup.

Hydride Formation as a Result of Cladding Oxidation

Based on calculation results for irradiated high burnup fuel rods including Zircaloy-4 and ZIRLO™, the amount of additional radial hydride as a result of cladding oxidation during air exposure after 40 years of storage will be less than [ ]. Thus, the postulated air exposure will not have any practical impact on the cladding degradation due to radial hydride formation.

12.2.9 Evaluation of Cladding Gross Rupture during Period of Extended Operation

12.2.9.1 Summary Description

This evaluation determines the maximum exposure time (incubation time) that the fuel cladding within a Standardized NUHOMS® dry shielded canister (DSC) remains undamaged for the hypothetical case in which the DSC confinement is breached during extended operation.

As described in [12.19, Appendix 5B], chloride-induced stress corrosion cracking (CISCC) could initiate on the DSC confinement boundary welds or heat affected zones after [ ] of storage and could penetrate the confinement boundary after [ ] of storage, depending on the fuel heat load and local chloride aerosol concentration. This evaluation provides a defense-in-depth analysis for the hypothetical case assuming that the confinement boundary of the DSC is breached after [ ] of storage. It is also assumed, in the case of a DSC breach, that the helium retained in the DSC cavity would be replaced instantaneously by air and the fuel cladding would be exposed to oxygen in air. If the temperature of the fuel rods is high enough and small cracks or pinholes are present, UO_2 may convert to U_3O_8 and expand. The expansion of the fuel pellet imposes a stress on the fuel rod cladding, which would cause the cladding to be compromised and split open.

This calculation determines the incubation time for the fuel cladding to remain undamaged when exposed to an oxidizing atmosphere after the DSC shell is compromised. The incubation time is calculated using data provided in [12.12] by Electric Power Research Institute (EPRI). Based on the calculated incubation time, this evaluation demonstrates that ample time would be available prior to release of fissile material even if the DSC confinement is beached in a hypothetical case.

12.2.9.2 Conclusion

[ ]. The calculated incubation times are also presented in Table 12.2-5.

[ ] for conversion of UO_2 to U_3O_8 to affect the fuel cladding and potentially release the fissile material into the DSC confinement when the DSC is hypothetically breached [ ] of dry storage. This assumes a [ ], but during the incubation time of [ ], the fuel cladding temperature will drop below [ ] for [ ] of dry storage. For this temperature, the incubation time increases to [ ]. This behavior continues during the long storage time. It follows that the development of a gross rupture due to a hypothetical breach of the DSC [ ] of dry storage is an unlikely event.

12.2.10 Structural Assessment of High Burnup Cladding Performance during Period of Extended Operation

12.2.10.1 Summary Description

This time-limited aging analysis (TLAA) evaluates the structural performance of high burnup fuel cladding after 20 years of storage and for the duration of the license renewal period. Both pressurized water reactor (PWR) and boiling water reactor (BWR) fuel assemblies are evaluated for normal and off-normal storage loads in order to assess if the cladding structural integrity and fuel assembly (FA) retrievability requirements in 10 CFR 72.122(h)(1) and 72.122(l), respectively, are met for storage periods longer than 20 years.

The applicable loads to be evaluated are self-weight, internal pressure, and handling. The applicable handling loads for the FA are those associated with retrievability of the FA from the dry shielded canister (DSC) in case of repackaging or if the FA needs to be moved back to the spent fuel pool.

12.2.10.2 Conclusions

As shown in Table 12.2-6 and Table 12.2-7, the minimum safety factor against material yield is 2.3 for normal handling loads and internal pressure.

This evaluation shows that the fuel can be safely handled after 60 years of storage. The decreasing temperature of the fuel could result in a ductile to brittle transition, but any reduction

in ductility due to radial hydrides is not a concern due to the low stress levels. The decrease in fuel rod internal pressure that is expected as a result of the decreasing temperatures has a beneficial effect.

12.2.11 Defense-in-Depth Thermal Evaluation of Dry Shielded Canister Internal Pressures Assuming High Burnup Fuel Cladding Failure during Period of Extended Operation

12.2.11.1 Summary Description

The purpose of this evaluation is to determine the confinement boundary internal pressure for the NUHOMS® dry shielded canisters (DSCs) loaded with high burnup fuel assemblies assuming that **[ ]** of high burnup fuel rods will rupture and release their fill and fission gases into the DSC cavity after 20 years of storage. The calculated DSC internal pressures are used in [12.19, Appendix 3M] to demonstrate that the structural integrity of the DSC confinement boundary is maintained as a defense–in-depth evaluation.

In addition, this calculation determines the bounding normal and off-normal internal pressures in the NUHOMS® DSCs for the following conditions:

a. Normal condition after 20 years of storage assuming that 1% of fuel rods rupture,

b. Off-normal condition after 20 years of storage assuming that 10% of fuel rods rupture,

c. Normal condition after 60 years of storage assuming that 1% of fuel rods rupture.

The bounding normal and off-normal pressures after 20 years of storage (conditions a and b above) are used in a defense–in-depth evaluation in [12.19, Appendix 3N] to calculate the critical DSC shell crack size caused by chloride-induced stress corrosion cracking (CISCC). The calculation of the critical crack size is also a defense-in-depth evaluation.

12.2.11.2 Conclusions

The resulting DSC internal pressures calculated for the bounding cases to be used for evaluation of the confinement boundary in [12.19, Appendix 3M] are shown in Table 12.2-8. These pressures are determined assuming **[ ]** of high burnup fuel rods are ruptured. The DSC types, the calculated total heat load of each DSC at the start and after 20 years of dry storage, the maximum fuel cladding temperatures, and the average cavity gas temperatures are also listed in Table 12.2-8 for reference. The DSC shell temperature profiles for the 61BTH Type 1, 32PT-S125, and 32PTH1-S DSCs are shown in Figure 12.2-4 through Figure 12.2-6.

The bounding DSC internal pressures for normal and off-normal conditions after 20 years of dry storage to be used for evaluation of the DSC confinement integrity in [12.19, Appendix 3N] are shown in Table 12.2-9. The average cavity gas temperatures for normal and off-normal conditions are listed in Table 12.2-9 for reference.

The bounding DSC internal pressures for normal condition after 60 years of dry storage are shown in Table 12.2-10. For this case, the heat load and the maximum fuel cladding temperature are also listed for reference.

12.2.12 Defense-in-Depth Structural Evaluation of Dry Shielded Canister Confinement and Retrievability Assuming High Burnup Fuel Cladding Failure during Period of Extended Operation

12.2.12.1 Summary Description

This time-limited aging analysis (TLAA) evaluates the dry shielded canisters (DSCs) loaded with high burnup fuel assemblies for normal and off-normal conditions. It is assumed that there is a [ ] % rupture of high burnup fuel after 20 years of storage.

The DSCs that may be loaded with high burnup fuel are the 61BTH (Type 1 and 2), 32PT (S100, S125, L100, and L125), 24PTH (S, L, and S-LC), 24PHB, 32PTH1 (S, M, and L), 37PTH (S and M), and 69BTH. These DSCs are categorized into four groups based on their designs. Table 12.2-11 lists all the key important parameters of these DSCs.

For higher internal pressure load, the inner and outer top cover plates of the DSC would act together to resist the bending. The combined thickness of the top cover plate assembly is used as the discriminator in the selection of DSCs for evaluation. The stresses are calculated accordingly using the equations from 12.13, and are shown in Table 12.2-11. Furthermore, the examination of maximum stress ratios for the DSC shell for 32PT (Appendix M, Table M.3.7-8) and 32PTH1 (Appendix U, Table U.3.7-18), documented in the Updated Final Safety Analysis Report (UFSAR) for Group 2 and Group 4, confirms that 32PT has higher stress ratio than the 32PTH1 DSC shell. As seen from the bending stresses in the top cover plates in Table 12.2-11, it can be concluded that the Group 1 and Group 2 DSCs are bounding. In these two groups, the 61BTH Type 1 and 32PT-S125 have the highest internal pressure of [ ] and [ ], respectively. Hence, the evaluation is performed for these two types of DSCs.

12.2.12.2 Conclusions

Based on the evaluation performed, the DSCs listed in CoC 1004 are structurally adequate for a hypothetical condition of [ ] rupture of high burnup fuel assemblies after 20 years of storage.

12.2.13 Bounding Evaluation of Dry Shielded Canister with Reduced Shell Thickness Due to Chloride Induced Stress Corrosion Cracking under Normal and Off Normal Conditions of Storage during Renewal Period

12.2.13.1 Summary Description

The purpose of this appendix is to determine the minimum thickness of the dry storage cask (DSC) shell required to demonstrate that the confinement function of the DSC is maintained and the requirement for ready retrieval of the DSC from the horizontal storage module (HSM) is met. The confinement function is considered to be met if the DSC confinement boundary stresses due to normal and off-normal loads meet the American Society of Mechanical Engineers (ASME) code stress limits for Level A and B conditions [12.14]. The minimum thickness is governed by the crack depth postulated to occur due to chloride-induced stress corrosion cracking (CISCC).

The time required to propagate the crack to reach the minimum thickness is also determined in this appendix.

12.2.13.2 Conclusions

The maximum stress ratio is found to be [ ] for unloading load combination UL-6 for a DSC shell thickness of [ ] inch considering maximum initial pressure and shell temperature.

Based on the analysis, a DSC shell thickness of [ ] inch is adequate to maintain confinement and retrievability of the DSC from horizontal storage modules. The analysis shows that the DSC with [ ] inch thickness can accommodate the stresses due to normal and off-normal loads while meeting the ASME Code stress limits. CISCC will not penetrate [ ] inch into a DSC shell for at least [ ] years of storage. Therefore, DSCs with a minimum shell thickness of 0.50 inch remain safe for storage and retrieval for this duration.

As a defense-in-depth, the DSC shell thickness was re-evaluated with the reduced pressure and temperature at the end of 20 years of storage, resulting in a minimum thickness of [ ] inch for load combination UL-6. Based on Figure 12.2-7, a minimum storage time of [ ] years is required for CISCC to progress to a depth of [ ] inch ([ ] mm), leaving a reduced thickness of [ ] inch in a 0.5 inch shell.

Table 12.2-1
OS197 Types and OS200 TC Material Specifications

Components	Material Specifications
Structural Shell (includes flanges)	SA-240 Type 304
Inner Liner Plate	SA-240 Type 304
Top Cover Plate	SA-240 Type 304
Bottom End Plate	SA-240 Type 304
Upper Trunnion & Sleeve	SA-182 Type F304
Trunnion Insert Plate	SA-240 Type 304
Upper Trunnion Pad	SA-240 Type 304
Lower Trunnion Sleeve	SA-182 Type F304N
One-Piece Upper Trunnion	SA-182 Type FXM-19
One-Piece Lower Trunnion	SA-182 Type F304N

Table 12.2-2
Standardized TC Material Specifications

Components	Material Specifications
Structural Shell (includes flanges)	SA-516 Gr. 70
Inner Liner Plate and SS Trunnion Plate	SA-240 Type 304
Top Cover Plate	SA-516 Gr. 70
Bottom End Plate	SA-240 Type 304
Upper Trunnion Sleeve	SA-533 Gr. B, Cl. 2 or SA-508 Cl. 3A
Upper Trunnion	SA-564 Gr. 630 PH
Trunnion Insert Plate	SA-516 Gr. 70
Lower Trunnion Sleeve	SA-516 Gr. 70 or SA-508 Cl. 3A
Lower Trunnion	SA-479 Type 304

Table 12.2-3
100 m Dose Summary for the 52B Confinement Calculations

Normal Conditions			
Organ	**10 CFR 72.104 Limit (mrem)**	**Calculated Dose (mrem)**	**Fraction**
Whole Body (TEDE)	25		
Thyroid	75		
Critical Organ	25		
Off-Normal Conditions			
Organ	**10 CFR 72.104 Limit (mrem)**	**Calculated Dose (mrem)**	**Fraction**
Whole Body (TEDE)	25		
Thyroid	75		
Critical Organ	25		
Accident Conditions			
Organ	**10 CFR 72.106 Limit (mrem)**	**Calculated Dose (mrem)**	**Fraction**
Whole Body (TEDE)	5,000		
Critical Organ	50,000		
Skin	50,000		
Lens of the eye	15,000		

Table 12.2-4
100 m Dose Summary for the 24P Confinement Calculations

Normal Conditions			
Organ	**10 CFR 72.104 Limit (mrem)**	**Calculated Dose (mrem)**	**Fraction**
Whole Body (TEDE)	25		
Thyroid	75		
Critical Organ	25		
Off-Normal Conditions			
Organ	**10 CFR 72.104 Limit (mrem)**	**Calculated Dose (mrem)**	**Fraction**
Whole Body (TEDE)	25		
Thyroid	75		
Critical Organ	25		
Accident Conditions			
Organ	**10 CFR 72.106 Limit (mrem)**	**Calculated Dose (mrem)**	**Fraction**
Whole Body (TEDE)	5,000		
Critical Organ	50,000		
Skin	50,000		
Lens of the eye	15,000		

Proprietary Information on Pages 12.2-19 through 12.2-24
Withheld Pursuant to 10 CFR 2.390

Table 12.2-11
DSC Loaded with High Burnup Fuel from CoC 1004

DSC Types	Group 1	Group 2(1)						Group 3(2)		Group 4(3)		
	61BTH Type 1	61BTH Type 2	32PT-S100	32PT-S125	32PT-L100	32PT-L125	24PTH (S and L)	24PTH-S-LC	24PHB	32PTH1 (M & L)	37PTH (S & M)	69BTH
Outer Top Cover Plate (in)												
Inner Top Cover Plate (in)												
Top Shield Plug (in)												
Diameter (in)												
Internal Pressure (psi)(4)												
Combined Top Cover Plates Bending Moment (lbs-in)(5)												
Combined Top Cover Plates Bending Stress (psi)(6)												

Notes:

(1) Per [12.19, Appendix 3L], 32PT-S125 has the bounding internal pressure for the Group 2 DSCs.

(2) For Group 3 the inner top cover plate and the top shield plug top casing plate form a composite plate encasing the top shield plug. Hence, for this group, the top end assembly is very stiff compared to other designs, hence is not considered bounding for internal pressure load.

(3) Per [12.19, Appendix 3L], 32PTH1-S has the bounding internal pressure for the Group 4 DSCs.

(4) The internal pressures are taken from [12.19, Appendix 3L].

(5) Bending moment at the center of the top cover plate with simply supported boundary condition is calculated as $M = pr^2(3+\nu)/16$ [12.13, Table 11.2].

(6) The bending stress in the top cover plates is calculated as $S=6M/(t_1^2+t_2^2)$ [12.13, Table 11.2].

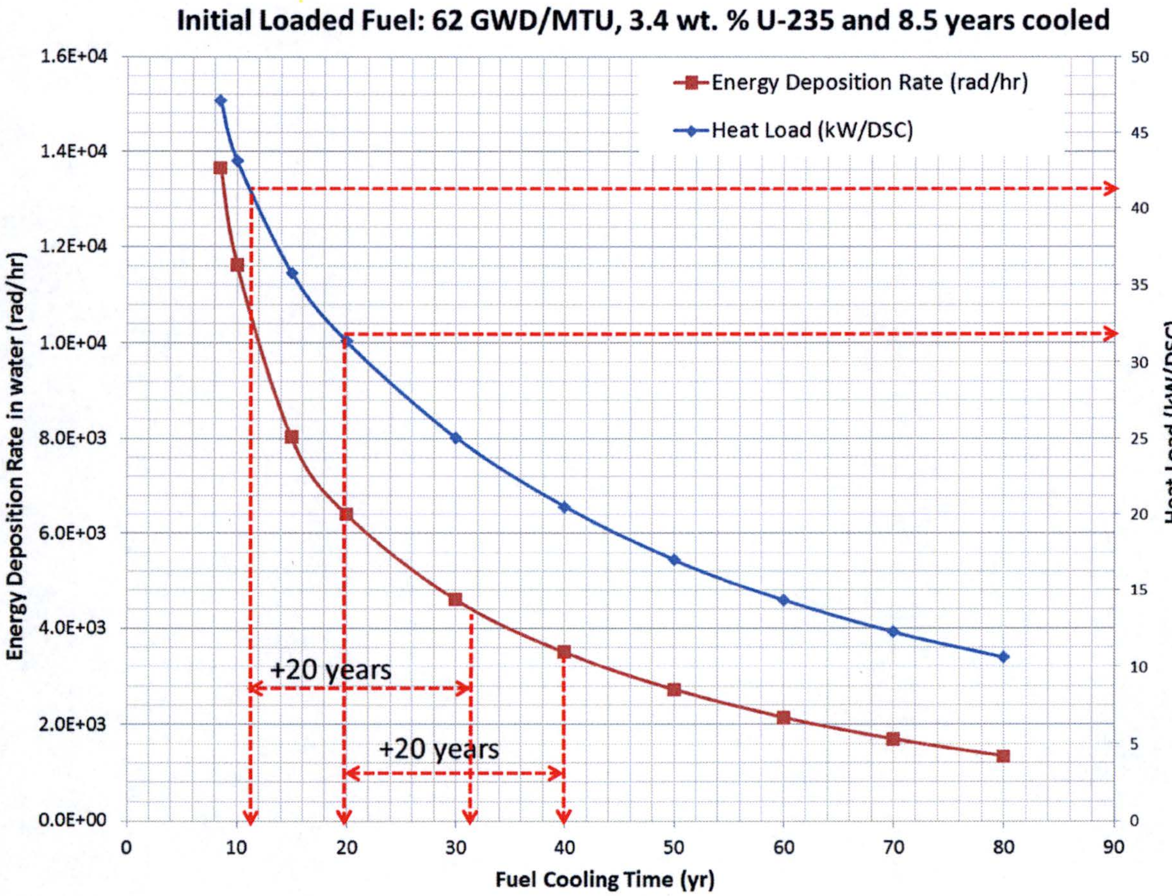

Figure 12.2-1
Heat Load vs. Energy Deposition Rate Curves

Proprietary Information on Pages 12.2-27 through 12.2-32
Withheld Pursuant to 10 CFR 2.390

12.3 Aging Management Program

Aging effects that could result in the loss of in-scope SSCs' intended function(s) are managed during the extended storage period. Many aging effects are adequately managed for the extended storage period using TLAA, as discussed in Section 12.2. An AMP is used to manage those aging effects that are not managed by TLAA. The AMPs that manage each of the identified aging effects for all in-scope SSCs include the following:

1. DSC External Surfaces Aging Management Program
2. DSC Aging Management Program for the Effects of Choride-Induced Stress Corrosion Cracking (Coastal Locations, Near Salted Roads, or in the Path of Effluent Downwind from the Cooling Tower(s))
3. Horizontal Storage Module Aging Management Program for External and Internal Surfaces
4. Horizontal Storage Module Inlets and Outlets Ventilation Aging Management Program
5. Transfer Cask Aging Management Program
6. High Burnup Fuel Aging Management Program

The AMPs are summarized in Table 12.3-1 through Table 12.3-6. Additional details are available in [12.19].

Table 12.3-1
DSC External Surfaces Aging Management Program
(2 Pages)

AMP Element	AMP Activity
Scope of Program	Inspection of external surfaces of the DSC shell assembly.
Preventative Actions	The program is a condition-monitoring program that does not include preventive actions.
Parameters Monitored or Inspected	• Surface Condition (Crevice Corrosion) • Surface Condition (Pitting Corrosion) • Surface Condition (Galvanic Corrosion) • Surface Condition, Cracks (Stress Corrosion Cracking)
Detection of Aging Effects	
Method or Technique:	Remote visual (general condition by VT-3; specific areas by VT-1 or equivalent).
Frequency:	At least once every 5 years ± 1 year.
Sample Size:	One or more DSCs at each ISFSI site unless bounded by another site's prior inspections.
Data Collection:	Record of the examination, photos, and videos. Records of any required corrective actions.
Timing of Inspections:	Generally, the initial baseline inspection will be performed on the selected DSC(s) prior to entering their period of extended operation; however, for general licensees who loaded early in the initial CoC licensed period, a graduated grace period is allowed
Monitoring and Trending	A baseline inspection is performed as part of the monitoring and trending activities so that the inspection results can be used for subsequent trending. The same DSC(s) shall be used for each subsequent examination for trending.
Acceptance Criteria	VT-3: No indication of pitting, rust, discoloration, or any indication of surface degradation. VT-1: • No indications of pitting or crevice corrosion • No indications of galvanic corrosion on the surface area contacting graphite lubricant • No indications of stress corrosion cracking • No indications of corrosion products near crevices • No indications of corrosion products on or adjacent to confinement boundary welds.
Corrective Actions	Deficiencies are either corrected, or are evaluated as acceptable for continued service through engineering analysis. Extent of condition investigation per the licensee's corrective action program may trigger additional inspections via a different method, increased inspection frequency and/or expanded inspection sample size.
Confirmation Process	Confirmatory actions, as needed, are implemented as part of the licensee's corrective action program.

Table 12.3-1
DSC External Surfaces Aging Management Program
(2 Pages)

AMP Element	AMP Activity
Administrative Controls	Administrative controls under the licensee's quality assurance procedures and corrective action program provide a formal review and approval process. Individual events and conditions not rising to the level of NRC reportability based on the criteria in 10 CFR Part 72 are communicated to the CoC holder.
Operating Experience	<u>Calvert Cliffs Nuclear Power Plant Experience</u> In 2012, Calvert Cliffs performed an inspection of the interior of two NUHOMS® HSMs and the exterior of their DSCs. On both DSCs selected for inspection, the entire surface of the top cover plate and the top cover plate weld were examined and found to be in good condition with no signs of corrosion. The shell of DSC-6 was observed to be in good general condition. A few small surface rust spots were noted on the DSC shell base metal. Calvert Cliffs believes that the few small spots of light rust on the shell were the result of contamination of the shell with free iron during fabrication or handling prior to being placed in service. The shell of DSC-11 (the lower heat load canister) was observed to be in good condition, and no signs of the rust were noted on the base metal or welds. The bottom end of both DSCs appeared polished, free of corrosion and in very good condition. Both grapple rings were examined and appeared to be in good condition.

Table 12.3-2
DSC Aging Management Program for the Effects of CISCC (Coastal Locations, Near Salted Roads, or in the Path of Effluent Downwind from the Cooling Tower(s))
(2 Pages)

AMP Element	AMP Activity
Scope of Program	This program monitors and inspects the external surfaces of DSCs for potential CISCC. The areas of DSC inspection inlcude fabrication welds of the confinement boundary and HAZ; crevice locations, upper surface of cylindrical shell; top and bottom ends of the cylinder, outer bottom cover plate, outer top cover plate. An ISFSI-specific evaluation is performed by the general licensee to determine if this AMP is applicable.
Preventative Actions	The program is a condition-monitoring program that does not include preventive actions.
Parameters Monitored or Inspected	• Surface Condition (Crevice Corrosion) • Surface Condition (Pitting Corrosion) • Surface Condition (Galvanic Corrosion) • Surface Condition, Cracks (Stress Corrosion Cracking)
Detection of Aging Effects	
Method or Technique:	Remote visual (general condition by VT-3; specific areas by VT-1 or equivalent).
Frequency:	At least once every 5 years ± 1 year.
Sample Size:	One or more DSCs at each ISFSI site unless bounded by another site's prior inspections.
Data Collection:	Record of the examination, photos, and videos. Records of any required corrective actions.
Timing of Inspections:	Generally, the initial baseline inspection will be performed on the selected DSC(s) prior to entering their period of extended operation; however, for general licensees who loaded early in the initial CoC licensed period, a graduated grace period is allowed.
Monitoring and Trending	A baseline inspection is performed as part of the monitoring and trending activities so that the inspection results can be used for subsequent trending. The same DSC(s) shall be used for each subsequent examination for trending.
Acceptance Criteria	VT-3: No indication of pitting, rust, discoloration, or any indication of surface degradation. VT-1: • No indications of pitting or crevice corrosion • No indications of stress corrosion cracking • No indications of corrosion products near crevices • No indications of corrosion products on or adjacent to confinement boundary welds. • No indications of galvanic corrosion on the surface area contacting graphite lubricant

Table 12.3-2
DSC Aging Management Program for the Effects of CISCC (Coastal Locations, Near Salted Roads, or in the Path of Effluent Downwind from the Cooling Tower(s))
(2 Pages)

AMP Element	AMP Activity
Corrective Actions	Deficiencies are either corrected, or are evaluated as acceptable for continued service through engineering analysis. Extent of condition investigation per the licensee's corrective action program may trigger additional inspections via a different method, increased inspection frequency and/or expanded inspection sample size.
Confirmation Process	Confirmatory actions, as needed, are implemented as part of the licensee's corrective action program.
Administrative Controls	Administrative controls under the licensee's quality assurance procedures and corrective action program provide a formal review and approval process. Individual events and conditions not rising to the level of NRC reportability based on the criteria in 10 CFR Part 72 are communicated to the CoC holder.
Operating Experience	NRC Information Notice 2012-20 (IN 2012-20) IN 2012-20 describes the potential for CISCC of austenitic stainless steel dry cask storage canisters. Several instances of CISCC have occurred in austenitic stainless steel components at nuclear power plants (NPPs) that were exposed to atmospheric conditions near salt-water bodies. The components that have failed because of this failure mechanism at NPPs are made from the same types of austenitic stainless steels typically used to fabricate dry cask storage system canisters. Calvert Cliffs Nuclear Power Plant (CCNPP) Experience Data analysis for the deposited salt collected from the DSC surface was conducted at Calvert Cliffs in 2012. Visual inspection on the DSC surfaces showed that the upper horizontal surface of the DSC canister was covered with dust layers of soil/clay and concrete material. Analysis of the deposits collected from the upper horizontal surface showed a relatively high concentration of sulfate, phosphate, and nitrate with little amount of chloride content. No visual indications of cracking were noted from the inspection. In 2012, CCNPP performed an inspection of the interior of two NUHOMS® HSMs and the exterior of the DSCs as part of their license renewal application. See Table 12.3-1's Operating Experience row for more details.

Table 12.3-3
HSM Aging Management Program for External and Internal Surfaces
(3 Pages)

AMP Element	AMP Activity
Scope of Program	Inspection of accessible internal and external HSM concrete and steel components and the ISFSI storage pad.
Preventative Actions	The program is a condition-monitoring program that does not include preventive actions.
Parameters Monitored or Inspected	For concrete structures, parameters monitored include: (1) cracking, loss of bond, and loss of material (spalling and scaling) due to corrosion of embedded steel, freeze-thaw, or aggressive chemical attack; (2) cracking due to expansion from reaction with aggregates alkali–silica reaction; (3) increase in porosity and permeability due to leaching of calcium hydroxide and carbonation or aggressive chemical attack; and (4) reduction of concrete anchorage capacity due to local concrete degradation. Cracking and distortion of the ISFSI pad due to settlement is also a parameter monitored based on operating experience. Groundwater chemistry sampling is used to monitor the below-grade inaccessible portions of the storage pad. Groundwater chemistry parameters monitored include pH, and sulfate and chloride concentrations. Carbon steel, stainless steel, and aluminum components are monitored for loss of material due to general, pitting, and crevice corrosion. Nitronic® DSC support rail plates are monitored for loss of material due to galvanic corrosion. Other conditions such as loose or missing anchors and missing or degraded grout are also part of the inspection. For coated HSM carbon steel subcomponents, the coating integrity is monitored for blistering, cracking, flaking, peeling, or other physical damage.
Detection of Aging Effects	The exterior surfaces of concrete and structural components are monitored using periodic visual inspection by qualified personnel to ensure that aging degradation will be detected and quantified before loss of intended functions. Potential degradation of the below-grade portion of the concrete pad is assessed by examining the results of groundwater sampling at a minimum of 3 locations in the area of the ISFSI at a frequency of 5 years ± 1 year.
Method or Technique:	Periodic visual inspections of the exterior and interior surfaces of HSM structures and structural components.
Frequency:	At least once every 5 years ± 1 year.
Sample Size:	One or more HSMs at each ISFSI site.
Data Collection:	Record of the examination, photos, and videos with crack maps developed. Records of any required corrective actions.
Timing of Inspections:	Generally, the initial baseline inspection will be performed on the selected HSM(s) prior to entering their period of extended operation; however, for general licensees who loaded early in the initial CoC licensed period, a graduated grace period is allowed.

Table 12.3-3
HSM Aging Management Program for External and Internal Surfaces
(3 Pages)

AMP Element	AMP Activity
Monitoring and Trending	A baseline inspection is performed as part of the monitoring and trending activities so that the inspection results can be used for subsequent trending. The same HSM(s) shall be used for each subsequent examination for trending. ACI 349.3R prescribes that crack maps shall be developed, monitored, and trended to identify progressive growth of defects that may indicate degradation due to specific aging effects such as alkali–silica reaction-induced expansion, freeze-thaw, or corrosion of rebar.
Acceptance Criteria	For metallic surfaces, any of the following indications of relevant degradation detected are evaluated: • Corrosion and material wastage (loss of material) • Crevice, pitting, and galvanic corrosion (loss of material) • Worn, flaking, or oxide-coated surfaces (loss of material) • Corrosion stains on adjacent components and structures (loss of material) • Surface cracks (cracking) • Stains caused by leaking rainwater For concrete, the following findings from a visual inspection are considered acceptable without requiring any further evaluation: • Absence of leaching and chemical attack, including microbiological chemical attack • Absence of signs of corrosion in the steel reinforcement • Absence of drummy areas (poorly consolidated concrete, air void with paste deficiencies per ACI 201.1R) • [ ] • Scaling less than [ ] • Spalling less than [ ] • Absence of corrosion staining of undefined source on concrete surfaces • [ ] • Passive settlements or deflections within the original design limits Coating acceptance criteria are established in accordance with ASTM D7167-12. Acceptance criteria for the groundwater chemistry sampling program are a pH $\geq$ 5.5, chloride concentration $\leq$ 500 ppm, and sulfate concentration $\leq$ 1500 ppm.
Corrective Actions	Deficiencies are either corrected or are evaluated to be acceptable for continued service through engineering analysis. Extent of condition investigation per the licensee's corrective action program may trigger additional inspections via a different method, increased inspection frequency and/or expanded inspection sample size.
Confirmation Process	Confirmatory actions, as needed, are implemented as part of the licensee's corrective action program.

Table 12.3-3
HSM Aging Management Program for External and Internal Surfaces
(3 Pages)

AMP Element	AMP Activity
Administrative Controls	Administrative controls under the licensee's QA procedures and corrective action program provide a formal review and approval process. Individual events and conditions not rising to the level of NRC reportability based on the criteria in 10 CFR Part 72 are communicated to the CoC holder.
Operating Experience	NUREG-1522 documents the results of a survey in 1992 to obtain information on the types of distress in the concrete and steel structures and components, the type of repairs performed, and the durability of the repairs. Licensees who responded to the survey reported cracking, scaling, and leaching of concrete structures. The degradation was attributed to drying shrinkage, freeze-thaw, and abrasion. The degradation also includes corrosion of component support members and anchor bolts, cracks and other deterioration of masonry walls, and groundwater leakage and seepage into underground structures. Information Notice IN 2013-07 provided operating experience on NUHOMS® DCSS systems that indicate water contributed to an accelerated aging process of concrete structures of the DCSS. NUHOMS® Experience HSM concrete cracking has been experienced in a few ISFSI installations with the primary cause being freeze-thaw damage. The concrete repair used a concrete mix with similar material properties to the original mix that has the ability to resist chloride ion penetration and good freeze-thaw resistance to ensure the HSM will continue to perform its original design functions. Calvert Cliffs Nuclear Power Plant Experience In 2012, Calvert Cliffs Nuclear Power Plant performed an inspection of the interior of two NUHOMS® HSMs and the exterior of the DSCs as part of their license renewal application. The accessible surfaces of the HSM concrete walls, roof, and floor all appeared to be in good condition with little to no signs of spalling or cracking. In both HSMs, the DSC structural support beams and rails were in good condition, with the coating intact in most areas. There were no signs of loose or missing bolting or fasteners. General corrosion of the carbon steel surface and bolting hardware was observed. TMI-2 at INL's Experience The Three Mile Island, Unit 2 ISFSI uses NUHOMS-12T HSMs. The licensee – the Department of Energy Idaho National Laboratory (INL), noted some cracks in the HSMs, crazing and spalling as well as increased efflorescence on the HSM surfaces. Cracking was observed in 28 of the 30 HSMs, in the area of the anchor bolt blockout holes with widths up to 0.95 centimeters (0.38 inches). Subsequent evaluations by the licensee determined that water had entered the anchor bolt blockout holes on the roof of the HSMs. Subsequent freeze and thaw cycles initiated the crack formation. Repetition of the process resulted in both continued crack growth and the efflorescence growth identified.

Table 12.3-4
HSM Inlets and Outlets Ventilation Aging Management Program

AMP Element	AMP Activity
Scope of Program	Visual inspection or thermal monitoring to verify that the HSM air inlets and outlet components are free from blockage.
Preventative Actions	The program is a condition-monitoring program. With the exception of daily surveillances to ensure HSM inlets and outlets are not obstructed, no preventive actions are performed.
Parameters Monitored or Inspected	Blockage of the inlet and outlet vents of the HSM.
Detection of Aging Effects	Daily visual inspections or remote monitoring of HSM temperatures are performed for all loaded HSMs to ensure that the HSM heat transfer function is maintained.
Method or Technique:	Visual inspections or remote HSM temperature indication.
Frequency:	Daily.
Sample Size:	All HSMs with loaded DSCs on the ISFSI site.
Data Collection:	Records of daily inspection or logs of remote HSM temperatures.
Timing of Inspections:	Daily
Monitoring and Trending	Inspections are performed daily and associated personnel are qualified in accordance with site-controlled procedures and processes as prescribed in Technical Specifications. Monitoring and trending activities are used to track degradation.
Acceptance Criteria	The inlet and outlet vents are free from blockage. The concrete temperatures are below the short-term concrete temperature limits for blocked vent condition.
Corrective Actions	If the surveillance shows blockage of air vents (inlets or outlets), they shall be cleared. Extent of condition investigation from the licensee's corrective action program may trigger additional inspections via a different method, increased inspection frequency and/or expanded inspection sample size.
Confirmation Process	Confirmatory actions, as needed, are implemented as part of the licensee's corrective action program.
Administrative Controls	Administrative controls under the licensee's QA procedures and corrective action program provide a formal review and approval process. Individual events and conditions not rising to the level of NRC reportability based on the criteria in 10 CFR 72 are communicated to the CoC holder.
Operating Experience	Partial blockage of HSM air inlet duct screens from snowfall has been identified by prior operating experience. Heat stored in and by the HSM thermal mass quickly melts any minor "snow build-ups" after the snowfall/movement ceases.

Table 12.3-5
Transfer Cask Aging Management Program
(2 Pages)

AMP Element	AMP Activity
Scope of Program	This program visually inspects and monitors the accessible TC subcomponent surfaces, including cask cavity surfaces (e.g., inner liner), and the OS197L supplemental shielding subcomponents, to ensure they are intact and free from loss of material due to general, crevice or pitting corrosion and loss of material due to wear.
Preventative Actions	The program is a condition-monitoring program. Demineralized water shall be used to fill the neutron shield, rather than municipal water. The neutron shield shall be drained before storage to prevent damage due to freezing and mitigate corrosion. When not in use the TC should be stored in a building or container that prevents direct exposure to precipitation. Tarpaulins, if used, should not be in contact with the TC surface to prevent accumulation of condensation. After fuel is loaded in the DSC and the cask is raised above the pool water surface, the cask is rinsed off with demineralized water.
Parameters Monitored or Inspected	Surface condition: wear, corrosion, and coating. Signs of leakage for the liquid neutron shield.
Detection of Aging Effects Method or Technique:	 Visual inspection per VT-3. Any area of the TC exhibiting evidence of possible crevices, pits, water stains or discoloration during the VT-3 examinations is subjected to a VT-1 examination per IWA-2211. Fasteners are inspected for threaded parts condition, corrosion, and signs of wear or other degradation. PT Exams of the upper and lower trunnion bearing surface and the accessible upper and lower trunnion welds. VT-3 exam is also performed to detect any signs of neutron shield leakage (TC with liquid neutron shield only) with VT-1 employed if there are any signs of corrosion.
Frequency:	VT-3: once per five years VT-1 if indications of possible deterioration during VT-3 inspection PT: once per five years Liquid neutron shield: once per five years
Sample Size: Data Collection:	Each TC. Records of inspection. Photos or video. Records of any required corrective actions.
Timing of Inspections:	At frequency defined above. If the TC has not been used for more than 5 years, TC aging management is not required, but the inspection must be performed prior to next use of the TC.
Monitoring and Trending	A baseline inspection is performed as part of the monitoring and trending activities so that the inspection results can be used for subsequent trending.

Table 12.3-5
Transfer Cask Aging Management Program
(2 Pages)

AMP Element	AMP Activity
Acceptance Criteria	• VT-3 and VT-1 examinations in accordance with Section XI IWA-2213 and IWA-2211, respectively. If corrosion on any of the transfer cask subcomponents or wear of the inner liner thickness are detected, the finding is entered into the licensee's corrective action program to determine, based on engineering evaluation, the extent and impact of the corrosion on the ability of the TC to perform its intended function. • PT exam acceptance of the trunnion bearing surfaces and accessible welds per ASME Section III, NC-5350. • Acceptable coatings are free of peeling or delamination. Blistering, cracking, flaking, rusting, and physical damage will be evaluated to determine acceptability.
Corrective Actions	Unsatisfactory degradation is entered in a corrective action program for resolution. Deficiencies are either corrected or are evaluated to be acceptable for continued service through engineering analysis. Extent of condition investigation per the licensee's corrective action program may trigger additional inspections via a different method, increased inspection frequency and/or expanded inspection sample size.
Confirmation Process	Confirmatory actions, as needed, are implemented as part of the CoC holder or licensee's corrective action program, as applicable.
Administrative Controls	Administrative controls under the CoC holder or licensee's QA procedures and corrective action program provide a formal review and approval process. Licensee individual events and conditions not rising to the level of NRC reportability based on the criteria in 10 CFR 72 are communicated to the CoC holder.
Operating Experience	The overall effectiveness of these inspections/activities in maintaining the condition and functionality of the casks is supported by the continued use of the transfer casks and their continued compliance with the certificate of compliance.

Table 12.3-6
High Burnup Fuel Aging Management Program
(2 Pages)

AMP Element	AMP Activity
Scope of Program	The High Burnup (HBU) Fuel Aging Management Program (AMP) is a generic program that is applicable to all licensees storing HBU FAs. The scope of the program includes factors that could affect the ability to comply with 10 CFR 72.122(h)(1) and (l), including fuel cladding temperature, fuel cladding breach, assembly distortion, residual moisture after drying, changes in the hydride structure of the cladding and cladding creep.
Preventative Actions	The HBU Fuel AMP is a condition-monitoring program to confirm there is no degradation of HBU FA that would result in a loss of intended function(s). However, the existing design limits placed on loading operations constitute preventive actions.
Parameters Monitored or Inspected	• Fuel cladding temperature • Cavity gas temperature, pressure, and gas composition
Detection of Aging Effects	Since limited AMP action can be taken inside a sealed DSC, this program relies on the surrogate monitoring inspections of the DOE's High Burnup Dry Storage Cask Research and Development Project (HDRP) or alternative program to verify no unexpected aging effects or identify such if they occur. The instrumentation detection techniques for the parameters monitored or inspected in the HDRP should meet the guidance in ISG-24.
Monitoring and Trending	As information from the HDRP becomes available, the licensees will monitor, evaluate, and trend the information via their operating experience program, corrective action program, or both to determine what actions should be taken to manage fuel and cladding performance, if any. Similarly, the licensees will determine what actions should be taken if they receive information from other sources than the HDRP on fuel performance.
Acceptance Criteria	If any of the following fuel performance criteria are not met in the HDRP, a corrective action is required: • Cladding Temperature – The maximum cladding temperature measured is less than or equal to that predicted by the thermal analysis methods in the UFSAR for the affected DSCs • Cladding Creep – total creep strain extrapolated to the total approved storage duration based on the best fit to the data, accounting for initial condition uncertainty shall be less than [ ] • Hydrogen – maximum hydrogen content of the cover gas over the approved storage period shall be extrapolated from the gas measurements to be less than [ ] • Drying – The moisture content in the DSC, accounting for measurement uncertainty, shall be less than the expected upper bound residual moisture content per the design-bases drying process. A total [ ] of residual water criterion is a reasonable upper bound • Fuel rod breach – fission gas analysis shall not indicate more than [ ] of the fuel rod cladding breaches

Table 12.3-6
High Burnup Fuel Aging Management Program
(2 Pages)

AMP Element	AMP Activity
Corrective Actions	The licensee's and CoC holder's corrective action programs shall capture and evaluate HDRP data, other information, and additional operating experience to initiate timely corrective actions, extent of condition evaluation, and actions to prevent reoccurrence. Corrective actions shall be implemented if data from a surrogate demonstration program or other sources of information indicate that any of the acceptance criteria in [12.19, Section 6A.8.2.6] for the HDRP are not met.
Confirmation Process	Confirmatory actions, as needed, are implemented as part of the licensee's and CoC holder's corrective action program to verify that corrective actions and preventive actions have been completed and are effective. The focus of the confirmation process is on the follow-up actions that must be taken to verify effective implementation of corrective actions. The measure of effectiveness is in terms of correcting the adverse condition and precluding repetition of significant conditions adverse to quality.
Administrative Controls	Administrative controls are implemented in accordance with the requirements of 10 CFR Part 50, Appendix B, and will continue for the period of extended operation. Individual events and conditions not rising to the level of NRC reportability based on the criteria in 10 CFR 72 are communicated to the CoC holder.
Operating Experience	Surrogate surveillance demonstration programs with storage conditions and fuel types similar to those in the dry storage system and that satisfy the ISG-24 acceptance criteria are a viable method to obtain operating experience. Data from other national and international programs, such as destructive testing of HBU fuel, shall also be monitored. The HBU tollgate process in Section 12.5.3.4 mentions several such programs to be monitored, and provides the mechanism for updating the HBU TLAAs and this AMP in response to new OE. The DOE HDRP will provide important degradation information and/or confirm degradation models to support establishment of the technical bases for extended storage.

12.4 Retrievability

Retrievability is the ability to remove spent nuclear fuel from storage. ISG-2 Revision 1 [12.15] provides NRC staff guidance on the subject of fuel retrievability.

The Standardized NUHOMS® System is designed to allow ready retrieval of the SFAs for further processing and disposal, in accordance with 10 CFR 72.122(1). As discussed in ISG-2, ready retrieval of the SFAs from the DSC requires: (1) the ability to transfer the DSC to a spent fuel pool (or other facility), and (2) the ability to unload the SFAs from the DSC for repackaging to allow removal from the reactor site, transportation, and ultimate disposition by the DOE.

The sliding surfaces of the DSC support rails of all the HSMs are fabricated from Nitronic® 60 austenitic stainless steel and are coated with a dry film lubricant to minimize friction during insertion and retrieval of the DSC. Graphite lubricants are suitable for very high and cryogenic temperature applications. The effect of radiation on these lubricants is minimal, since these are inorganic and consist entirely of graphite. The coefficient of friction associated with these lubricants is below 0.05, while the design basis calculations employed a coefficient of friction of 0.25. The mechanical system to be used for DSC transfer is capable of exerting an extraction force equal to the loaded weight of a DSC. Depending on the DSC type, an effective coefficient of friction ranging from 72 to 100% of the loaded DSC weight has been used for these "jammed DSC" analyses. The support structure is also designed for this loading. Therefore, loss of lubrication is not an aging effect requiring management since the dry film lubricant is not relied upon for DSC retrieval.

[12.19, Appendix 3N] presents the evaluation to demonstrate that the confinement function of the DSC is maintained and that the requirement of ready retrieval of the DSC from the HSM is met. This evaluation demonstrates that, even when conservatively assuming initial temperatures and internal pressure for normal storage conditions and an extraction force of 80 kips (about 2.5 times the expected sliding force per UFSAR, Section U.3.6.1.1 for the analyzed DSC), the DSC shell thickness could be reduced to 0.25 in. and the DSC shell stresses required to maintain confinement and to ensure retrievability are below the ASME Code Level A stress limits.

The results of the AMR, along with the AMAs, provide reasonable assurance that SFAs will be retrievable. [12.19, Appendix 3J] presents an assessment of HBU cladding stresses under normal storage conditions including the handling loads associated with retrievability of the FA from the DSC. The evaluation shows that cladding stresses due to handling of the FA are well below yield and do not impose ductility demands on the cladding. Other fuel assembly hardware (e.g., spacer grids, top and bottom nozzles, guide tubes, etc.) is less limiting. Thus, the SFAs will be capable of being retrieved by normal means. Based on the AMR results of the SFAs and the implementing AMPs for the DSC, HSM and HBU fuel, there is reasonable assurance that the SFAs will be retrievable by normal means during the period of extended operation.

12.5 Tollgate Assessments

Tollgate assessments are written evaluations, performed by licensees at each tollgate, of the aggregate impact of aging-related dry cask storage system OE, research, monitoring, and inspections on the intended functions of in-scope SSCs. Tollgate assessments are intended to include non-nuclear and international operating information on a best-effort basis. Corrective or mitigative actions arising from tollgate assessments are managed through the corrective action program of the licensee and/or the CoC holder.

General licensees have tollgate assessment responsibilities, as discussed below.

12.5.1 Tollgate Assessments by General Licensees

During the twenty-fifth calendar year following initial loading of a general licensee ISFSI, that general licensee shall conduct and document a tollgate assessment, which should address the following areas:

- A summary of research findings, OE, monitoring data, and inspection results
- Aggregate impact of findings
- Consistency with assumptions and inputs in TLAAs
- Effectiveness of AMPs
- Corrective actions
- Summary and conclusions

Evaluate information from the following sources and perform a written assessment of the aggregate impact of the information:

  - DOE/EPRI High Burnup Dry Storage Cask Research and Development Project" (HDRP)
  - EPRI chloride-induced stress corrosion cracking (CISCC) research
- Relevant results of other domestic and international research (including non-nuclear)
- Relevant domestic and international OE (including non-nuclear)
- Relevant results of domestic and international ISFSI and dry cask storage system performance monitoring
- Relevant results of domestic and international ISFSI and dry cask storage system inspections

See Section 12.5.3 for description of CoC 1004 aging management tollgates.

12.5.2 The Role of the CoC Holder for Tollgate Assessments

Upon request, the CoC holder shall use OE information provided by the general licensees related to the areas required to be covered in the tollgate assessment.

12.5.3 Aging Management Tollgates

12.5.3.1 Introduction

Aging management programs (AMPs) are defined in [12.19, Appendix 6A] for the horizontal storage module (HSM) concrete and steel, for the dry shielded canister (DSC) external surfaces, for the transfer cask (TC), for atmospheric chloride-induced stress corrosion cracking (CISCC) of the DSC, and for the integrity of high burnup (HBU) fuel cladding. These AMPs are subject to modification under 10 CFR 72.48 as new operating experience (OE) accumulates.

For two of these AMPs, the present state of knowledge and the difficulty of directly inspecting for the aging effects requires that the process of periodic assessment and, if necessary, revision of the AMPs, be formalized by a tollgate process:

1. DSC AMP for the Effects of CISCC [12.19, Appendix 6A.4]
2. HBU Fuel AMP [12.19, Appendix 6A.8]

12.5.3.2 Generic Tollgate Process

This application adopts these definitions from the draft NEI 14-03 [12.16]:

Tollgate A requirement included in a renewed certificate of compliance (CoC) and associated Updated Final Safety Analysis Report (UFSAR) for the licensee to perform and document an assessment of the aggregate impact of aging-related dry cask storage (DCS) OE, research, monitoring, and inspections at specific points in time during the renewed operating period.

Tollgate Assessment A written evaluation, performed by licensees at each tollgate, of the aggregate impact of aging-related DCS OE, research, monitoring, and inspections on the intended functions of in-scope DCS structures, systems, and components (SSCs). Tollgate assessments are intended to include non-nuclear and international operating information on a best-effort basis. Corrective or mitigative actions arising from tollgate assessments are managed through the corrective action programs of the licensee, the certificate holder, or both.

Corrective actions may include

- Modification of time-limited aging analyses (TLAAs)
- Adjustment of the scope, frequency, or both of AMPs
- Repair or replacement of SSCs

Licensees and AREVA Inc. assess new information relevant to aging management, as it becomes available, in accordance with normal corrective action and OE programs. Tollgates are an opportunity to seek out other information that may be available and perform an aggregate assessment.

Assessments are not stopping points. No action other than performing an assessment is required to continue NUHOMS® dry storage system operation.

The tollgate process applies only to those licensees for whom the corresponding AMP applies.

Tollgate assessment reports are not required to be submitted to the NRC, but are available for inspection.

12.5.3.3 CISCC Tollgates

Table 12.5-1 defines the tollgates for the DSC AMP for the Effects of CISCC. The tollgate schedule may be accelerated (i.e., the next tollgate is performed earlier) whenever sufficient new information has accumulated that could warrant a change in the AMP.

12.5.3.4 High Burnup Fuel Tollgates

Table 12.5-2 defines the tollgates for the HBU Fuel AMP. If, at the second or further tollgates, the assessment confirms the ability of the HBU fuel assemblies (FAs) to perform their intended functions for the remainder of the period of extended operations, subsequent assessments may be cancelled.

If at any tollgate the information available is insufficient to demonstrate the ability of the HBU FAs to perform their intended functions through the period to the next tollgate, then

1. the interval to the next tollgate shall be shortened, and
2. the licensee shall either demonstrate that no more than 1% of fuel rods in any canister has failed, or shall evaluate the consequences of failure in excess of 1%.

The tollgate schedule may be accelerated (i.e., the next tollgate is performed earlier) whenever sufficient new information has accumulated that could warrant a change in the AMP.

Table 12.5-1
DSC AMP for the Effects of CISCC Tollgates

Tollgate	Year	Assessment
1	per [12.19, Appendix 6A.4]	Perform initial inspection of selected DSCs as specified in [12.19, Appendix 6A.4] and as updated at the time that planning for the inspection begins.
2	$T_o + 5$ (note 1)	Evaluate information from the following sources and perform a written assessment of the aggregate impact of the information, including but not limited to corrective actions required and the effectiveness of the CISCC AMP [12.19, Appendix 6A.4]: • Results of research and development programs focused specifically on initiation, propagation, inspection, and mitigation of atmospheric CISCC, such as those conducted by Electric Power Research Institute (EPRI), Central Research Institute of Electric Power Industry (CRIEPI), the Department of Energy (DOE), and DOE/University programs • Results of tollgate 1 inspections, including trending of chloride surface concentration, temperature, and humidity conditions compared to the latest research on CISCC initiation. • Relevant results of other domestic and international nuclear and non-nuclear research. • Relevant domestic and international nuclear and non-nuclear OE. • Relevant results of domestic and international performance monitoring for welded canister dry storage systems. • Relevant results of domestic and international inspections of welded canister dry storage systems. • Availability of improved technologies to inspect DSCs for stress corrosion cracking and for chemistry of surface deposits.
3	T_o+10	Evaluate additional information gained from the sources listed in tollgate 2 along with any new relevant sources and perform a written assessment of the aggregate impact of the information, including results of tollgate 2. The age-related degradation mechanisms evaluated at this tollgate and the time at which it is conducted may be adjusted based on the results of the tollgate 2 assessment.
4	T_o+20	Same as tollgate 2 as informed by the results of tollgates 2 and 3
5	T_o+30	Same as tollgate 3 as informed by the results of tollgates 2, 3, and 4

Notes:
T_o is twenty years after the first DSC at the ISFSI was loaded.

Table 12.5-2
High Burnup Fuel AMP Tollgates

Tollgate	Year	Assessment
1	$T_o + 5$ (note 1)	Evaluate information from the following sources and perform a written assessment of the aggregate impact of the information, including but not limited to corrective actions required and the effectiveness of the HBU AMP [12.19, Appendix 6A.8] • Initial data on gas analysis and cladding temperature from the EPRI and DOE "High Burnup Dry Storage Cask Research and Development Project" (HDRP) [12.17] or an alternative program meeting the guidance in Interim Staff Guidance (ISG) 24 [12.18]. • Published research into HBU fuel performance in dry storage and transport, including fuel swelling, ductile to brittle transition of cladding, and mechanical testing by DOE national laboratories, the Institute for Transuranium Elements (ITU, Karlsruhe), Japan Nuclear Energy Safety Organization (JNES), Commissariat à l'énergie atomique et aux énergies alternatives (CEA), Korea Atomic Energy Research Institute (KAERI), etc.
2	T_o+10	Evaluate, if available, information obtained from the destructive and non-destructive examination of the fuel placed into storage in the HDRP along with other available sources of information. If the destructive examination data from the HDRP has not been obtained in time to support the assessment required by this tollgate, then the general licensee will coordinate with the certificate holder and the certificate holder will submit a CoC amendment application to the NRC outlining plans to obtain evidence to demonstrate that the fuel performance acceptance criteria in [12.19, Section 6A.8.2.6] continue to be met.
3	T_o+20	Same as tollgate 2, as informed by the results of tollgates 1 and 2
4	T_o+30	Same as tollgate 3, as informed by the results of tollgates 1, 2, and 3

Notes:

1) T_o is twenty years after the first DSC at the ISFSI was loaded with fuel with assembly-averaged burnup > 45 GWd/MTU.

12.6 References

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12.19 Enclosure 3, "Certificate of Compliance Renewal Application for the Standardized NUHOMS® System, Certificate of Compliance No. 1004 (Docket No. 72-1004), Revision 3 (Proprietary Version)," to Letter from Jayant Bondre (AREVA TN) to NRC Document Control Desk, "Response to Re-Issue of Second Request for Additional Information - AREVA Inc. Renewal Application for the Standardized NUHOMS® System - CoC 1004 (Docket No. 72-1004, CAC No. L24964)," dated September 29, 2016.

C.4.1 DSC Fatigue Analysis

NOTE: The discussion that follows is for the DSC fatigue analysis for the period of initial licensing. The TLAA for DSC fatigue analysis, performed for the initial CoC 1004 renewal application, is provided in Section 12.2.1.

Renewal

Fatigue effects on the DSC are addressed using the criteria contained in NB-3222.4 of the ASME Code (Reference C-3). Fatigue effects need not be specifically evaluated provided the criteria contained in NB-3222.4(d) are met. A summary of the six criteria and their application to the DSC are presented in the paragraphs which follow:

A. The first criterion states that the DSC is adequate for fatigue effects provided that the total number of atmospheric-to-operating pressure cycles during normal operation (including startup and shutdown) does not exceed the number of cycles on the applicable fatigue curve corresponding to an S_a value of three times the S_m value of the material at operating temperatures. This condition is satisfied for the DSC since the pressure is not cycled during its design life. The pressure established at the time that the DSC is sealed following fuel loading and DSC closure operations is maintained during normal storage in the HSM.

B. The second criterion states that DSC is adequate for fatigue effects provided that the specified full range of pressure fluctuations during normal operation does not exceed the quantity (1/3) x design pressure x (S_a/S_m), where S_a is the value obtained from the applicable fatigue curve for the total specified number of significant pressure fluctuations, and S_m is the allowable stress intensity for the material at operating temperatures. Significant pressure fluctuations are those for which the total excursion exceeds (1/3) x design pressure x (S/S_m), where S equals the value of S_a for 10^6 cycles. For a DSC maximum normal operating pressure of 6.9 psig, an S_m value of 18,700 psi, and an S value of 28,200 psi, the total range for a significant pressure fluctuation is 3.5 psig. This small pressure fluctuation may occur during normal storage as a result of seasonal ambient temperature changes. Ambient temperature cycles significant enough to cause a measurable pressure fluctuation are assumed to occur five times per year for 50 years. The number of fluctuations with this pressure range is expected to be 250 for the DSC. The value of S_a associated with this number of cycles is 186 ksi. Hence the value of (1/3) x design pressure x (S_a/S_m) is equal to 22.9 psig. Clearly this value will not be exceeded during the pressure fluctuation of the DSC. Therefore the second criterion is satisfied for the DSC.

C. The third criterion states that the DSC is adequate for fatigue effects provided that the temperature differences between any two adjacent points on the DSC during normal operation do not exceed $S_a/2E\alpha$, where S_a is the value obtained from the applicable fatigue curve for the specified number of startup-shutdown cycles, α is the instantaneous coefficient of thermal expansion at the mean value of the temperatures at the two points, and E is the modulus of elasticity at the mean value of the temperatures at the two points. For an operational cycle of the DSC, thermal gradients occur during fuel loading, DSC closure, transfer to the HSM, and transfer of the DSC to the HSM. This half-cycle is approximately reversed

Renewal

for DSC unloading operations. However, this normal operational cycle occurs only once in the 50-year design service life[1] of a DSC. Since there is only one startup-shutdown cycle associated with the DSC, the value of S_a is very large (>800 ksi). Hence the value of $S_m/2E\alpha$ is very large (>1500°F). This is far greater than the temperature difference between any two adjacent points on the canister. Thus, the third criterion is satisfied for the DSC.

D. The fourth criterion states that the DSC is adequate for fatigue effects provided that the temperature difference between any two adjacent points on the DSC does not change during normal operation by more than the quantity $S_a/2E\alpha$, where S_a is the value obtained from the applicable fatigue curve for the total specified number of significant temperature-difference fluctuations. Small fluctuations in the DSC thermal gradients during normal storage in the HSM occur as a result of seasonal ambient temperature changes. Ambient temperature cycles significant enough to cause a measurable thermal gradient fluctuation are assumed to occur five times per year for 50 years. The DSC stresses resulting for thermal gradient fluctuations are small since the structural capacity of the DSC is designed for extreme accident loads such as cask drop loads which are postulated to be a one time occurrence. A temperature difference fluctuation is considered to be significant if its total algebraic range exceeds the quantity $S/2E\alpha$, where S is the value of S_a obtained from the applicable fatigue curve for 10^6 cycles. Taking the value of S = 28,200 psi, E = 26.6 x 10^6 psi and α = 9.8 x 10^{-6} in./in./°F, the value of $S/2E\alpha$ = 54°F. The most significant fluctuation in normal operating temperature occurs during a change in ambient temperature from 0°F to 100°F. This fluctuation results in an estimated change of temperature difference of 20°F. The effects of this temperature difference is not significant, therefore the fourth condition is satisfied for the DSC.

[1] *With NRC approval of the CoC 1004 renewal application, the license is extended to a total of 60 years. The TLAAs identified as #1, #4, and #5 in Section 12.2 performed for the renewal of this design conservatively used a service life of 100 years.*

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E. The fifth criterion states that for components fabricated from materials of differing moduli of elasticity or coefficients of thermal expansion, the total algebraic range of temperature fluctuation experienced by the component during normal operation must not exceed the magnitude $S_a/2(E_1\alpha_1 - E_2\alpha_2)$, where S_a is the value obtained from the applicable fatigue curve for the total specified number of significant temperature fluctuations, E_1 and E_2 are the moduli of elasticity, and α_1 and α_1 are the values of the instantaneous coefficients of thermal expansion at the mean temperature value involved for the two materials of construction. A temperature fluctuation is considered to be significant if its total excursion exceeds the quantity $S/2(E_1\alpha_1 - E_2\alpha_2)$, where S is the value of S_a obtained from the applicable fatigue curve for 10^6 cycles. If the two materials used have different applicable design fatigue curves, the lower value of S_a shall be used. Since the structural material used to construct the DSC is homogeneous (all materials are stainless steel), this fifth condition is not applicable.

C.4.2 Transfer Cask Fatigue Analysis

NOTE: The discussion that follows is for the TC fatigue analysis for the period of initial licensing. The TLAA for TC fatigue analysis, performed for the initial CoC 1004 renewal application, is provided in Section 12.2.2.

Renewal

Fatigue effects on the transfer cask are addressed using the criteria contained in NC-3219.2 of the ASME Code (Reference C-3). Fatigue effects need not be specifically evaluated provided the criteria contained in NC-3219.2 (Condition A or Condition B) are met. In this evaluation the six criteria contained in Condition B are addressed. A summary of the six criteria and their application to the transfer cask are presented in the paragraphs which follow:

A. The first criterion states that the transfer cask is adequate for fatigue effects provided that the total number of atmospheric-to-operating pressure cycles during normal operation does not exceed the number of cycles on the applicable fatigue curve corresponding to an S_a value of three times the S_m value of the material at operating temperatures. The transfer cask is not a pressure retaining boundary, hence this first criterion is not applicable.

B. The second criterion states that transfer cask is adequate for fatigue effects provided that the specified full range of pressure fluctuations during normal operation does not exceed the quantity (1/30 x design pressure x (S_a/S_m), where S_a is the value obtained from the applicable fatigue curve for the total specified number of significant pressure fluctuations, and S_m is the allowable stress intensity for the material at operating temperatures. Significant pressure fluctuations are those for which the total excursion exceeds (1/3) x design pressure x (S/S_m), where S equals the value of S_a for 10^6 cycles. Since the transfer cask is not pressure retaining, this second criterion is not applicable.

C. The third criterion states that the transfer cask is adequate for fatigue effects provided that the temperature differences between any two adjacent points on the transfer cask during normal operation do not exceed $S_a/2E\alpha$, where S_a is the value obtained from the applicable fatigue curve for the specified number of startup-shutdown cycles, α is the instantaneous coefficient of thermal expansion at the mean value of the temperatures at the two points, and E is the modulus of elasticity at the mean value of the temperatures at the two points. The temperature difference is a maximum for a point on the inner surface of the cask and the corresponding point on the outer surface of the cask, through the cask wall thickness. It is conservatively postulated that the transfer cask will be used approximately 1,200 times during its designed life to transfer DSCs to and from the HSMs. The S_a associated with this number of cycles is 75 ksi. Therefore the quantity $S_a/2E\alpha = 168$ °F. The maximum temperature difference between any two adjacent points on the transfer cask is conservatively calculated as 70 °F. Therefore this criterion is satisfied for the transfer cask.

D. The fourth criterion states that the transfer cask is adequate for fatigue effects provided that the temperature difference between any two adjacent points on the

a comparative evaluation with the solid steel shield plug design, and a discussion of the licensing acceptability basis is provided in this Appendix.

As shown in this Appendix, the margins of safety demonstrated in the CSAR are not reduced by use of the long cavity DSC design. Operations and technical specifications are also unaffected. Therefore, the long cavity DSC described herein and in Appendix E is acceptable for use with the NUHOMS® system, and meets all applicable requirements of 10 CFR 72.

Aging Management Program Requirements

AMP requirements for use of the 24P Long Cavity System during the period of extended storage operations are contained in Section 12.3. TLAAs performed for the initial CoC 1004 renewal application are provided in Section 12.2.

H.1.2 Description

With the exception of the shield plugs and support rods, the long cavity DSC is nearly identical to the standardized NUHOMS®-24P DSC. The external dimensions of the long cavity DSC are identical to those of the standard length DSC, as shown in Figure 4.2-1.

The top shield plug assembly is a stand-alone, cast lead-encased component, located between the support ring of the DSC shell and the inner top cover plate. The top shield plug is not welded or otherwise connected to the DSC shell or inner top cover plate. The casing is fabricated of welded carbon steel plates and the interior is cast lead. Both, the inner and outer top cover plates remain unchanged from the standard 24P design. The overall composite thickness of the plug is 5.0 inches

The bottom shield plug is a cast lead-encased component, structurally integrated with the outer bottom cover plate and the grapple ring assembly. The bottom shield plug is placed into the bottom end of the DSC during fabrication. This is similar to the process for installing the solid steel shield plug. The composite thickness of the bottom plug is 5.25 inches. The resulting cavity length of the DSC is a nominal 173 inches. The outer bottom cover plate is welded to the DSC shell and is part of the DSC pressure and containment boundary. The design of the top and bottom lead shield plug is shown in Figures H-1 and Figure H-2.

Both the top and bottom shield plugs designs incorporate radial stiffeners and a ring stiffener located at the center of the shield plug. Radial stiffeners connect the top and bottom plates of the shield plugs, provide shear transfer capability between the top and bottom plates, and allow the plug steel assembly to act as a composite section. The ring stiffener provides additional connection between the top and bottom plates and also serves to ease the connection of the radial stiffeners at the center of the shield plug.

The incorporation of lead shield plugs into the DSC results in some minor changes to certain DSC components. At the bottom end of the DSC, the inner bottom cover plate location is moved 2.75 inches closer to the bottom of the canister. At the top end of the DSC, the support ring, lifting lugs, and the machined step on the vent and siphon block are moved 3.25 inches closer to the top end of the canister. This reflects the thinner lead shield plugs, and results in an additional 6.00 inch long cavity, as shown in Figure 4.2-1. The cover plates to DSC shell weld details are unaffected. Also, as shown in Figure 4.2-2, the support rod length is 6.00 inches longer because of the longer cavity.

J.1 General Description

J.1.1 Introduction

The purpose of this amendment application is to add intact Burnable Poison Rod Assemblies (BPRAs) and BPRAs with cladding failures for the B&W 15x15 and Westinghouse 17x17 fuel assembly types as authorized contents of the NUHOMS® 24P Long Cavity DSC. The evaluations in this Appendix address the impact of these BPRAs on the previously approved structural, thermal, shielding and criticality analyses.

Aging Management Program Requirements

AMP requirements for use of the 24P Long Cavity System during the period of extended storage operations are contained in Section 12.3. TLAAs performed for the initial CoC 1004 renewal application are provided in Section 12.2.

J.1.2 General Description of the Storage Cask

The Cask description remains unchanged. Only the authorized contents of the Cask changes with this amendment request.

K.1 General Discussion

Appendix K addresses the Important to Safety aspects of storing spent fuel in the NUHOMS®-61BT system.

The NUHOMS®-61BT system consists of a NUHOMS®-61BT Dry Shielded Canister (DSC) stored in a Model 80 or Model 102 or Model 152 or Model 202 NUHOMS® Horizontal Storage Module (HSM). The storage of the NUHOMS®-61BT DSC in HSM Models 152 and 202 is described and evaluated in UFSAR Appendix R and Appendix V, respectively, and is not addressed further in this Appendix. In addition, an upgraded version of the HSM, designated as HSM-HS, is also provided to allow storage of the NUHOMS®-61BT DSC in locations where higher seismic levels exist. The HSM-HS design configuration, described in UFSAR Appendix U.1, is modified to accommodate the smaller diameter of the NUHOMS®-61BT DSC. The generic term, "HSM," as used in this Appendix, refers to Model 80, Model 102, Model 152, Model 202, HSM-H, or HSM-HS except where a specific HSM configuration is called out.

The NUHOMS®-61BT DSC is transferred in an OS197 or OS197H or OS197L Transfer Cask (TC). The use of the OS197L TC for the transfer of the NUHOMS®-61BT DSC is described and evaluated in Appendix W.1 and is not addressed further in this Appendix. The NUHOMS®-61BT DSC is also transferred in a modified version of the OS200 TC described in Appendix U.1. The OS200 TC is fitted with an aluminum sleeve and a cask spacer to accommodate the smaller diameter and shorter length of the 61BT DSC. The generic term, "TC," as used in this Appendix, refers to OS197 or OS197H or OS200 transfer cask except where a specific TC configuration is called out.

The analysis presented in this Appendix shows that the NUHOMS®-61BT system meets all the requirements of 10CFR72 [1.2].

The NUHOMS®-61BT system provides confinement, shielding, criticality control and passive heat removal independent of any other facility structures or components. The NUHOMS®-61BT DSC also maintains structural integrity of the fuel during storage.

The addition of NUHOMS®-61BT DSC to the standardized NUHOMS® system was approved by the NRC effective September 12, 2001 as documented in Amendment No. 3 to CoC 1004 and the associated Safety Evaluation Report [1.4].

The list of approved contents authorized for storage in the NUHOMS®-61BT system was revised to include additional fuel types and damaged fuel as documented in Amendment No. 7 to CoC 1004 [1.7] and the associated Safety Evaluation Report.

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

Aging Management Program Requirements

AMP requirements for use of the 24P Long Cavity System during the period of extended storage operations are contained in Section 12.3. TLAAs performed for the initial CoC 1004 renewal application are provided in Section 12.2.

Any changes on this page are a part of CoC 1004 renewal.

K.2.3 Safety Protection Systems

K.2.3.1 General

The NUHOMS®-61BT DSC is designed to provide storage of spent fuel for at least 40 years. [1] The cask cavity pressure is always above atmospheric during the storage period as a precaution against the in-leakage of air which could be harmful to the fuel. Since the confinement vessel consists of a steel cylinder with an integrally-welded bottom closure, and a seal welded top closure that is verified to be leak tight after loading, the cavity gas cannot escape. Renewal

Only those features that are not addressed in Chapter 3, or have been revised, are addressed in this Section. Those features include the thermal and nucleonic performance of the poison plates, and their acceptance. Components of the NUHOMS®-61BT DSC that are "Important to Safety" and "Not Important to Safety" are listed in Table K.2-8.

K.2.3.2 Protection By Multiple Confinement Barriers and Systems

The NUHOMS®-61BT DSC provides a leak tight confinement of the spent fuel. Although similar to the existing -52B DSC, sealing of the NUHOMS®-61BT DSC involves leak testing in accordance with ANSI N14.5 [2.3] after loading and sealing the canister, as described in Section K.9.

The NUHOMS®-61BT DSC poison plates are required to meet the minimum uniform boron concentration limits of Table K.2-4 in support of criticality safety. A detailed acceptance program for the neutron poison material is given in Section K.9. The program also requires that the plates be tested to verify they meet the minimum thermal conductivity limits given in Section K.4.

K.2.3.3 Protection By Equipment and Instrumentation Selection

No change to Section 3.3.3.

K.2.3.4 Nuclear Criticality Safety

K.2.3.4.1 Control Methods for Prevention of Criticality

The design criterion for criticality is that an upper subcritical limit (USL) of 0.95 minus benchmarking bias and modeling bias will be maintained for all postulated arrangements of fuel within the DSC. The intact fuel assemblies and the damaged fuel assemblies are assumed to stay within their basket compartment based on the DSC and basket geometry.

[1] *With NRC approval of the CoC 1004 renewal application, the license is extended to a total of 60 years. The TLAAs identified as #1, #4, and #5 in Section 12.2 performed for the renewal of this design conservatively used a service life of 100 years.* 72.48

The control method used to prevent criticality is incorporation of poison material in the basket material and favorable geometry. The quantity and distribution of boron in the poison material is controlled by specific manufacturing and acceptance criteria of the poison plates. The acceptance of the plates is described in Section K.9.

K.2.5 Summary of NUHOMS®-61BT DSC Design Criteria

The additional principal design criteria for the NUHOMS®-61BT DSC are presented in Table K.2-1. The NUHOMS®-61BT DSC is designed to store 61 intact, or up to 16 damaged and the remainder intact, for a total of 61, standard BWR fuel assemblies with or without fuel channels with assembly average burnup, initial enrichment and cooling time as described in Table K.2-1, Table K.2-2 and Table K.2-4.

The maximum total heat generation rate of the stored fuel is limited to 0.3 kW per fuel assembly and 18.3 kW per NUHOMS®-61BT DSC in order to keep the maximum fuel cladding temperature below the limit necessary to ensure cladding integrity for 40 years *of* storage [2.4]. [(1)] The fuel cladding integrity is assured by the NUHOMS®-61BT DSC and basket design which limits fuel cladding temperature and maintains a nonoxidizing environment in the cask cavity [2.5], as described in Section K.4.

Renewal

The NUHOMS®-61BT DSC (shell and closure) is designed and fabricated to the maximum practicable extent as a Class I component in accordance with the rules of the ASME Boiler and Pressure Vessel Code, Section III, Subsection NB, Article NB-3200.

The NUHOMS®-61BT DSC is designed to maintain a subcritical configuration during loading, handling, storage and accident conditions. Poison materials in the fuel basket are employed to maintain the upper subcritical limit of 0.9414. The basket is designed and fabricated to the maximum practicable extent in accordance with the rules of the ASME Boiler and Pressure Vessel Code, Section III, Subsection NG, Article NG-3200.

The NUHOMS®-61BT DSC design, fabrication and testing are covered by TN's Quality Assurance Program which conforms to the criteria in Subpart G of 10 CFR 72.

The NUHOMS®-61BT DSC is designed to withstand the effects of severe environmental conditions and natural phenomena such as earthquakes, tornadoes, lightning and floods. Section K.11 describes the NUHOMS®-61BT DSC behavior under these accident conditions.

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[1] *With NRC approval of the CoC 1004 renewal application, the license is extended to a total of 60 years. The TLAAs identified as #1, #4, and #5 in Section 12.2 performed for the renewal of this design conservatively used a service life of 100 years.* 72.48

presented in Section K.4.4, K.4.5 and K.4.6 for normal, off-normal and accident transfer conditions, respectively. The thermal evaluation of NUHOMS®-61BT DSC in the OS200 transfer cask is presented in Section K.4.9.

Boundary Conditions, Storage

Normal and off-normal analyses of the NUHOMS®-52B DSC within the HSM have been previously performed in Section 8.1.3 for the following ambient conditions:

- Maximum normal ambient temperature of 100 °F with insolation. This case bounds the lifetime average ambient temperature of 70°F for 50 years *of* service life. [(1)]
- Minimum off-normal extreme ambient temperature of -40 °F without insolation. This case bounds the 0 °F minimum normal (winter) average ambient temperature.
- Maximum off-normal extreme ambient temperature of 125 °F with insolation.

Renewal

These analyses for the NUHOMS®-52B DSC, which use a total decay heat load of 19.2 kW, determine temperature distributions for the NUHOMS®-52B DSC under normal and off-normal conditions of storage that bound those for the NUHOMS®-61BT with its lower decay heat load of 18.3 kW. These temperature distributions, shown in Figure K.4-1 through Figure K.4-3, which represent the upper half of the DSC in the HSM are applied as boundary conditions to the finite element models for normal and off-normal conditions of storage.

Accident analysis for the 61BT DSC is based on the HSM model described in Section 8.1.3.1 and was performed for the following ambient condition:

- Maximum ambient temperature of 125 °F and maximum insolation with HSM vents totally blocked for 40 hours.

This analysis, which assumed a total decay heat load of 18.3 kw per DSC, provides a two dimensional temperature for the surface of the DSC during blocked vent accident as shown in Figure K.4-4.

Boundary Conditions, Transfer

Analyses of the NUHOMS®-61BT DSC within the OS197 transfer cask is performed for the following ambient conditions:

- Maximum normal ambient temperature of 100 °F with insolation
- Minimum off-normal extreme ambient temperature of -40 °F without insolation
- Vacuum Drying under an ambient of 100 °F without insolation

[1] *With NRC approval of the CoC 1004 renewal application, the license is extended to a total of 60 years. The TLAAs identified as #1, #4, and #5 in Section 12.2 performed for the renewal of this design conservatively used a service life of 100 years.* 72.48

These analyses, which use a total decay heat load of 18.3 kW per DSC, determine maximum temperatures within the DSC of 378 °F and 308 °F for the maximum normal and minimum off-normal conditions, respectively. These maximum temperatures are conservatively applied to the entire exterior surface of the DSC in the finite element model.

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

21. *If this is the final loading, fully drain the liquid neutron shield.*

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

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

K.9 Acceptance Tests and Maintenance Program

Background for this particular UFSAR chapter:

Beginning with CoC 1004 Amendment 10, which was incorporated into UFSAR Revision 11, Chapter K.9, "Acceptance Tests and Maintenance Program," contained information which was incorporated by reference into the Technical Specifications (TS) associated with a particular amendment. It is known that certain general licensees reconcile the CoC 1004 UFSAR revisions provided to them to their loaded systems, pursuant to 10 CFR 72.48 and 10 CFR 72.212. In doing so they sometimes find the changed UFSAR portions incorporated by reference into the TS to be impossible to reconcile because the 10 CFR 72.48 regulation does not allow proposed activities which involve changes to the TS.

In order to facilitate this reconciliation process by general licensees, the following statements are provided, addressing the licensing basis for certain amendments, as they relate to certain UFSAR chapters which contain TS incorporated by reference. Additionally, so that the actual information is contained in the current CoC 1004 UFSAR, to facilitate the reconciliation by general licensees, the UFSAR Revision 11, 12, 13, and 14 versions of Chapter K.9 are inserted and annotated in this part of the UFSAR. For clarity, this includes annotating the version of Chapter K.9 directly associated with the latest UFSAR revision in which a change to Chapter K.9 occurred.

- Systems loaded to CoC 1004 Amendment 10 have Technical Specifications incorporated by reference from UFSAR Revisions 11 and 12 in Chapter K.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to systems loaded to Amendment 10.

- Systems loaded to CoC 1004 Amendment 11 have Technical Specifications incorporated by reference from UFSAR Revision 13 Chapter K.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to Amendment 11.

- Note that CoC 1004 Amendment 12 was submitted and docketed, associated with a U.S. Department of Energy project, but due to a lack of review funding the NRC returned it without a review.

- Systems loaded to CoC 1004 Amendment 13 have Technical Specifications incorporated by reference from UFSAR Revisions 14 and 15 Chapter K.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to Amendment 13.

- Systems loaded to CoC 1004 Amendment 14 have Technical Specifications incorporated by reference from UFSAR Revision*s* 16 *and 17* Chapter K.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to Amendment 14.

This version of Chapter K.9 is associated with CoC 1004 Amendment 14 and is from UFSAR Revision 17. Please see Page K.9 Introduction - 1 for a discussion as to why certain versions of Chapter K.9 are being maintained in the UFSAR.

K.9 Tests and Maintenance Program

K.9.1 Acceptance Tests

The pre-operational testing requirements for the *Standardized* NUHOMS® system are given in Section 9.0 with the exceptions described in the following sections. The NUHOMS®-61BT DSC has been enhanced to provide leaktight confinement and the basket includes an updated poison plate design. Additional acceptance testing of the NUHOMS®-61BT DSC welds and of the poison plates are described. AMD 11

K.9.1.1 Visual Inspection

No change *to Section 4.5.1.*

K.9.1.2 Structural.

The NUHOMS®-61BT DSC confinement welds are designed, fabricated, tested and inspected in accordance with ASME B&PV Code Subsection NB [9.1] with exceptions as listed in Section K.3.1. The following requirements are unique to the NUHOMS®-61BT DSC:

- The inner bottom cover weld is inspected in accordance with Article NB-5231.
- The outer bottom cover weld root and cover are penetrant tested.
- The canister shell longitudinal and circumferential welds are 100% radiographically inspected.
- The outer top cover plate weld root, middle and cover are penetrant tested.

The NUHOMS®-61BT DSC basket is designed, fabricated, and inspected in accordance with ASME B&PV Code Subsection NG [9.1] with exceptions as listed in Section K.3.1. The following requirements are unique to the NUHOMS®-61BT DSC:

- The fuel compartment wrapper welds are inspected in accordance with Article NG-5231.
- The fuel compartment welds are inspected in accordance with Article NG-5231.

K.9.1.3 Leak Tests

The NUHOMS®-61BT DSC confinement is leak tested to verify it is leaktight in accordance with ANSI N14.5 [9.2].

The leak tests are typically performed using the helium mass spectrometer method. Alternative methods are acceptable, provided that the required sensitivity is achieved.

K.9.1.4 Components

The Standardized NUHOMS® system does not include any components such as valves, rupture discs, pumps, or blowers. No other components of the Standardized NUHOMS® system require testing, except as discussed in this Appendix.

K.9.1.5 Shielding Integrity

No change to Section 4.3.9 and Appendix U, Section U.9.1.5.

K.9.1.6 Thermal Acceptance

No thermal acceptance testing is required to verify the performance of each storage unit other than that specified in the Technical Specifications for initial loading.

The heat transfer analysis for the basket includes credit for the thermal conductivity of neutron-absorbing materials, as specified in Section K.4.3. Because these materials do not have publicly documented values for thermal conductivity, testing of such materials will be performed in accordance with Section K.9.1.7.6.

K.9.1.7 Poison Acceptance

CAUTION

Sections K.9.1.7.1 through K.9.1.7.4 below are incorporated by reference into the NUHOMS® CoC 1004 Technical Specifications 4.1 (Note 1) and shall not be deleted or altered in any way without approval from the NRC. The text of these sections is shown in bold type to distinguish it from other sections.

The neutron absorber used for criticality control in the DSC basket may consist any of the following types of material:

(a) Borated aluminum

(b) Boron carbide / aluminum metal matrix composite (MMC)

(c) BORAL®

The 61BT DSC safety analyses do not rely upon the tensile strength of these materials. 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 three types of materials is given in Table K.9-1.

References to metal matrix composites throughout this appendix are not intended to refer to BORAL®, which is described later in this section.

All changes on this page are AMD 13

K.9.1.7.1 Borated Aluminum

See the Caution in Section K.9.1.7 before deletion or modification to this section.

The material is produced by direct chill (DC) or permanent mold casting with boron precipitating primarily as a uniform fine dispersion of discrete AlB_2 or TiB_2 particles in the matrix of aluminum or aluminum alloy (other boron compounds, such as AlB_{12}, can also occur). 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. 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 K.9.1.7.7. 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.

K.9.1.7.2 Boron Carbide / Aluminum Metal Matrix Composites (MMCs)

See the Caution in Section K.9.1.7 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, *molten metal infiltration* or thermal spray techniques. The boron carbide content shall not exceed 40% by volume. The boron carbide content for MMCs with an integral aluminum cladding *or produced by molten metal infiltration* 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.

At least 50% by weight of the B_4C particles in MMCs shall be smaller than 40 microns. No more than 10% of the particles shall be over 60 microns.

Prior to use in the 61BT DSC, MMCs shall pass the qualification testing specified in Section K.9.1.7.8, and shall subsequently be subject to the process controls specified in Section K.9.1.7.9.

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 K.9.1.7.7. 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.

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K.9.1.7.3 BORAL®

See the Caution in Section K.9.1.7 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. Before rolling, at least 80% by weight of the B_4C particles in BORAL® shall be smaller than 200 microns. 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.

K.9.1.7.4 Visual Inspections of Neutron Absorbers

See the Caution in Section K.9.1.7 before deletion or modification to this section.

Neutron absorbers shall be 100% visually inspected in accordance with the Certificate Holder's QA procedures. *Blisters shall be treated as non-conforming. For clad MMCs and 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. Material that does not meet these criteria shall be reworked, repaired, or scrapped.*

K.9.1.7.5 Other Visual Inspections Criteria (non-Technical Specifications)

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" [9.5]. Local or cosmetic conditions such as scratches, nicks, die lines, inclusions, abrasion, isolated pores, or discoloration are acceptable.

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K.9.1.7.6 Thermal Conductivity Testing

Acceptance testing shall conform to ASTM E1225[1], ASTM E1461[2], or equivalent method, performed at roomtemperature on coupons taken from the rolled or extruded production material. Initial sampling shall be one test per lot, and may be reduced if the first five tests meet the specified minimum thermal conductivity. For cast products, the lot shall be defined by the heat or ingot. For other products, the lot shall be defined as material produced in a single production campaign using the same heat or lots of aluminum and boron carbide feed materials.

If a thermal conductivity test result is below the specified minimum, at least four additional tests shall be performed on the material from that lot. If the mean value of those tests, including the original test, falls below the specified minimum, the associated lot shall be rejected.

After twenty five tests of a single type of material, with the same aluminum alloy matrix, the same boron content, and the same primary boron phase, e.g., B_4C, TiB_2, or AlB_2, if the mean value of all the test results less two standard deviations meets the specified thermal conductivity, no further testing of that material is required. This exemption may also be applied to the same type of material if the matrix of the material changes to a more thermally conductive alloy (e.g., from 6000 to 1000 series aluminum), or if the boron content is reduced without changing the boron phase.

The measured thermal conductivity values shall satisfy the minimum required conductivities as specified in Section K.4.3.

In cases where the specified thickness of the neutron absorber may vary, the equations introduced in Section K.4.3 shall be used to determine the minimum required effective thermal conductivity.

The thermal conductivity test requirement does not apply to aluminum that is paired with the neutron absorber.

K.9.1.7.7 Specification for Acceptance Testing of Neutron Absorber *Content*

Acceptance testing for Neutron Absorber content shall be performed by either neutron transmission or by B-10 volume density measurement.

CAUTION

Portions of Section K.9.1.7.7 are incorporated by reference into the NUHOMS® CoC 1004 Technical Specifications 4.1 (Note 1) and shall not be deleted or altered in any way without approval from the NRC. The text of this section is shown in bold type to distinguish it from other sections.

[1] ASTM E1225, "Thermal Conductivity of Solids by Means of the Guarded-Comparative-Longitudinal Heat Flow Technique."

[2] ASTM E1461, "Thermal Diffusivity of Solids by the Flash Method."

K.9.1.7.7.1 *Specification for Acceptance Testing of Neutron Absorbers by Neutron Transmission*

a) 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.

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The B10 areal density is measured using a collimated thermal neutron beam up to 1.1 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 B10 at that energy.

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.

b) The following illustrates one acceptable method and is intended to be utilized as an example. Therefore, the following text is not part of the Technical Specifications. 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 [9.6].

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 K.9.1.7.7 a) 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. Edge effects due to manufacturing

operations such as shearing, deburring, and chamfering need not be included in this determination.

Non-conforming material shall be evaluated for acceptance in accordance with the Certificate Holder's QA procedures.

K.9.1.7.7.2 *Specification for Acceptance Testing of Neutron Absorbers by B-10 Volume Density Measurement*

a) ***B-10 volume density measurement 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, as long as it results in accumulating material that is uniform for sampling purposes.

The sampling rate for B-10 volume density measurements shall be such that there is at least one density measurement for each 2000 square inches of final product in each lot.

Areal density is determined by measuring the B-10 volume density in test samples and converting the measured values to areal density. The method of measurement of B-10 volume density shall be subject to approval by the certificate holder. The method of measurement of B-10 volume density shall be qualified against neutron transmission testing. Results of the two test methods shall be compared and a penalty shall be derived to account for the performance based results of neutron transmission testing.

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.

b) *The following illustrates one acceptable method and is intended to be utilized as an example. Therefore, the following text is not part of the Technical Specifications. The acceptance criterion for individual plates is determined from a statistical analysis of the test results for their lot. The B-10 areal densities are determined by volume density as described above. The lower tolerance limit of B-10 volume density is then determined, defined as the mean value of B-10 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 [9.6]. Finally, the minimum specified value of B-10 areal density is divided by the lower tolerance limit of B-10*

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volume density to arrive at the minimum plate thickness that provides the specified B-10 areal density.

Any plate that is thinner than the statistically derived minimum thickness from K.9.1.7.7.2 a) or the minimum design thickness, whichever is greater, shall be treated as nonconforming, with the following exception. Local depressions are acceptable, as 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. Edge effects due to manufacturing operations such as shearing, deburring, and chamfering need not be included in this determination.

Non-conforming material shall be evaluated for acceptance in accordance with the Certificate Holder's QA procedures.

K.9.1.7.8 Specification for Qualification Testing of Metal Matrix Composites

CAUTION

Portions of Section K.9.1.7.8.4 and Section K.9.1.7.8.5 are incorporated by reference into the NUHOMS® CoC 1004 Technical Specifications 4.1 (Note 1) and shall not be deleted or altered in any way without approval from the NRC. The text of this section is shown in bold type to distinguish it from other sections.

K.9.1.7.8.1 Applicability and Scope

MMCs acceptable for use in the 61BT DSC are described in Section K.9.1.7.2.

Prior to initial use in a spent fuel dry storage or 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 K.9.1.7.9 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.

K.9.1.7.8.2 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 storage/ transport system. This is demonstrated by the tests in Section K.9.1.7.8.4. It must have a uniform distribution of boron carbide. This is demonstrated by the tests in Section K.9.1.7.8.5.

K.9.1.7.8.3 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 storage, about 10^{15} neutrons/cm^2.

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Thermal damage and corrosion (hydrogen generation) testing shall be performed unless such tests on materials of the same chemical composition have already been performed and found acceptable. The following paragraphs illustrate two cases where such testing is not required.

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 storage or transport[3].

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[4].

K.9.1.7.8.4 **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[5]) 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[6]. 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 %.

Delamination Testing of Clad MMC

c) ***Clad MMCs shall be subjected to thermal damage testing following water immersion to ensure that delamination does not occur under normal conditions of storage.*** *An example of such a test would be: (1) immerse a specimen at least 6 x 6 inches in water under pressure ≥30 psig for at least 24 hours, (2) place the specimen in a vacuum furnace preheated to at least 300°F and evacuate the furnace. Acceptance criterion: no blistering or delamination of the cladding.*

K.9.1.7.8.5 **Required Tests and Examinations to Demonstrate B10 Uniformity**

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[3] Sung, C., "Microstructural Observation of Thermally Aged and Irradiated Aluminum/Boron Carbide (B_4C) Metal Matrix Composite by Transmission and Scanning Electron Microscope," 1998

[4] Boralyn testing submitted to the NRC under docket 71-1027, 1998

[5] ASTM B557 Standard Test Methods of Tension Testing Wrought and Cast Aluminum and Magnesium-Alloy Products

[6] ASTM E290, Standard Methods for Bend Testing of Materials for Ductility

Uniformity of the boron distribution shall be verified either by:

a) **Neutron radioscopy or radiography (ASTM E94[7], E142[8], and E545[9]) 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, the boron carbide weight fraction, *or the boron 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 K.9.1.7.7, or by chemical analysis for boron carbide *or boron* content in the composite.**

K.9.1.7.8.6 Qualification Report

Qualification report shall be prepared by, or subject to approval by the Certificate Holder.

K.9.1.7.9 Specification for Process Controls for Metal Matrix Composites

CAUTION

Sections K.9.1.7.9.1 and K.9.1.7.9.2 are incorporated by reference into the NUHOMS® CoC 1004 Technical Specifications (paragraph 4.1 ((Note 1)) and shall not be deleted or altered in any way without approval from the NRC. The text of this section is shown in bold type to distinguish it from other sections.

K.9.1.7.9.1 **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 K.9.1.7.8 is required, depending on the characteristics of the material that could be affected by the process change.

K.9.1.7.9.2 **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, reduce the mechanical strength or ductility of the MMC.

K.9.1.7.9.3 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 K.9.1.7.9.2.

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7 ASTM E94, Recommended Practice for Radiographic Testing

8 ASTM E142, Controlling Quality of Radiographic Testing

9 ASTM E545, Standard Method for Determining Image Quality in Thermal Neutron Radiographic Testing

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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 *(d50)* 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.

K.9.2 Maintenance Program

NUHOMS®-61BT system is a totally passive system and therefore will require little, if any, maintenance over the lifetime of the ISFSI. Typical NUHOMS®-61BT system maintenance tasks will be performed in accordance with Section 4.

K.9.3 References

9.1 ASME Boiler and Pressure Vessel Code, Section III, 1998 Edition including 1999 addenda.

9.2 ANSI N14.5-1997, "American National Standard for Leakage Tests on Packages for Shipment of Radioactive Materials," February 1998.

9.3 *Deleted.*

9.4 *Deleted.*

9.5 "Aluminum Standards and Data, 2003" The Aluminum Association.

9.6 Natrella, "Experimental Statistics," Dover, 2005.

9.7 *Deleted.*

9.8 *Deleted.*

9.9 *Deleted.*

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Table K.9-1
B10 Specification for the NUHOMS® 61BT Poison Plates

Basket Type	*Specified Minimum B10 Areal Density for Borated Aluminum/MMC for 90% credit (g/cm²)*	*Specified Minimum B10 Areal Density for BORAL® for 75% credit (g/cm²)*
Type 1 DSC		
A	*0.021*	*0.025*
B	*0.032*	*0.038*
C	*0.040*	*0.048*
For Damaged Fuel		
C	*0.040*	*0.048*

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Table K.9-2
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Table K.9-3
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L.1 General Discussion

Appendix L addresses the addition of the transportable 24PT2 DSC to the NUHOMS® system. The NUHOMS®-24PT2 series consists of the 24PT2S and the 24PT2L DSCs. The 24PT2S DSC has a cavity length similar to the standardized NUHOMS® 24P DSC, and is designed to store 24 PWR fuel assemblies without control components. The 24PT2L DSC has a cavity length similar to the long cavity 24P DSC and is designed to store 24 PWR fuel assemblies with or without Burnable Poison Rod Assemblies (BPRAs). The fuel assembly and BPRA types are the same as the NUHOMS® 24P DSC. The 24PT2S and 24PT2L DSCs utilize a NUHOMS® Transfer Cask (TC) for transfer operations and the NUHOMS® Horizontal Storage Module (HSM) for storage. The format of this Appendix follows the guidance provided in NRC Regulatory Guide 3.61 [1.1].

The NUHOMS®-24PT2 system provides confinement, shielding, criticality control and passive heat removal independent of any other facility structures or components. The NUHOMS®-24PT2 DSC also maintains structural integrity of the fuel during storage.

Aging Management Program Requirements

AMP requirements for use of the 24PT2 System during the period of extended storage operations are contained in Section 12.3. Applicable time-limited aging analyses performed for the initial CoC 1004 renewal application are provided in Section 12.2.

Any changes on this page are a part of CoC 1004 renewal.

L.2.3 Safety Protection Systems

L.2.3.1 General

The NUHOMS®-24PT2 DSC is designed to provide storage of spent fuel for at least 40 years.[1] The cask cavity pressure is always above atmospheric during the storage period as a precaution against the in-leakage of air which could be harmful to the fuel. Renewal

Safety protection systems for the NUHOMS®-24PT2 DSC are the same as those for the NUHOMS®-24P DSC as addressed in Chapter 3, except as listed below in the following sections. Components of the NUHOMS®-24PT2 DSC that are "Important to Safety" are listed in Table 3.4-1. Components of the NUHOMS®-24PT2 DSC that are "Not Important to Safety" are the same as those for the NUHOMS®-24P DSC as listed in Table 3.4-1.

L.2.3.2 Protection By Multiple Confinement Barriers and Systems

No change to Section 3.3.2.

L.2.3.3 Protection By Equipment and Instrumentation Selection

No change to Section 3.3.3.

L.2.3.4 Nuclear Criticality Safety

L.2.3.4.1 Control Methods for Prevention of Criticality

No change. However, one important difference between the 24PT2S/24PT2L and the 24P/long cavity 24P canister designs is the fixed poison sheets (Boral®) in the 24PT2S/24PT2L canisters. No credit is taken in the 10CFR72 (storage) criticality evaluation for the fixed poison. The poison plates are conservatively modeled as pure aluminum. This is very conservative and ensures that only canister geometry and soluble boron are credited in the criticality analysis consistent with the licensing basis for the standard 24P and the long cavity 24P DSC designs. The criticality analyses are described in Section L.6.

L.2.3.4.2 Error Contingency Criteria

No change to Section 3.3.4.

L.2.3.4.3 Verification Analysis-Benchmarking

No change to Section 3.3.4.

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[1] *With NRC approval of the CoC 1004 renewal application, the license is extended to a total of 60 years. The TLAAs identified as #1, #4, and #5 in Section 12.2 performed for the renewal of this design conservatively used a service life of 100 years.* 72.48

L.8.1 Procedures for Loading the Cask

Process flow diagrams for loading and retrieval of the 24PT2 system are identical to those presented in Figures 5.1-1 and 5.1-2 respectively of Chapter 5.

L.8.1.1 Preparation of the Transfer Cask and DSC

No change relative to Chapter 5, except that for plants with a 100-ton crane capacity, the transfer cask neutron shield water may need to be removed. If this option is used, the neutron shield needs to be filled with *demineralized* water once the cask is downended on the transfer trailer in Section 5.1.1.5.

CAUTION: The radiation dose rates around the surface of the transfer cask without water in the neutron shield (until the cask is downended and the neutron shield is re-filled) are expected to be high. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.

L.8.1.2 DSC Fuel Loading

No change to Section 5.1.1.2.

L.8.1.3 DSC Drying and Backfilling

No change to Section 5.1.1.3.

L.8.1.4 DSC Sealing Operations

No change to Section 5.1.1.4.

L.8.1.5 Transfer Cask Downending and Transfer to ISFSI

No change to Section 5.1.1.5.

L.8.1.6 DSC Transfer to the HSM

No change to Section 5.1.1.6.

L.8.1.7 Monitoring Operations

No change to Section 5.1.1.7.

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M.1. General Discussion

This Appendix M to the NUHOMS® Updated Final Safety Analysis Report (UFSAR) addresses the Important to Safety aspects of storing spent fuel including high burnup fuel (up to 55 GWd/MTU)in the NUHOMS®-32PT system.

The NUHOMS®-32PT system consists of a NUHOMS®-32PT Dry Shielded Canister (DSC) stored in a Model 80 or Model 102 or Model 152 or Model 202 NUHOMS® Horizontal Storage Module (HSM). The NUHOMS® HSM Models 152 and 202 are described and evaluated in Appendix R and Appendix V, respectively. In addition, an upgraded version of the HSM, designated as HSM-HS, is also provided to allow storage of the NUHOMS®-32PT DSC in locations where higher seismic levels exist. The HSM-HS design configuration, described in Appendix U.1, is modified to accommodate the smaller diameter of the NUHOMS®-32PT DSC.

The NUHOMS®-32PT DSC is transferred in an OS197 or OS197H Transfer Cask (TC). The NUHOMS®-32PT is also qualified for transfer in an OS197L TC, within certain limitations, as described in Appendix W.1. Finally, the NUHOMS®-32PT DSC is also transferred in a modified version of the OS200 TC described in UFSAR Appendix U.1. The OS200 TC is fitted with an aluminum sleeve and a spacer to accommodate the smaller diameter of the 32PT DSC.

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

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

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

Aging Management Program Requirements

AMP requirements for use of the 32PT System during the period of extended storage operations are contained in Section 12.3. Applicable TLAAs performed for the initial CoC 1004 renewal application are provided in Section 12.2.

M.2.3 Safety Protection Systems

M.2.3.1 General

The NUHOMS®-32PT DSC is designed to provide storage of spent fuel for at least 40 years[1]. The DSC cavity is inerted and backfilled with helium and the internal pressure is always above atmospheric during the storage period as a precaution against in-leakage of air, which could be harmful to the fuel. Since the confinement vessel consists of a steel cylinder with an integrally-welded bottom closure, and a seal welded top closure that is verified to be leak tight after loading, the DSC cavity gas cannot escape. Renewal

Only those features that are not addressed in the existing FSAR, Chapter 3, or have been revised, are addressed in this Section. Those features include the thermal and nucleonic performance of the poison plates, and their acceptance. Components of the NUHOMS®-32PT DSC that are "Important to Safety" and "Not Important to Safety" are listed in Table M.2-18.

M.2.3.2 Protection By Multiple Confinement Barriers and Systems

The NUHOMS®-32PT DSC provides a leak tight confinement of the spent fuel. Although similar to the existing NUHOMS®-24P DSC, sealing of the NUHOMS®-32PT DSC involves leak testing in accordance with ANSI N14.5 [2.4] after loading and sealing the canister, as described in Section M.9.

M.2.3.3 Protection By Equipment and Instrumentation Selection

No change to Section 3.3.3.

M.2.3.4 Nuclear Criticality Safety

M.2.3.4.1 Control Methods for Prevention of Criticality

The design criterion for criticality is that an upper subcritical limit (USL) of 0.95 minus benchmarking bias and modeling bias will be maintained for all postulated arrangements of fuel within the DSC. The intact fuel assemblies are assumed to stay within their basket compartment based on the DSC and basket geometry.

The control method used to prevent criticality is incorporation of poison material in the basket material, soluble boron in the pool and favorable geometry. The quantity and distribution of boron in the poison material is controlled by specific manufacturing and acceptance criteria of the poison plates and PRAs. The acceptance criteria of the plates and PRAs is described in Section M.9.

The basket has been designed to assure an ample margin of safety against criticality under the conditions of fresh fuel in a DSC flooded with borated pool water. The method of criticality control is in accordance with the requirements of 10CFR72.124.

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[1] *With NRC approval of the CoC 1004 renewal application, the license is extended to a total of 60 years. The TLAAs identified as #1, #4, and #5 in Section 12.2 performed for the renewal of this design conservatively used a service life of 100 years.* 72.48

Table M.2-2
PWR Fuel Assembly Design Characteristics for the NUHOMS®-32PT DSC

Assembly Class	B&W 15x15	WE 17x17	CE 15x15[(3), (4)]	WE 15x15	CE 14x14	WE 14x14
DSC Configuration	**Maximum Unirradiated Length (in)**					
32PT-S100/32PT-S125	165.75[(1)]	165.75[(1)]	165.75	165.75[(1)]	165.75[(1)]	165.75[(1)]
32PT-L100/32PT-L125	171.71[(1)]	171.71[(1)]	171.71	171.71[(1)]	171.71[(1)]	171.71[(1)]
Fissile Material	UO_2	UO_2	UO_2	UO_2	UO_2	UO_2
Maximum MTU/assembly[(2)]	0.475	0.475	0.475	0.475	0.475	0.475
Maximum Number of Fuel Rods	208	264	216	204	176	179
Maximum Number of Guide/ Instrument Tubes	17	25	9	21	5	17

(1) Maximum Assembly + CC Length (unirradiated).
(2) The maximum MTU/assembly is based on the shielding analysis. The listed value is higher than the actual.
(3) CE 15x15 assemblies with stainless steel plugging clusters installed are acceptable.
(4) Control Components that extend into the active fuel region are not authorized for storage with CE 15x15 class assemblies.

Table M.2-2a

The detailed information associated with this table can be found in CoC 1004 Amendment 14 Technical Specifications Table 1-1ee. 72.48

The design-basis fuel, 0.475 MTU of heavy metal weight, source terms for this evaluation are defined as the source terms from fuel with the burnup/initial enrichment/cooling time combination given in Table M.2-5 through Table M.2-9 (with or without CCs) and located in the basket as shown in Figure M.2-1, Figure M.2-2 or Figure M.2-3, that gives the maximum dose rate on the surface of the HSM and/or OS197/OS197H TC. This approach is consistent with the method used to generate the fuel qualification tables for the Standardized NUHOMS®-24P and -52B canister designs as described in Section 7.2.3.

The fuel qualification tables shown in Table M.2-5 through Table M.2-9 are developed for the design basis heavy metal loading of 0.475 MTU with SAS2H/ORIGEN-S modules of SCALE 4.4 [5.1] and for the heavy metal loading of 0.400 MTU with SAS2H/ORIGEN-S modules of SCALE 5.0 [5.14]. Section *7.2.3.2* of Chapter *7* provides the methods for determining minimum required cooling times using fitting equations or linear interpolation for a given MTU between 0.400 MTU and 0.475 MTU.

The Heat Load Zoning Configuration 2 (Figure M.2-2) is the configuration that produces the highest dose rates on the surfaces of the HSM and TCs. These bounding gamma and neutron source terms are then used in the radiation shielding models to conservatively calculate dose rates on and around the NUHOMS®-32PT System. In order to model Heat Load Zoning

M.5.6 References

5.1 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.

5.2 "DORT-PC - Two-Dimensional Discrete Ordinates Transport Code System," CCC-532, Oak Ridge National Laboratory, RSIC Computer Code Collection, Version 2.10.1, October 1991.

5.3 RSICC Data Library Collection, "CASK-81*: 22-Neutron, 18-Gamma-Ray Group, P3, Cross Sections for Shipping Cask Analysis,*" DLC-23, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab. (updated September 1987).

5.4 Ludwig, S.B., and J.P. Renier, "Standard- and Extended-Burnup PWR and BWR Reactor Models for the ORIGEN2 Computer Code," ORNL/TM-11018 Oak Ridge National Laboratory, December 1989.

5.5 "ANISN-ORNL - One-Dimensional Discrete Ordinates Transport Code System with Anisotropic Scattering", CCC-254, Oak Ridge National Laboratory, RSIC Computer Code Collection, April 1991.

5.6 NUHOMS® MP187 Multi-Purpose Cask Transportation Safety Analysis Report," Revision 10, NRC Docket Number 71-9255.

5.7 "Topical Report on Actinide-Only Burnup Credit for PWR Spent Nuclear Fuel Packages", Rev. 0, Office of Civilian Radioactive Waste Management, DOE/RW-0472 Rev. 0, May 1995.

5.8 "Addition of 61BT DSC to Standardized NUHOMS® System," Amendment No. 3, NUHOMS® CoC 1004, TAC No. L23137.

5.9 Jenal, J. P., P. J. Erickson, W. A. Rhoades, D. B. Simpson, and M. L. Williams, "The Generation of a Computer Library for Discrete Ordinates Quadrature Sets," ORNL/TM-6023, Oak Ridge National Laboratory, October 1977.

5.10 "American National Standard Neutron and Gamma-Ray Flux-to-Dose Rate Factors," ANSI/ANS-6.1.1-1977, American Nuclear Society, LaGrange Park, Illinois, March 1977.

5.11 O. W. Hermann, R. M. Westfall, "ORIGEN-S: SCALE System Module to Calculate Fuel Depletion, Actinide Transmutation, Fission Product Buildup and Decay, and Associated Radiation Source Terms," NUREG/CR-0200, Revision 6, Volume 2, Section F7. Published September 1998.

5.12 W. C. Jordan, S. M. Bowman, "SCALE Cross-Section Libraries," NUREG/CR-0200, Revision 6, Volume 3, Section M4. Published September 1998.

3. Move the scaffolding away from the cask as necessary. Engage the lifting yoke and lift the cask over the cask support skid on the transfer trailer.

4. The transfer trailer should be positioned so that cask support skid is accessible to the crane with the trailer supported on the vertical jacks.

5. Position the cask lower trunnions onto the transfer trailer support skid pillow blocks.

6. Move the crane forward while simultaneously lowering the cask until the cask upper trunnions are just above the support skid upper trunnion pillow blocks.

7. Inspect the positioning of the cask to insure that the cask and trunnion pillow blocks are properly aligned.

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

9. Inspect the trunnions to insure that they are properly seated onto the skid. Install the trunnion tower closure plates (optional for the OS197 TC and the OS197H TC).

10. Fill the neutron shield *with demineralized water*, if it was drained in M.8.1.5 step 1.

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

M.8.1.6 DSC Transfer to the HSM

NOTE: If using the HSM-HS module for storage of the NUHOMS®-32PT DSC at sites with high seismic levels, verify that at least 3 modules are connected together per the requirements of Technical Specification 4.3.1.

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

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

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

   CAUTION: Verify that the requirements of Technical Specification 5.3.1.B, "TC/DSC Transfer Operations at High Ambient Temperatures" are met prior to next step.

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

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

22. *If this is the final loading, fully drain the liquid neutron shield.*

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

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

M.8.1.7 Monitoring Operations

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

Note: Perform one of two alternative surveillance activities listed below.

2a. Perform a daily visual surveillance of the HSM air inlets and outlets to insure that no debris is obstructing the HSM vents in accordance with Technical Specification 5.2.5.a requirements.

2b. Perform a temperature measurement of the thermal performance, for each HSM, on a daily basis in accordance with Technical Specification 5.2.5.b requirements.

unloading the DSC in a fuel pool are presented here. However, wet or dry unloading procedures are essentially identical to those of DSC loading through the DSC weld removal (beginning of preparation to placement of the cask in the fuel pool). Prior to opening the DSC, the following operations are to be performed.

1. The cask may now be transferred to the cask handling area inside the plant's fuel/reactor building.

2. Position and ready the trailer for access by the crane and install the ram access penetration cover plate.

3. Attach the lifting yoke to the crane hook.

4. Engage the lifting yoke with the trunnions of the cask.

5. Visually inspect the yoke lifting hooks to insure that they are properly aligned and engaged onto the cask trunnions.

6. If unloading 32PT-S100 or 32PT-L100 DSC (qualified for 100-ton crane capacity), drain water from the neutron shield.

   CAUTION: The radiation dose rates around the surface of the transfer cask without water in the neutron shield (through step M.8.2.2.9) are expected to be high. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.

7. Lift the cask approximately one inch off the trunnion supports. Visually inspect the yoke lifting hooks to insure that they are properly positioned on the trunnions.

8. Move the crane backward in a horizontal motion while simultaneously raising the crane hook vertically and lift the cask off the trailer. Move the cask to the cask decon area.

9. Lower the cask into the cask decon area in the vertical position. Fill the neutron shield with *demineralized* water if it was drained in Step M.8.2.2.6. Verify that the HSM dose rates are compliant with the limits specified in Technical Specifications 5.4.1 and 5.4.2.

10. Wash the cask to remove any dirt which may have accumulated on the cask during the DSC loading and transfer operations.

11. Place scaffolding around the cask so that any point on the surface of the cask is easily accessible to handling personnel.

12. Unbolt the cask top cover plate.

13. Connect the rigging cables to the cask top cover plate and lift the cover plate from the cask. Set the cask cover plate aside and disconnect the lid lifting cables. If using the OS200 TC to unload, remove the sleeve ring spacer at the top of the aluminum sleeve placed in Section M.8.2.1, step 14.

14. Install temporary shielding to reduce personnel exposure as required. Fill the cask/DSC annulus with clean demineralized water and seal the annulus.

M.9 Acceptance Tests and Maintenance Program

Background for this particular UFSAR chapter:

Beginning with CoC 1004 Amendment 10, which was incorporated into UFSAR Revision 11, Chapter M.9, "Acceptance Tests and Maintenance Program," contained information which was incorporated by reference into the Technical Specifications (TS) associated with a particular amendment. It is known that certain general licensees reconcile the CoC 1004 UFSAR revisions provided to them to their loaded systems, pursuant to 10 CFR 72.48 and 10 CFR 72.212. In doing so they sometimes find the changed UFSAR portions incorporated by reference into the TS to be impossible to reconcile because the 10 CFR 72.48 regulation does not allow proposed activities which involve changes to the TS.

In order to facilitate this reconciliation process by general licensees, the following statements are provided, addressing the licensing basis for certain amendments, as they relate to certain UFSAR chapters which contain TS incorporated by reference. Additionally, so that the actual information is contained in the current CoC 1004 UFSAR, to facilitate the reconciliation by general licensees, the UFSAR Revision 11, 12, 13, and 14 versions of Chapter M.9 are inserted and annotated in this part of the UFSAR. For clarity, this includes annotating the version of Chapter M.9 directly associated with the latest UFSAR revision in which a change to Chapter M.9 occurred.

- Systems loaded to CoC 1004 Amendment 10 have Technical Specifications incorporated by reference from UFSAR Revisions 11 and 12 in Chapter M.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to systems loaded to Amendment 10.
- Systems loaded to CoC 1004 Amendment 11 have Technical Specifications incorporated by reference from UFSAR Revision 13 Chapter M.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to Amendment 11.
- Note that CoC 1004 Amendment 12 was submitted and docketed, associated with a U.S. Department of Energy project, but due to a lack of review funding the NRC returned it without a review.
- Systems loaded to CoC 1004 Amendment 13 have Technical Specifications incorporated by reference from UFSAR Revisions 14 and 15 Chapter M.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to Amendment 13.
- Systems loaded to CoC 1004 Amendment 14 have Technical Specifications incorporated by reference by FCN 721004-1575, which has been incorporated into UFSAR *Revisions* 16 *and 17* Chapter M.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to Amendment 14.

This version of Chapter M.9 is associated with CoC 1004 Amendment 14 and is from UFSAR Revision 17. Please see Page M.9 Introduction - 1 for a discussion as to why certain versions of Chapter M.9 are being maintained in the UFSAR.

All changes on this page are AMD 11

M.9 Acceptance Tests and Maintenance Program

M.9.1 Acceptance Tests

The acceptance requirements for the NUHOMS®-32PT system are given in the *U*FSAR except as described in the following sections. The NUHOMS®-32PT DSC has been enhanced to provide leaktight confinement and the basket includes an updated poison plate design. Additional acceptance testing of the NUHOMS®-32PT DSC welds and poison plates are described.

M.9.1.1 Visual Inspection

Visual examinations are performed at the fabricator's facility to ensure that the NUHOMS®-32PT system components conform to the fabrication specifications and drawings.

Visual examination of all finished absorber plates and rods are done to ensure that they are free of cracks, porosity, blisters, or foreign substances. Dimensional inspections of the plates and rods are done to ensure that their functional requirements listed in M.9.17.1 are met.

M.9.1.2 Structural Tests

The NUHOMS®-32PT DSC confinement welds are designed, fabricated, tested and inspected in accordance with ASME B&PV Code Section III, Subsection NB [9.1] with exceptions as listed in Section M.3.1. The following requirements are unique to the NUHOMS®-32PT DSC:

- The inner bottom cover weld is inspected in accordance with Article NB-5231,
- The outer bottom cover weld root and cover are penetrant tested, and
- The outer top cover plate weld root and cover are penetrant tested.

The NUHOMS®-32PT DSC basket is designed, fabricated, and inspected in accordance with ASME B&PV Code Section III, Subsection NG [9.1] with exceptions as listed in Section M.3.1. The following requirement is unique to the NUHOMS®-32PT DSC basket:

- The fuel compartment welds are inspected in accordance with Article NG-5260.

M.9.1.3 Leak Tests

The NUHOMS®-32PT DSC confinement boundary is leak tested to verify that it is leaktight in accordance with ANSI N14.5 [9.2]. The personnel performing the leak test are qualified in accordance with SNT-TC-1A [9.14].

The leak tests are typically performed using the helium mass spectrometer method. Alternative methods are acceptable, provided that the required sensitivity is achieved.

M.9.1.4 Component Tests

The Standardized NUHOMS® system does not include any components such as valves, rupture discs, pumps, or blowers. No other components of the Standardized NUHOMS® system require testing, except as discussed in this Appendix.

M.9.1.5 Shielding Integrity Tests

No changes to Section 4.3.9 and Appendix U, Section U.9.1.5.

M.9.1.6 Thermal Acceptance Tests

No thermal acceptance testing is required to verify the performance of each storage unit other than that specified in the Technical Specifications for initial loading.

The heat transfer analysis for the basket includes credit for the thermal conductivity of neutron absorbing materials, as specified in Section M.4.3. Because these materials do not have publicly documented values for thermal conductivity, testing of such materials will be performed in accordance with Section M.9.1.7.6.

M.9.1.7 Poison Acceptance

CAUTION

Sections M.9.1.7.1 through M.9.1.7.4 below are incorporated by reference into the NUHOMS® CoC 1004 Technical Specifications 4.1 (Note 2) and shall not be deleted or altered in any way without approval from the NRC. The text of these sections is shown in bold type to distinguish it from other sections.

The neutron absorber used for criticality control in the DSC basket may consist any of the following types of material:

(a) Borated aluminum

(b) Boron carbide/aluminum metal matrix composite (MMC)

The 32PT DSC safety analyses do not rely upon the tensile strength of these materials. 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 for these materials is given in Table M.9-1.

M.9.1.7.1 **Borated Aluminum**

See the Caution in Section M.9.1.7 before deletion or modification to this section.

The material is produced by direct chill (DC) or permanent mold casting with boron precipitating primarily as a uniform fine dispersion of discrete AlB_2 or TiB_2 particles in the

matrix of aluminum or aluminum alloy (other boron compounds, such as AlB_{12}, can also occur). 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. 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 M.9.1.7.7. 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.

M.9.1.7.2 <u>Boron Carbide/Aluminum Metal Matrix Composites (MMC*s*)</u>

See the Caution in Section M.9.1.7 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, *molten metal infiltration,* or thermal spray techniques. The boron carbide content shall not exceed 40% by volume. The boron carbide content for MMCs with an integral aluminum cladding *or produced by molten metal infiltration* 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.

At least 50% by weight of the B_4C particles in MMCs shall be smaller than 40 microns. No more than 10% of the particles shall be over 60 microns.

Prior to use in the 32PT DSC, MMCs shall pass the qualification testing specified in Section M.9.1.7.8, and shall subsequently be subject to the process controls specified in Section M.9.1.7.9.

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 M.9.1.7.7. 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.

All changes on this page are AMD 13

M.9.1.7.3 **Not Used**

M.9.1.7.4 **Visual Inspections of Neutron Absorbers**

See the Caution in Section M.9.1.7 before deletion or modification to this section.

Neutron absorbers shall be 100% visually inspected in accordance with the Certificate Holder's QA procedures. Blisters shall be treated as non-conforming. For *clad MMCs*, 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. *Material that does not meet the following acceptance criteria shall be reworked, repaired, or scrapped.*

M.9.1.7.5 Other Visual Inspections Criteria (non-Technical Specifications)

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" [9.5]. Local or cosmetic conditions such as scratches, nicks, die lines, inclusions, abrasion, isolated pores, or discoloration are acceptable.

M.9.1.7.6 Thermal Conductivity Testing of Poison Plates

Acceptance testing shall conform to ASTM E1225[1], ASTM E1461[2], or equivalent method, performed at room temperature on coupons taken from the rolled or extruded production material. *Initial sampling shall be one test per lot, and may be reduced if the first five tests meet the specified minimum thermal conductivity. For cast products, the lot shall be defined by the heat or ingot. For other products, the lot shall be defined as material produced in a single production campaign using the same heat or lots of aluminum and boron carbide feed materials.*

If a thermal conductivity test result is below the specified minimum, at least four additional tests shall be performed on the material from that lot. If the mean value of those tests, including the original test, falls below the specified minimum, the associated lot shall be rejected.

After *twenty five* tests of a single type of material, with the same aluminum alloy matrix, the same boron content, and the same primary boron phase, e.g., B_4C, TiB_2, or AlB_2, if the mean value of all the test results less two standard deviations meets the specified thermal conductivity, no further testing of that material is required. This exemption may also be applied to the same type of material if the matrix of the material changes to a more thermally conductive alloy (e.g., from 6000 to 1000 series aluminum), or if the boron content is reduced without changing the boron phase.

The measured thermal conductivity values shall satisfy the minimum required conductivities as specified in Section M.4.3

[1] ASTM E1225, "Thermal Conductivity of Solids by Means of the Guarded-Comparative-Longitudinal Heat Flow Technique."

[2] ASTM E1461, "Thermal Diffusivity of Solids by the Flash Method."

In cases where the specified thickness of the neutron absorber may vary, the equations introduced in Section M.4.3 shall be used to determine the minimum required effective thermal conductivity.

The thermal conductivity test requirement does not apply to aluminum that is paired with the neutron absorber.

M.9.1.7.7 Specification for Acceptance Testing of Neutron Absorber *Content*

Acceptance testing for neutron absorber content shall be performed by either neutron transmission or by B-10 volume density measurement.

CAUTION

Portions of Section M.9.1.7.7 are incorporated by reference into the NUHOMS® CoC 1004 Technical Specifications 4.1 (Note 2) and shall not be deleted or altered in any way without approval from the NRC. The text of this section is shown in bold type to distinguish it from other sections.

M.9.1.7.7.1 *Specification for Acceptance Testing of Neutron Absorbers by Neutron Transmission*

a) 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 up to 1.1 inch diameter.

This version of Chapter M.9 is associated with CoC 1004 Amendment 14 and is from UFSAR Revision 17. Please see Page M.9 Introduction - 1 for a discussion as to why certain versions of Chapter M.9 are being maintained in the UFSAR.

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 B10 at that energy.

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.

b) The following illustrates one acceptable method and is intended to be utilized as an example. Therefore, the following text is not part of the Technical Specifications. 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 [9.12].

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 M.9.1.7.7a) 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. Edge effects due to manufacturing operations such as shearing, deburring, and chamfering need not be included in this determination.

Non-conforming material shall be evaluated for acceptance in accordance with the Certificate Holder's QA procedures.

M.9.1.7.7.2 *Specification for Acceptance Testing of Neutron Absorbers by B-10 Volume Density Measurement*

a) B-10 volume density measurement 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, as long as it results in accumulating material that is uniform for sampling purposes.

The sampling rate for B-10 volume density measurements shall be such that there is at least one density measurement for each 2000 square inches of final product in each lot.

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.

Areal density is determined by measuring the B-10 volume density in test samples and converting the measured values to areal density. The method of measurement of B-10 volume density shall be subject to approval by the certificate holder. The method of measurement of B-10 volume density shall be qualified against neutron transmission testing. Results of the two test methods shall be compared and a penalty shall be derived to account for the performance based results of neutron transmission testing.

b) The following illustrates one acceptable method and is intended to be utilized as an example. Therefore, the following text is not part of the Technical Specifications. The acceptance criterion for individual plates is determined from a statistical analysis of the test results for their lot. The B-10 areal densities are determined by volume density as described above. The lower tolerance limit of B-10 volume density is then determined, defined as the mean value of B-10 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 [9.12]. Finally, the minimum specified value of B-10 areal density is divided by the lower tolerance limit of B-10 volume density to arrive at the minimum plate thickness that provides the specified B-10 areal density.

Any plate that is thinner than the statistically derived minimum thickness from M.9.1.7.7.2 a) or the minimum design thickness, whichever is greater, shall be treated as nonconforming, with the following exception. Local depressions are acceptable, as 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. Edge effects due to manufacturing operations such as shearing, deburring, and chamfering need not be included in this determination.

Non-conforming material shall be evaluated for acceptance in accordance with the certificate holder's QA procedures.

M.9.1.7.8 Specification for Qualification Testing of Metal Matrix Composites

CAUTION

Portions of Section M.9.1.7.8.4 and Section M.9.1.7.8.5 are incorporated by reference into the NUHOMS® CoC 1004 Technical Specifications 4.1 (Note 2) and shall not be deleted or altered in any way without approval from the NRC. The text of this section is shown in bold type to distinguish it from other sections.

M.9.1.7.8.1 Applicability and Scope

MMCs acceptable for use in the 32PT DSC are described in Section M.9.1.7.2.

Prior to initial use in a spent fuel dry storage or 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 M.9.1.7.9 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 *C*ertificate *H*older.

All changes on this page are AMD 13

M.9.1.7.8.2 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 storage/ transport system. This is demonstrated by the tests in Section M.9.1.7.8.4. It must have a uniform distribution of boron carbide. This is demonstrated by the tests in Section M.9.1.7.8.5.

M.9.1.7.8.3 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 storage, about 10^{15} neutrons/cm^2.

Thermal damage and corrosion (hydrogen generation) testing shall be performed unless such tests on materials of the same chemical composition have already been performed and found acceptable. The following paragraphs illustrate two cases where such testing is not required.

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 storage or transport[3].

Corrosion testing is not required for full density 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[4]

[3] Sung, C., "Microstructural Observation of Thermally Aged and Irradiated Aluminum/Boron Carbide (B_4C) Metal Matrix Composite by Transmission and Scanning Electron Microscope," 1998

[4] Boralyn testing submitted to the NRC under docket 71-1027, 1998

This version of Chapter M.9 is associated with CoC 1004 Amendment 14 and is from UFSAR Revision 17. Please see Page M.9 Introduction - 1 for a discussion as to why certain versions of Chapter M.9 are being maintained in the UFSAR.

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M.9.1.7.8.4 **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[5]) 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[6]. 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 %.**

c) ***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 storage. *An example of such a test would be: (1) immerse a specimen at least 6 x 6 inches in water under pressure ≥30 psig for at least 24 hours, (2) place the specimen in a vacuum furnace preheated to at least 300°F and evacuate the furnace. Acceptance criterion: no blistering or delamination of the cladding.*

M.9.1.7.8.5 **Required Tests and Examinations to Demonstrate B10 Uniformity**

Uniformity of the boron distribution shall be verified either by:

a) **Neutron radioscopy or radiography (ASTM E94[7], E142[8], and E545[9]) 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**

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5 ASTM B557 Standard Test Methods of Tension Testing Wrought and Cast Aluminum and Magnesium-Alloy Products

6 ASTM E290, Standard Methods for Bend Testing of Materials for Ductility

7 ASTM E94, Recommended Practice for Radiographic Testing

8 ASTM E142, Controlling Quality of Radiographic Testing

9 ASTM E545, Standard Method for Determining Image Quality in Thermal Neutron Radiographic Testing

b) **Quantitative testing for the B10 areal density, B10 density, the boron carbide weight fraction, *or the boron 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 M.9.1.7.7, or by chemical analysis for boron carbide *or boron* content in the composite.**

M.9.1.7.8.6 Qualification Report

Qualification report shall be prepared by, or subject to approval by the Certificate Holder.

M.9.1.7.9 Specification for Process Controls for Metal Matrix Composites

CAUTION
Sections M.9.1.7.9.1 and M.9.1.7.9.2 are incorporated by reference into the NUHOMS® CoC 1004 Technical Specifications 4.1 (Note 2) and shall not be deleted or altered in any way without approval from the NRC. The text of this section is shown in bold type to distinguish it from other sections.

M.9.1.7.9.1 **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 M.9.1.7.8 is required, depending on the characteristics of the material that could be affected by the process change.

M.9.1.7.9.2 **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, reduce the mechanical strength or ductility of the MMC.

M.9.1.7.9.3 **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 M.9.1.7.9.2.

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 (d50) 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.

M.9.1.7.10 B_4C Linear Density Testing for Poison Rod Assemblies (PRAs)

The PRAs are shown in Figure M.1-2, and additional physical requirements are listed in Table M.2-4. The B_4C poison is inserted into the stainless steel tubes shown in Figure M.1-2. Table M.2-4 specifies the minimum B_4C content per unit length in the axial direction of the rods for the various PRA designs. The minimum B_4C content per unit length is consistent with the criticality analysis (Section M.6) with an additional 25% margin.

Pellets or powder representing each powder lot shall be tested per ASTM C751 [9.6] or ASTM C750 (Type 2) [9.7] (or equivalent). Density and diameter shall be measured to verify conformance to the specification requirements.

Deviations from the specified dimensions or density may be accepted, so long as the resulting minimum B_4C mass per unit length is maintained.

Justification for Durability of B_4C Pellets:

B_4C is essentially inert and will not be attacked even by hot hydrofluoric or nitric acids[9.8]. It is insoluble in water [9.9], resistant to steam at temperatures of 200 to 300°C [9.10] and has a melting point of 2450°C [9.10]. Mechanically, B_4C is extremely hard (Mohs hardness of 9.3 vs. 10 for diamond) and is used in abrasion- and wear-resistant applications and in bullet-proof tiles. It has a compressive strength of 398,000 psi. In the PRAs, the B_4C pellets are sealed within stainless steel. With this configuration there is nothing that could cause the material to degrade

In the unlikely event that a pellet were to crack or break, the total mass would be confined by the steel to the same dimensions.

The irradiation-induced swelling is due to neutron capture by the ^{10}B isotope. Using data from [9.11] and by determining the neutron absorption in the B_4C (^{10}B capture) from the shielding analyses, the swelling is determined to be negligible ~ 0.00002%. Finally, according to [9.11], the first intergranular cracks do not start to appear until fluences are 5.5 orders of magnitude greater than those calculated for 50 years *of* operation. [(1)]

Renewal

[1] *With NRC approval of the CoC 1004 renewal application, the license is extended to a total of 60 years. The TLAAs identified as #1, #4, and #5 in Section 12.2 performed for the renewal of this design conservatively used a service life of 100 years.* 72.48

This version of Chapter M.9 is associated with CoC 1004 Amendment 14 and is from UFSAR Revision 17. Please see Page M.9 Introduction - 1 for a discussion as to why certain versions of Chapter M.9 are being maintained in the UFSAR.

M.9.2 Maintenance Program

NUHOMS®-32PT system is a totally passive system and therefore requires little, if any, maintenance over the lifetime of the ISFSI. Typical NUHOMS®-32PT system maintenance tasks are performed in accordance with the *U*FSAR.

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M.9.3 References

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9.1 ASME Boiler and Pressure Vessel Code, Section III, *2004* Edition *through 2006* addenda.

9.2 ANSI N14.5-1997, "American National Standard for Leakage Tests on Packages for Shipment of Radioactive Materials," February 1998.

9.3 *Deleted.*

9.4 *Deleted.*

9.5 "Aluminum Standards and Data, 2003," The Aluminum Association.

9.6 ASTM C751, "Standard Specification for Nuclear-Grade Boron Carbide Pellets."

9.7 ASTM C750, "Standard Specification for Nuclear-Grade Boron Carbide Powder."

9.8 The Merck Index, *9th edition, Merck & Co., 1976.*

9.9 *Grant (ed.),* Hackh's Chemical Dictionary, *4th edition, McGraw-Hill, 1969.*

9.10 *Lipp, A., "Boron Carbide: Production, Properties, Application," Reprint from* Technische Rundschau, *Nos. 14, 28, 33 (1995) and 7 (1966).*

9.11 *Stoto, T. et al., "Swelling and Microcracking of Boron Carbide Subjected to Fast Neutron Irradiations,"* Journal of Applied Physics, *Vol. 68, No.7, October 1, 1990, pp. 3198-3206.*

9.12 Natrella, "Experimental Statistics," Dover, 2005.

9.13 Not Used.

9.14 SNT-TC-1A, "American Society for Nondestructive Testing, Personnel Qualification and Certification in Nondestructive Testing," 1992.

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Table M.9-1
B10 Specification for the NUHOMS® - 32PT Poison Plates

Poison Type	***32PT Basket Type***	***Minimum Poison Loading (B10 g/cm²)***	***% Credit Used in Criticality Analysis***
Borated Aluminum /MMC	*A/B/C/D*	*0.007*	*90*
Borated Aluminum /MMC	*A1*	*0.015*	*90*
Borated Aluminum /MMC	*A2*	*0.020*	*90*

All changes on this page are AMD 11

Aging Management Program Requirements

AMP requirements for use of the 24PHB System during the period of extended storage operations are contained in Section 12.3. Applicable TLAAs performed for the initial CoC 1004 renewal application are provided in Section 12.2.

N.2.3 Safety Protection Systems

N.2.3.1 General

The NUHOMS®-24PHB DSC is designed to provide storage of spent fuel for at least 40 years.[1] The DSC cavity is vacuum dried and backfilled with helium and the internal pressure is always above atmospheric during the storage period as a precaution against in-leakage of air, which could be harmful to the fuel. Since the confinement vessel consists of a steel cylinder with an integrally-welded bottom closure, and a seal welded top closure that is verified to be leak tight after loading, the DSC cavity gas cannot escape.

Renewal

N.2.3.2 Protection By Multiple Confinement Barriers and Systems

The NUHOMS®-24PHB DSC provides a leak tight confinement of the spent fuel. Although similar to the existing NUHOMS®-24P DSC, sealing of the NUHOMS®-24PHB DSC involves leak testing in accordance with ANSI N14.5 [2.3] after loading and sealing the canister, as described in Section N.9.

N.2.3.3 Protection By Equipment and Instrumentation Selection

No change to Section 3.3.3.

N.2.3.4 Nuclear Criticality Safety

N.2.3.4.1 Control Methods for Prevention of Criticality

The design criterion for criticality is an upper subcritical limit (USL) of 0.9413 (0.95 minus benchmarking bias and modeling bias) that is maintained for all postulated arrangements of fuel within the DSC. The intact fuel assemblies are assumed to stay within their basket compartment based on the DSC and basket geometry.

The control method used to prevent criticality is soluble boron in the pool and favorable geometry.

The basket is designed to assure an ample margin of safety against criticality under the conditions of fresh fuel in a DSC flooded with borated pool water. The method of criticality control is in accordance with the requirements of 10 CFR 72.124.

The criticality analyses are described in Section N.6.

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[1] *With NRC approval of the CoC 1004 renewal application, the license is extended to a total of 60 years. The TLAAs identified as #1, #4, and #5 in Section 12.2 performed for the renewal of this design conservatively used a service life of 100 years.* 72.48

N.2.3.4.2 Error Contingency Criteria

Provision for error contingency is built into the criterion used in Section N.2.3.4.1 above. The criterion used in the criticality analysis is common practice for licensing submittals. Because conservative assumptions are made in modeling, it is not necessary to introduce additional contingency for error.

Aging Management Program Requirements

AMP requirements for use of the 24PTH System during the period of extended storage operations are contained in Section 12.3. Applicable TLAAs performed for the initial CoC 1004 renewal application are provided in Section 12.2.

Table P.2-22 and P.2-23 define the minimum required cooling time after reactor discharge for a failed fuel assembly at 400 kgU/FA heavy metal load with or without CCs for a given assembly heat load, burnup, and maximum initial enrichment parameters.

The method for determining the minimum required cooling times for the fuel assemblies with heavy metal loads between 400 and 490 kgU/FA is provided in *Chapter 7*, Section *7.2.3.2*. The method for determining the minimum required cooling times for assemblies at 492 kgU/FA is provided in Appendix P, Section P.5.4.10. Use Table P.2-24 and its notes for determining the minimum required cooling times for the assemblies at 492 kgU/FA heavy metal load.

Renewal

The NUHOMS®-24PTH DSC is inerted and backfilled with helium at the time of loading. The maximum fuel assembly weight with a CC is 1682 lbs.

The maximum fuel cladding temperature limit of 400 °C (752 °F) is applicable to normal conditions of storage and all short term operations from spent fuel pool to ISFSI pad including vacuum drying and helium backfilling of the NUHOMS®-24PTH DSC per NUREG-1536 [2.1]. In addition, NUREG-1536 [2.1] does not permit thermal cycling of the fuel cladding with temperature differences greater than 65 °C (117 °F) during DSC drying, backfilling and transfer operations.

The maximum fuel cladding temperature limit of 570 °C (1058 °F) is applicable to accidents or off-normal thermal transients [2.1].

Calculations were performed to determine the fuel assembly type which was most limiting for each of the analyses including shielding, criticality, thermal and confinement. These evaluations are performed in Chapter P.5, P.6, P.4 and P.7, respectively. The fuel assembly classes considered are listed in Table P.2-3. It was determined that the B&W 15x15 is the enveloping fuel design for the shielding source term calculation because of its total assembly weight and highest initial heavy metal loading. For criticality safety, the B&W 15x15 assembly is the most reactive assembly type for a given enrichment. This assembly is used to determine the most reactive configuration in the DSC. Using this most reactive configuration, criticality analysis for all other fuel assembly classes is performed to determine the maximum enrichment allowed as a function of the soluble boron concentration and fixed poison plate loading. For thermal analysis, the WE 14x14 fuel assembly is limiting for the 24PTH-S and -L DSCs, and B&W 15x15 fuel assembly for the 24PTH-S-LC DSC since they result in the lowest fuel conductivity. The confinement analysis is based on B&W 15x15 fuel assembly, since it results in a smaller free volume inside the DSC cavity as compared to a 14x14 fuel assembly.

For calculating the maximum internal pressure in the NUHOMS®-24PTH DSC, it is assumed that 1% of the fuel rods are damaged for normal conditions, up to 10% of the fuel rods are damaged for off normal conditions, and 100% of the fuel rods will be damaged following a design basis accident event. A minimum of 100% of the fill gas and 30% of the fission gases within the ruptured fuel rods are assumed to be available for release into the DSC cavity, consistent with NUREG-1536 [2.1].

P.2.3 Safety Protection Systems

P.2.3.1 General

The NUHOMS®-24PTH DSC is designed to provide storage of spent fuel for at least 40 years.[1] The DSC cavity is inerted and backfilled with helium and the internal pressure is always above atmospheric during the storage period as a precaution against in-leakage of air, which could be harmful to the fuel. Since the confinement vessel consists of a steel cylinder with an integrally welded bottom closure, and a seal welded top closure that is verified to be leak tight after loading, the DSC cavity gas cannot escape.

Renewal

Only those features that are not addressed in the existing FSAR, Chapter 3, or have been revised, are addressed in this Section. Those features include the thermal and nucleonic performance of the poison plates, and their acceptance. Components of the NUHOMS®-24PTH DSC that are "Important to Safety" and "Not Important to Safety" are listed in Table P.2-17.

P.2.3.2 Protection By Multiple Confinement Barriers and Systems

The NUHOMS®-24PTH DSC provides a leak tight confinement of the spent fuel. Although similar to the existing NUHOMS®-24P DSC, sealing of the NUHOMS®-24PTH DSC involves leak testing to the criteria of ANSI N14.5 [2.4] after loading and sealing the canister, as described in Section P.7.

P.2.3.3 Protection By Equipment and Instrumentation Selection

No change to Section 3.3.3.

P.2.3.4 Nuclear Criticality Safety

P.2.3.4.1 Control Methods for Prevention of Criticality

The design criterion for criticality is that an upper subcritical limit (USL) of 0.95 minus benchmarking bias and modeling bias will be maintained for all postulated arrangements of fuel within the DSC. The intact fuel assemblies are assumed to stay within their basket compartment based on the DSC and basket geometry.

The control method used to prevent criticality is incorporation of poison material in the basket material, soluble boron in the pool and favorable geometry. The quantity and distribution of boron in the poison material is controlled by specific manufacturing and acceptance criteria of the poison plates. The acceptance criteria of the plates is described in Section P.9.

The basket has been designed to assure an ample margin of safety against criticality under the conditions of fresh fuel in a DSC flooded with borated pool water. The method of criticality control is in accordance with the requirements of 10CFR72.124 [2.10].

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[1] *With NRC approval of the CoC 1004 renewal application, the license is extended to a total of 60 years. The TLAAs identified as #1, #4, and #5 in Section 12.2 performed for the renewal of this design conservatively used a service life of 100 years.* 72.48

give the maximum dose rate on the surface of the HSM and/or TC. This approach is consistent with the method used to generate the fuel qualification tables for the Standardized NUHOMS®-24P and -52B DSC designs as described in Section 7.2.3, or 32PT DSC design as described in Appendix M. The design basis fuel source term is then added to the design basis CC source term (Table P.5-12) to create the total fuel assemblies plus CC source term used in the calculations.

The fuel qualification tables shown in Table P.2-6 through Table P.2-13, and Tables P.2-22 and P.2-23 are developed for the design basis heavy metal loading of 0.490 MTU with SAS2H/ORIGEN-S modules of SCALE 4.4 [5.1] and for the heavy metal loading of 0.400 MTU with SAS2H/ORIGEN-S modules of SCALE 5.0 [5.16]. Section *7.2.3.2* of Chapter *7* provides the methods for determining minimum required cooling times using fitting equations or linear interpolation for a given MTU between 0.400 MTU and 0.490 MTU.

For the 24PTH-L DSC, Heat Load Zoning Configuration 2 (Figure P.2-2) is the configuration that produces the highest dose rates on the surfaces of the HSM-H and OS197FC TC as compared to configurations 1, 2 and 3 because the highest source fuel assemblies are on the outer periphery of the basket region where self-shielding due to adjacent assemblies is limited. This configuration 2 consists of 20 2.0 kW fuel assemblies located in the outer regions of the DSC. For the 24PTH-S-LC, which has only one heat load zoning configuration (Configuration 5, Figure P.2-5). To bound the shielding analysis for heat load zoning configuration 5, fuel assemblies with a decay heat of 1.5 kW at all 24 location is used. This results in a shielding analysis corresponding to a total of 36 kW decay heat per DSC which is very conservative because the total decay heat in 24PTH-S-LC DSC is limited to 24kW. These bounding gamma and neutron source terms are then used in the radiation shielding models to conservatively calculate dose rates on and around the NUHOMS®-24PTH system.

The bounding burnup, minimum initial enrichment and cooling time combinations for the fuel assemblies used in the shielding analyses of the 24PTH-L DSC in the HSM-H and the OS197FC TC are as follows:

- Dose rates with 24PTH-L DSC in HSM-H: 41 GWd/MTU, 3.3 wt. % U-235, 3.0-year cooled fuel
- Dose rates with 24PTH-L DSC in OS197FC TC: 62 GWd/MTU, 3.4 wt. % U-235, 5.6-year cooled fuel

The bounding burnup, minimum initial enrichment and cooling time combinations for the fuel assemblies used in the shielding analysis of the 24PTH-S-LC DSC are as follows:

- Dose rates with 24PTH-S-LC DSC in Standardized TC: 32 GWd/MTU, 2.6 wt. % U-235, 3.0-year cooled fuel
- Dose rates with 24PTH-S-LC DSC in HSM-Model 102: 32 GWd/MTU, 2.6 wt. % U-235, 3.0-year cooled fuel (same as for Standardized TC)

assume that the required cooling time for a higher enrichment assembly is the same as that for a lower enrichment assembly with the same burnup. The required cooling time for initial enrichments that fall between any two SAS2H runs are assumed to be that of the lower enrichment case results.

Fuel qualification tables for fuel without CCs at 490 kgU/FA and 400 kgU/FA heavy metal weight are listed in Table P.2-6 through Table P.2-9. However, some assemblies will contain a CC, which adds up to 8 watts of decay heat per assembly. Therefore, an additional set of fuel qualification tables are developed, as shown in Table P.2-10 through Table P.2-13, for fuel that contains CCs. The fuel qualification tables for fuel with CCs have slightly longer cooling times when compared to fuel without CCs. Also, the method for determining the minimum required cooling times for the fuel assemblies with heavy metal loads between 400 and 490 kgU/FA is provided in *Chapter 7*, Section *7.2.3.2*. The method for determining the minimum required cooling times for assemblies at 492 kgU/FA is provided in Appendix P, Section P.5.4.10. Use Table P.2-24 and its notes for determining the minimum required cooling times for the assemblies at 492 kgU/FA heavy metal load.

Reconstituted and/or damaged fuel is also acceptable for the DSC payload. Reconstituted fuel may contain up to 10 solid stainless steel rods that replace fuel rods. Reconstituted fuel has a rather small effect on the dose rate such that for cooling times less than 10 years, 1 year of cooling time is added if reconstituted stainless steel rods are present. If the cooling time is greater than 10 years, no additional cooling time is needed. Additional discussion on the method used to analyze reconstituted fuel is provided in Section P.5.2.5. Damaged fuel has essentially no impact on the dose rate as the source term would not be impacted and gross axial source redistribution is not likely.

The design-basis source terms are defined as the burnup/initial enrichment/cooling time combination given in the fuel qualification tables that result in the maximum dose rate on the surface of the HSM (either type) or TC (all types). Note that for a given DSC design, the design basis HSM source will not necessarily be the same as the corresponding design basis TC source. The 1-D discrete ordinates code ANISN [5.5] and the CASK-81 22 neutron, 18 gamma-ray energy group, coupled cross-section library [5.3] is used to determine the HSM and TC dose rate for each entry in the fuel qualification tables and thereby determine the design basis source. As ANISN is a 1-D code, a single dose location must be selected for both the HSM and TC for analysis purposes. For the HSM, the roof is selected as the dose location, and for the TC the cask side is selected as the dose location. This approach, described in detail in Section P.5.2.4, is consistent with the method used to determine the fuel qualification tables for the Standardized NUHOMS® canister designs described in Section 7.2.3 and Appendix M.5. The radiological source terms generated in the SAS2H/ORIGEN-S runs are used in the ANISN evaluations to calculate the surface dose rates. The ANISN models are similar to the appropriate MCNP4C2 models for the locations of interest.

10. If damaged fuel assemblies are included in a specific loading campaign, place the required number of bottom end caps provided (up to a maximum of 12) into the cell locations per Technical Specification 2.1. Place and verify that the bottom fuel assembly spacers, if required, are present in the fuel cells. Optionally, this step may be performed at any prior time.

10a If failed fuel is to be loaded in the DSC (24PTHF *Basket* only), place the empty failed fuel cans (refer to Appendix P.1, drawing NUH24PTH-1008-SAR) 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).

11. Fill the DSC cavity with water from the fuel pool or an equivalent source which meets the requirements of Technical Specification 3.2.

11. Raise the TC 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 onto the DSC. If not, lower the cask and reposition the top shield plug. Repeat Steps 11 and 12 as necessary.

13. Continue to raise the TC 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* water from the DSC as necessary to meet the plant lifting crane capacity limits. Consistent with ISG-22 [8.5] guidance and Technical Specification 3.1.1, helium at 1-3 psig is used to backfill the DSC with an inert gas as water is being removed from the DSC.

    CAUTION: The radiation dose rates around the surface of the transfer cask without water in the neutron shield and/or in the DSC cavity (through step P.8.1.2.19) are expected to be high. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.

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

18. Move the TC with loaded DSC to the cask decon area.

19. If applicable to keep the occupational exposure ALARA, replace the water removed from the DSC in Step 16 with spent fuel pool water of the proper boron concentration. Fill the neutron shield with demineralized water if it was drained in Step P.8.1.1.5. Temporary shielding may be installed as necessary to minimize personnel exposure.

P.8.1.3 DSC Drying and Backfilling

CAUTION: During performance of steps listed in Section 8.1.3, 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 in accordance with the limits specified in Technical Specification 5.2.4.d for the DSC surfaces. Temporary shielding may be installed as necessary to minimize personnel exposure.

2. Place scaffolding around the cask so that any point on the surface of the cask is easily accessible to personnel.

5. Position the cask lower trunnions onto the transfer trailer support skid pillow blocks.

6. Move the crane forward while simultaneously lowering the cask until the cask upper trunnions are just above the support skid upper trunnion pillow blocks.

7. Inspect the positioning of the cask to insure that the cask and trunnion pillow blocks are properly aligned.

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

9. Inspect the trunnions to ensure that they are properly seated onto the skid. Install the trunnion tower closure plates (optional for the OS197 TC or the OS197H or OS200 TC).

10. Fill the neutron shield *with demineralized water*, if it was drained in P.8.1.5.1 step 1, and verify that the NS is filled, in accordance with Technical Specification 5.2.4.a.

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

P.8.1.6 DSC Transfer to the HSM

Note: If using the HSM-HS module for storage of the NUHOMS®-24PTH DSC at sites with high seismic levels, verify that at least 3 modules are connected together per the requirements of Technical Specification 4.3.1.

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

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

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

   CAUTION: Verify that the requirements of Technical Specification 5.3.1.B are met prior to next step.

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

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

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

20. The trailer may be moved as necessary to install the HSM door. Install the HSM door and secure it in place. Door may be welded for security. Verify that the HSM dose rates are compliant with the limits specified in Technical Specifications 5.4.1 and 5.4.2.

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

22. *If this is the final loading, fully drain the liquid neutron shield.*

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

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

P.8.1.7 <u>Monitoring Operations</u>

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

2. Perform a daily visual surveillance of the HSM air inlets and outlets to insure that no debris is obstructing the HSM vents in accordance with Technical Specification 5.2.5.a requirements OR perform a temperature measurement of the thermal performance, for each HSM, on a daily basis in accordance with Technical Specification 5.2.5.b requirements.

essentially identical to those of DSC loading through the DSC weld removal (beginning of preparation to placement of the cask in the fuel pool). Prior to opening the DSC, the following operations are to be performed.

CAUTION: Verify that the applicable time limits of Technical Specification 3.1.3 are met until the completion of Step P.8.2.2.14.

1. The TC may now be transferred to the cask handling area inside the plant's fuel/reactor building.

2. Position and ready the trailer for access by the crane and install the ram access penetration cover plate.

3. Attach the lifting yoke to the crane hook.

4. Engage the lifting yoke with the trunnions of the TC.

5. Visually inspect the yoke lifting hooks to insure that they are properly aligned and engaged onto the TC trunnions.

6. If unloading with OS197/OS197FC TC, drain the TC water from the neutron shield to an acceptable location as required to meet the plant lifting crane capacity limit.

   CAUTION: The radiation dose rates around the surface of the transfer cask without water in the neutron shield (through step P.8.2.2.9) are expected to be high. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.

7. Lift the TC approximately one inch off the trunnion supports. Visually inspect the yoke lifting hooks to insure that they are properly positioned on the trunnions.

8. Move the crane backward in a horizontal motion while simultaneously raising the crane hook vertically and lift the TC off the trailer. Move the TC to the cask decon area.

9. Lower the TC into the cask decon area in the vertical position. Fill the neutron shield with *demineralized* water if it was drained in Step P.8.2.2.6, and verify that the NS is filled, in accordance with Technical Specification 5.2.4.a.

10. Wash the TC to remove any dirt which may have accumulated on the TC during the DSC loading and transfer operations.

11. Place scaffolding around the TC so that any point on the surface of the TC is easily accessible to handling personnel.

12. Unbolt the TC top cover plate.

13. If using the OS200/OS200FC TC to unload, remove the sleeve ring spacer at the top of the aluminum sleeve placed in Section P.8.2.1, step 13. Connect the rigging cables to the TC

30. *Drain* a minimum of 750 gallons of water from the DSC. The neutron shield water from the TC may also need to be drained as required, to meet plant crane limits.

    CAUTION: The radiation dose rates around the surface of the transfer cask without water in the neutron shield and/or in the DSC cavity (through step P.8.2.2.37) are expected to be high. Use proper ALARA practices (e.g., use of temporary shielding, appropriate positioning of personnel, etc.) to minimize personnel exposure.

31. The cask should be lifted just far enough to allow the weight of the TC to be distributed onto the yoke lifting hooks. Inspect the lifting hooks to insure that they are properly positioned on the trunnions.

32. Install suitable protective material onto the bottom of the TC to minimize cask contamination. Move the cask to the fuel pool.

33. 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.

34. Lower the cask into the fuel pool leaving the top surface of the cask approximately one foot above the surface of the pool water.

35. Fill the DSC with appropriate amount pool water.

P.9 Acceptance Tests and Maintenance Program

Background for this particular UFSAR chapter:

Beginning with CoC 1004 Amendment 10, which was incorporated into UFSAR Revision 11, Chapter P.9, "Acceptance Tests and Maintenance Program," contained information which was incorporated by reference into the Technical Specifications (TS) associated with a particular amendment. It is known that certain general licensees reconcile the CoC 1004 UFSAR revisions provided to them to their loaded systems, pursuant to 10 CFR 72.48 and 10 CFR 72.212. In doing so they sometimes find the changed UFSAR portions incorporated by reference into the TS to be impossible to reconcile because the 10 CFR 72.48 regulation does not allow proposed activities which involve changes to the TS.

In order to facilitate this reconciliation process by general licensees, the following statements are provided, addressing the licensing basis for certain amendments, as they relate to certain UFSAR chapters which contain TS incorporated by reference. Additionally, so that the actual information is contained in the current CoC 1004 UFSAR, to facilitate the reconciliation by general licensees, the UFSAR Revision 11, 12, 13, and 14 versions of Chapter P.9 are inserted and annotated in this part of the UFSAR. For clarity, this includes annotating the version of Chapter P.9 directly associated with the latest UFSAR revision in which a change to Chapter P.9 occurred.

- Systems loaded to CoC 1004 Amendment 10 have Technical Specifications incorporated by reference from UFSAR Revisions 11 and 12 in Chapter P.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to systems loaded to Amendment 10.

- Systems loaded to CoC 1004 Amendment 11 have Technical Specifications incorporated by reference from UFSAR Revision 13 Chapter P.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to Amendment 11.

- Note that CoC 1004 Amendment 12 was submitted and docketed, associated with a U.S. Department of Energy project, but due to a lack of review funding the NRC returned it without a review.

- Systems loaded to CoC 1004 Amendment 13 have Technical Specifications incorporated by reference from UFSAR Revisions 14 and 15 Chapter P.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to Amendment 13.

- Systems loaded to CoC 1004 Amendment 14 have Technical Specifications incorporated by reference by FCN 721004-1575, which will be incorporated into UFSAR Revision*s* 16 *and 17* Chapter P.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to Amendment 14.

This version of Chapter P.9 is associated with CoC 1004 Amendment 14 and is added from UFSAR Revision 17. Please see Page P.9 Introduction - 1 for a discussion as to why certain versions of Chapter P.9 are being maintained in the UFSAR.

P.9 Acceptance Tests and Maintenance Program

P.9.1 Acceptance Tests

The acceptance requirements for the NUHOMS®-24PTH system are given in the UFSAR except as described in the following sections. The NUHOMS®-24PTH DSC has been enhanced to provide leaktight confinement and the basket includes an updated poison plate design. The requirements for the poison plate material acceptance tests and the NUHOMS®-24PTH DSC welds for the 24PTH system are described.

P.9.1.1 Visual Inspection

Visual examinations are performed at the fabricator's facility to ensure that the NUHOMS®-24PTH system components conform to the fabrication specifications and drawings.

P.9.1.2 Structural Tests

The NUHOMS®-24PTH DSC confinement welds are designed, fabricated, tested and inspected in accordance with ASME B&PV Code Section III, Subsection NB [9.1] with exceptions as listed in Section P.3.1. The following requirements are unique to the NUHOMS®-24PTH DSC:

- The inner bottom cover weld is inspected in accordance with Article NB-5231 when the weld joint design is per Figure NB-4243-1,
- The outer bottom cover weld is penetrant tested, and
- The outer top cover plate weld root and cover are penetrant tested.

The NUHOMS®-24PTH DSC basket is designed, fabricated, and inspected in accordance with ASME B&PV Code Section III, Subsection NG [9.1] with exceptions as listed in Section P.3.1.

P.9.1.3 Leak Tests

The NUHOMS®-24PTH DSC confinement boundary is leak tested to verify that it is leaktight in accordance with the criteria of ANSI N14.5 [9.2]. The personnel performing the leak test are qualified in accordance with SNT-TC-1A [9.8].

The leak tests are typically performed using the helium mass spectrometer method. Alternative methods are acceptable, provided that the required sensitivity is achieved.

P.9.1.4 Component Tests

The NUHOMS® system does not include any components such as valves, rupture discs, pumps, or blowers. No other components of the NUHOMS® system require testing, except as discussed in this chapter.

This version of Chapter P.9 is associated with CoC 1004 Amendment 14 and is added from UFSAR Revision 17. Please see Page P.9 Introduction - 1 for a discussion as to why certain versions of Chapter P.9 are being maintained in the UFSAR.

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P.9.1.5 Shielding Integrity Tests

The transfer cask poured lead shielding integrity will be confirmed via gamma scanning prior to first use. The detector and examination grid will be matched to provide coverage of the entire lead-shielded surface area. For example, for a 6"x 6" grid, the detector will encompass a 6"x 6" square. The acceptance criterion is attenuation greater than or equal to that of a test block matching the cask through-wall configuration with lead and steel thicknesses equal to the design minima less 5%.

The radial neutron shielding is provided by filling the neutron shield shell with water during operations. No testing is necessary. The neutron shield material in the lid and bottom end is a proprietary polymer resin. The shielding performance of the resin will be assured by written procedures controlling temperature, measuring, and mixing of the components, degassing of the resin, and verification of the mass or volume of resin installed.

The gamma and neutron shielding materials of the storage system itself are limited to concrete HSM components and steel shield plugs in the DSC. The integrity of these shielding materials is ensured by the control of their fabrication in accordance with the appropriate ASME, ASTM or ACI criteria. No additional acceptance testing is required.

P.9.1.6 Thermal Acceptance Tests

No thermal acceptance testing is required to verify the performance of each storage unit other than that specified in the Technical Specifications for initial loading.

The heat transfer analysis for the basket includes credit for the thermal conductivity of neutron-absorbing materials, as specified in Section P.4.3. Because these materials do not have publicly documented values for thermal conductivity, testing of such materials will be performed in accordance with Section P.9.1.7.6.

P.9.1.7 Poison Acceptance

CAUTION

Sections P.9.1.7.1 through P.9.1.7.4 below are incorporated by reference into the NUHOMS® CoC 1004 Technical Specifications 4.1 (Note 3) and shall not be deleted or altered in any way without approval from the NRC. The text of these sections is shown in bold type to distinguish it from other sections.

The neutron absorber used for criticality control in the DSC basket may consist any of the following types of material:

(a) Borated *a*luminum

(b) Boron carbide/*a*luminum metal matrix composite (MMC)

(c) BORAL®

This version of Chapter P.9 is associated with CoC 1004 Amendment 14 and is added from UFSAR Revision 17. Please see Page P.9 Introduction - 1 for a discussion as to why certain versions of Chapter P.9 are being maintained in the UFSAR.

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The 24PTH DSC safety analyses do not rely upon the tensile strength of these materials. 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 for these materials is given in Table P.9-1.

References to metal matrix composites throughout this chapter are not intended to refer to BORAL®, which is described later in this section.

P.9.1.7.1 **Borated Aluminum**

See the Caution in Section P.9.1.7 before deletion or modification to this section.

The material is produced by direct chill (DC) or permanent mold casting with boron precipitating primarily as a uniform fine dispersion of discrete AlB_2 or TiB_2 particles in the matrix of aluminum or aluminum alloy (other boron compounds, such as AlB_{12}, can also occur). 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. 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 P.9.1.7.7. 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.

P.9.1.7.2 **Boron Carbide / Aluminum Metal Matrix Composites (MMC)**

See the Caution in Section P.9.1.7 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, *molten metal infiltration,* or thermal spray techniques. The boron carbide content shall not exceed 40% by volume. The boron carbide content for MMCs with an integral aluminum cladding *or produced by molten metal infiltration* 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

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0.5 volume % interconnected porosity of the core and cladding as a unit of the final product.

At least 50% by weight of the B_4C particles in MMCs shall be smaller than 40 microns. No more than 10% of the particles shall be over 60 microns.

Prior to use in the 24PTH DSC, MMCs shall pass the qualification testing specified in Section P.9.1.7.8, and shall subsequently be subject to the process controls specified in Section P.9.1.7.9.

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 P.9.1.7.7. 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.

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P.9.1.7.3 BORAL®

See the Caution in Section P.9.1.7 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. Before rolling, at least 80% by weight of the B_4C particles in BORAL® shall be smaller than 200 microns. 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.

P.9.1.7.4 Visual Inspections of Neutron Absorbers

See the Caution in Section P.9.1.7 before deletion or modification to this section.

Neutron absorbers shall be 100% visually inspected in accordance with the Certificate Holder's QA procedures. *Blisters shall be treated as non-conforming. For clad MMCs and 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.* Material that does not meet *these* acceptance criteria shall be reworked, repaired, or scrapped.

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P.9.1.7.5 Other Visual Inspections Criteria (non-Technical Specifications)

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" [9.5]. Local or cosmetic conditions such as scratches, nicks, die lines, inclusions, abrasion, isolated pores, or discoloration are acceptable.

P.9.1.7.6 Thermal Conductivity Testing of Poison Plates

*Acceptance t*esting shall conform to ASTM E1225[1], ASTM E1461[2], or equivalent method, performed at room temperature on coupons taken from the rolled or extruded production material. Initial sampling shall be one test per lot, and may be reduced if the first five tests meet the specified minimum thermal conductivity. *For cast products, the lot shall be defined by the heat or ingot. For other products, the lot shall be defined as material produced in a single production campaign using the same heat or lots of aluminum and boron carbide feed materials.*

If a thermal conductivity test result is below the specified minimum, at least four additional tests shall be performed on the material from that lot. If the mean value of those tests, including the original test, falls below the specified minimum, the associated lot shall be rejected.

After *twenty five* tests of a single type of material, with the same aluminum alloy matrix, the same boron content, and the same primary boron phase, e.g., B_4C, TiB_2, or AlB_2, if the mean value of all the test results less two standard deviations meets the specified thermal conductivity, no further testing of that material is required. This exemption may also be applied to the same type of material if the matrix of the material changes to a more thermally conductive alloy (e.g., from 6000 to 1000 series aluminum), or if the boron content is reduced without changing the boron phase.

The measured thermal conductivity values shall satisfy the minimum required conductivities as specified in Section P.4.3.

In cases where the specified thickness of the neutron absorber may vary, the equations introduced in Section P.4.3 shall be used to determine the minimum required effective thermal conductivity.

The thermal conductivity test requirement does not apply to aluminum that is paired with the neutron absorber.

1 ASTM E1225, "Thermal Conductivity of Solids by Means of the Guarded-Comparative-Longitudinal Heat Flow Technique"

2 ASTM E1461, "Thermal Diffusivity of Solids by the Flash Method"

P.9.1.7.7 Specification for Acceptance Testing of Neutron Absorber *Content*

Acceptance testing for neutron absorber content shall be performed by either neutron transmission or by B-10 volume density measurement.

CAUTION

Portions of Section P.9.1.7.7 are incorporated by reference into the NUHOMS® CoC 1004 Technical Specifications 4.1 (Note 3) and shall not be deleted or altered in any way without approval from the NRC. The text of this section is shown in bold type to distinguish it from other sections.

P.9.1.7.7.1 *Specification for Acceptance Testing of Neutron Absorbers by Neutron Transmission*

a) 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 up to 1.1 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 B10 at that energy.

This version of Chapter P.9 is associated with CoC 1004 Amendment 14 and is added from UFSAR Revision 17. Please see Page P.9 Introduction - 1 for a discussion as to why certain versions of Chapter P.9 are being maintained in the UFSAR.

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.

b) The following illustrates one acceptable method and is intended to be utilized as an example. Therefore, the following text is not part of the Technical Specifications. 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 for a normal distribution with 95% probability and 95% confidence [9.6].

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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 P.9.1.7.7 a) 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. Edge effects due to manufacturing operations such as shearing, deburring, and chamfering need not be included in this determination.

Non-conforming material shall be evaluated for acceptance in accordance with the Certificate Holder's QA procedures.

P.9.1.7.7.2 *Specification for Acceptance Testing of Neutron Absorbers by B10 Volume Density Measurement*

a) B-10 volume density measurement 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, as long as it results in accumulating material that is uniform for sampling purposes.

The sampling rate for B-10 volume density measurements shall be such that there is at least one density measurement for each 2000 square inches of final product in each lot.

Areal density is determined by measuring the B-10 volume density in test samples and converting the measured values to B-10 areal density. The method of measurement of B-10 volume density as well as the conversion method shall be subject to approval by the certificate holder. The method of conversion shall be qualified by performing benchmarking with both neutron transmission and B-10 volume density measurement to confirm transmissibility between methods. The B-10 volume density shall be checked against the minimum areal density by multiplying the volume realized by the coupon thickness.

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.

b) The following illustrates one acceptable method and is intended to be utilized as an example. Therefore, the following text is not part of the Technical Specifications. The acceptance criterion for individual plates is determined from a statistical analysis of the test results for their lot. The B-10 areal densities are determined by volume density as described above. The lower tolerance limit of B-10 volume density is then determined, defined as the mean value of B-10 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 [9.6]. Finally, the minimum specified value of B-10 areal density is divided by the lower tolerance limit of B-10 volume density to arrive at the minimum plate thickness that provides the specified B-10 areal density.

Any plate that is thinner than the statistically derived minimum thickness from P.9.1.7.7.2 a) or the minimum design thickness, whichever is greater, shall be treated as nonconforming, 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. Edge effects due to manufacturing operations such as shearing, deburring, and chamfering need not be included in this determination.

Non-conforming material shall be evaluated for acceptance in accordance with the certificate holder's QA procedures.

P.9.1.7.8 <u>Specification for Qualification Testing of Metal Matrix Composites</u>

CAUTION
Portions of Section P.9.1.7.8.4 and Section P.9.1.7.8.5 are incorporated by reference into the NUHOMS® CoC 1004 Technical Specifications 4.1 (Note 3) and shall not be deleted or altered in any way without approval from the NRC. The text of this section is shown in bold type to distinguish it from other sections.

This version of Chapter P.9 is associated with CoC 1004 Amendment 14 and is added from UFSAR Revision 17. Please see Page P.9 Introduction - 1 for a discussion as to why certain versions of Chapter P.9 are being maintained in the UFSAR.

P.9.1.7.8.1 Applicability and Scope

Metal matrix composites (MMCs) acceptable for use in the 24PTH DSC are described in Section P.9.1.7.2.

Prior to initial use in a spent fuel dry storage or 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 P.9.1.7.9 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.

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ASTM test methods and practices are referenced below for guidance. Alternative methods may be used with the approval of the Certificate Holder.

P.9.1.7.8.2 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 storage/ transport system. This is demonstrated by the tests in SectionP.9.1.7.8.4. It must have a uniform distribution of boron carbide. This is demonstrated by the tests in Section P.9.1.7.8.5.

P.9.1.7.8.3 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 storage, about 10^{15} neutrons/cm^2.

Thermal damage and corrosion (hydrogen generation) testing shall be performed unless such tests on materials of the same chemical composition have already been performed and found acceptable. The following paragraphs illustrate two cases where such testing is not required.

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 storage or transport[3].

Corrosion testing is not required for full density 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[4].

P.9.1.7.8.4 **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[5]) demonstrating that the material has the following tensile properties:**

- **Minimum yield strength, 0.2% offset: 1.5 ksi**
- **Minimum ultimate strength: 5 ksi**

[3] Sung, C., "Microstructural Observation of Thermally Aged and Irradiated Aluminum/Boron Carbide (B_4C) Metal Matrix Composite by Transmission and Scanning Electron Microscope," 1998.

[4] Boralyn testing submitted to the NRC under docket 71-1027, 1998.

[5] ASTM B557 Standard Test Methods of Tension Testing Wrought and Cast Aluminum and Magnesium-Alloy Products.

- **Minimum elongation in 2 inches: 0.5%**

As an alternative to the elongation requirement, ductility may be demonstrated by bend testing per ASTM E290[6]. 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 %.**

c) **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 storage. An example of such a test would be: (1) immerse a specimen at least 6 x 6 inches in water under pressure ≥30 psig for at least 24 hours, (2) place the specimen in a vacuum furnace preheated to at least 300°F and evacuate the furnace. Acceptance criterion: no blistering or delamination of the cladding.

P.9.1.7.8.5 **Required Tests and Examinations to Demonstrate B10 Uniformity**

Uniformity of the boron distribution shall be verified either by:

a) **Neutron radioscopy or radiography (ASTM E94[7], E142[8], and E545[9]) 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, the boron carbide weight fraction, *or the boron 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 P.9.1.7.7, or by chemical analysis for boron carbide *or boron* content in the composite.**

P.9.1.7.8.6 Qualification Report

Qualification report shall be prepared by, or subject to approval by the Certificate Holder.

6 ASTM E290, Standard Methods for Bend Testing of Materials for Ductility
7 ASTM E94, Recommended Practice for Radiographic Testing
8 ASTM E142, Controlling Quality of Radiographic Testing
9 ASTM E545, Standard Method for Determining Image Quality in Thermal Neutron Radiographic Testing

P.9.1.7.9 Specification for Process Controls for Metal Matrix Composites

All changes on this page are AMD 13

CAUTION

Sections P.9.1.7.9.1 and P.9.1.7.9.2 are incorporated by reference into the NUHOMS® CoC 1004 Technical Specifications 4.1 (Note 3) and shall not be deleted or altered in any way without approval from the NRC. The text of this section is shown in bold type to distinguish it from other sections.

P.9.1.7.9.1 **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 P.9.1.7.8 is required, depending on the characteristics of the material that could be affected by the process change.

P.9.1.7.9.2 **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, reduce the mechanical strength or ductility of the MMC.

P.9.1.7.9.3 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 P.9.1.7.9.2.

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 *(d50)* 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,

This version of Chapter P.9 is associated with CoC 1004 Amendment 14 and is added from UFSAR Revision 17. Please see Page P.9 Introduction - 1 for a discussion as to why certain versions of Chapter P.9 are being maintained in the UFSAR.

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.

All changes on this page are AMD 13

This version of Chapter P.9 is associated with CoC 1004 Amendment 14 and is added from UFSAR Revision 17. Please see Page P.9 Introduction - 1 for a discussion as to why certain versions of Chapter P.9 are being maintained in the UFSAR.

P.9.2 Maintenance Program

All changes on this page are AMD 11

NUHOMS®-24PTH system is a totally passive system and therefore requires little, if any, maintenance over the lifetime of the ISFSI. Typical NUHOMS®-24PTH system maintenance tasks are performed in accordance with the *U*FSAR.

This version of Chapter P.9 is associated with CoC 1004 Amendment 14 and is added from UFSAR Revision 17. Please see Page P.9 Introduction - 1 for a discussion as to why certain versions of Chapter P.9 are being maintained in the UFSAR.

All changes on this page are AMD 11

P.9.3 References

9.1 ASME Boiler and Pressure Vessel Code, Section III, 1998 Edition including 2000 addenda.

9.2 ANSI N14.5-1997, "American National Standard for Leakage Tests on Packages for Shipment of Radioactive Materials," February 1998.

9.3 *Deleted.*

9.4 *Deleted.*

9.5 "Aluminum Standards and Data, 2003" The Aluminum Association.

9.6 Natrella, "Experimental Statistics," Dover, 2005.

9.7 *Deleted.*

9.8 SNT-TC-1A, "American Society for Nondestructive Testing, Personnel Qualification and Certification in Nondestructive Testing," 1992.

9.9 *Deleted.*

9.10 *Deleted.*

This version of Chapter P.9 is associated with CoC 1004 Amendment 14 and is added from UFSAR Revision 17. Please see Page P.9 Introduction - 1 for a discussion as to why certain versions of Chapter P.9 are being maintained in the UFSAR.

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Table P.9-1
B10 Specification for the NUHOMS®-24PTH Poison Plates

Poison Type	24PTH Basket Type	Minimum Poison Loading (B10 mg/cm^2)	% Credit Used in Criticality Analysis
Borated Aluminum /MMC	1A or 2A	7	90
	1B or 2B	15	
	1C or 2C	32	
BORAL®	1A or 2A	9	75
	1B or 2B	19	
	1C or 2C	40	

R.1 General Discussion

Appendix R to the NUHOMS® Final Safety Analysis Report (FSAR) addresses the Important to Safety aspects of adding the HSM Model 152 to the Standardized NUHOMS® system described in the FSAR. The HSM Model 152 is added to the FSAR as an alternative to the HSM Model 80 and Model 102. The primary reason for adding a third HSM design (Model 152) is to include an HSM design that offers even greater biological shielding capabilities than currently available.

The Model 152 is a "one size fits all" module, which can accommodate both PWR (187") and BWR (197") length Dry Shielded Canisters (DSCs). The varying lengths of the DSCs are accommodated through the use of rail spacers. Similar to the design basis, function, and operation of the HSM Model 80 and Model 102, the Model 152 provides an independent, passive system with heat removal capacity sufficient to ensure that peak cladding temperatures during long term storage of spent fuel assemblies remain below acceptable limits to assure fuel cladding integrity.

The format of this Appendix follows the guidance provided in NRC Regulatory Guide 3.61 [1.1]. The analyses presented in this Appendix demonstrates that the HSM Model 152 system meets all the requirements of 10 CFR 72 [1.2].

Several sections of this Appendix have been identified as "No Change." For these sections, the description or analysis presented in the corresponding sections of the FSAR for the Standardized NUHOMS® system is also applicable to the HSM Model 152. In addition, tables and figures presented in the FSAR which remain unchanged due to the addition of the HSM Model 152 to the Standardized NUHOMS® system are not repeated in this Appendix.

Note: References to sections or chapters within this Appendix are identified with a prefix R (e.g., Section R.2.3 or Chapter R.2). References to sections or chapters of the FSAR outside of this Appendix (i.e., main body of the FSAR) are identified with the applicable FSAR section or chapter number (e.g., Section 2.3 or Chapter 2). The references used in this Appendix are identified as [X.X] (e.g., [1.1] is reference 1.1 at the end of Chapter R.1).

Aging Management Program Requirements

AMP requirements for use of the HSM Model 152 during the period of extended storage operations are contained in Section 12.3. Applicable TLAAs performed for the initial CoC 1004 renewal application are provided in Section 12.2.

R.1.1 Introduction

This Appendix adds the HSM Model 152 to the NUHOMS® system. Only those features that are being revised or added to the NUHOMS® system are addressed and evaluated in this Appendix. Sections of this Appendix which are not affected by the addition of the HSM Model 152 are indicated in this Appendix with "No Change." The various DSCs and Transfer Cask (TC) in the Standardized NUHOMS® system remain unchanged.

In general, the HSM Model 152 is similar to the existing HSM Model 80 and Model 102. The material and physical properties for all three HSM models are basically the same. The major differences between the HSM Model 152 and the existing Model 80 and Model 102 are listed in *Table R.1-1* and highlighted below.

- The HSM Model 152 has the roof thickness increased to 5'-8" to improve shielding performance.

These alternate NUHOMS®-61BTH System configurations are summarized below:

System Configuration	61BTH DSC Type	Neutron Absorber Plate Type	Max. Heat Load (kW) per DSC	Transfer Cask	Storage Module
1	1	Borated Aluminum, or MMC or Boral®	19.4	OS197 or OS197H or OS197FC-B or OS200 or OS200FCB	HSM Model 80 or Model 102 or Model 152 or Model 202 or HSM-H or HSM-HS
2		Borated Aluminum	22.0		
3	2	Borated Aluminum, or MMC or Boral®	27.4	OS197FC-B or OS200FC	HSM-H or HSM-HS
4		Borated Aluminum	31.2		

The NUHOMS®-61BTH system provides structural integrity, confinement, shielding, criticality control and passive heat removal independent of any other facility structures or components.

The format of this Appendix follows the guidance provided in NRC Regulatory Guide 3.61 [1.1]. The analysis presented in this Appendix shows that the NUHOMS®-61BTH system meets all the requirements of 10CFR72 [1.2]. A separate analysis will be submitted to address the safety related aspects of transporting spent fuel in the NUHOMS®-61BTH DSC in accordance with 10CFR71 [1.3].

Several sections of this Appendix have been identified as "No change." For these sections, the description or analysis presented in the corresponding sections of the UFSAR for the Standardized NUHOMS® system is also applicable to the 61BTH system. In addition, tables and figures presented in the UFSAR, which remain unchanged due to the addition of the 61BTH system to the Standardized NUHOMS® system, are not repeated in this Appendix.

Note: References to sections or chapters within this Appendix are identified with a prefix T (e.g., Section T.2.3 or Appendix T.2 or Chapter T.2). References to sections or chapters of the UFSAR outside of this Appendix (main body or other appendices of the UFSAR) are identified with the applicable UFSAR section or chapter number (e.g., Section 2.3 or Chapter 2) or appendix (e.g., Appendix K). The references used in this appendix are identified as [X.X] (e.g., [1.1] is reference 1.1 at the end of Section T.1).

Aging Management Program Requirements

AMP requirements for use of the 61BTH System during the period of extended storage operations are contained in Section 12.3. Applicable TLAAs performed for the initial CoC 1004 renewal application are provided in Section 12.2.

T.2.3 Safety Protection Systems

T.2.3.1 General

The NUHOMS®-61BTH system is designed to provide storage of spent fuel for at least 40 years.[1] The DSC cavity is inerted and backfilled with helium and the internal pressure is always above atmospheric during the storage period as a precaution against in-leakage of air, which could be harmful to the fuel. Since the confinement vessel consists of a steel cylinder with an integrally welded bottom closure, and a seal welded top closure that is verified to be leak tight after loading, the DSC cavity gas cannot escape.

Renewal

Only those features that are not addressed in the existing UFSAR, Chapter 3, or have been revised, are addressed in this Section. Those features include the thermal and nucleonic performance of the poison plates, and their acceptance. The quality category classification for the various NUHOMS® System Components is described in Section 3.4. The quality categories for the 61BTH system are summarized in Table T.2.15. The detailed quality category of components of the NUHOMS®-61BTH DSC and OS197FC-B TC that are "Important to Safety" and "Not Important to Safety" are also shown on the drawings listed in Section T.1.5.

T.2.3.2 Protection By Multiple Confinement Barriers and Systems

The NUHOMS®-61BTH DSC provides a leak tight confinement of the spent fuel. Similar to the existing NUHOMS®-61BT DSC, sealing of the NUHOMS®-61BTH DSC involves leak testing to the criteria of ANSI N14.5 [2.3] after loading and sealing the canister, as described in Chapter T.7.

T.2.3.3 Protection By Equipment and Instrumentation Selection

No change to Section 3.3.3.

T.2.3.4 Nuclear Criticality Safety

T.2.3.4.1 Control Methods for Prevention of Criticality

The design criterion for criticality is that an upper subcritical limit (USL) of 0.95 minus benchmarking bias and modeling bias will be maintained for all postulated arrangements of fuel within the DSC. The fuel assemblies are assumed to stay within their basket compartment based on the DSC and basket geometry.

The control method used to prevent criticality is incorporation of neutron absorber material in the basket material and favorable geometry. The quantity and distribution of boron in the poison material is controlled by specific manufacturing and acceptance criteria of the poison plates. The acceptance criteria of the neutron absorber materials is described in Chapter T.9.

[1] *With NRC approval of the CoC 1004 renewal application, the license is extended to a total of 60 years. The TLAAs identified as #1, #4, and #5 in Section 12.2 performed for the renewal of this design conservatively used a service life of 100 years.* 72.48

The basket has been designed to assure an ample margin of safety against criticality under the conditions of fresh fuel in a DSC flooded with pool water. The method of criticality control is in accordance with the requirements of 10CFR72.124 [2.5].

The basket layout for Type 1 and Type 2 DSC configurations is identical except for the basket transition rails. Each DSC configuration is designed to store up to 61 intact BWR fuel assemblies or up to 61 damaged fuel assemblies in accordance with Figure T.2-9. For shielding purposes radiological sources related to the 61BTH Type 2 bound the 61BTH Type 1 because assemblies with higher neutron and gamma sources are loaded in the outer zones. The presence of solid aluminum rails that fill the space between the peripheral fuel compartments and the DSC shell results in a more effectively shielded configuration for the Type 2 DSC. When such bounding neutron and gamma sources are placed in a Type 1 DSC the resulting shielding configuration, HSM and TC dose rates are bounding for all the shielding configurations. Therefore, the shielding evaluation presented herein is performed for the hypothetical shielding configuration where radiological source terms bounding for Type 2 DSC are analyzed with the Type 1 DSC.

The NUHOMS® 61BTH Type 1 DSC is identical to the NUHOMS® 61BT DSC analyzed in UFSAR Appendix K, except for an optional redesigned basket hold-down ring. Relative to the existing 61BT DSC, the 61BTH Type 1 DSC allows for an increase in heat load from 18.3 kW to 22 kW, increase in maximum burnup from 40,000 MWd/MTU to 62,000 MWd/MTU, and an increase in maximum initial fuel enrichment from 4.4 wt. % U-235 to 5 wt. % U-235.

The 61BTH Type 2 DSC is also based on the basket design for the 61BT DSC with modifications to the shell assembly (cover plate thicknesses are increased to handle higher internal pressures) and to the basket transition rails to allow storage of fuel assemblies with a total heat load of up to 31.2 kW, with burnup of up to 62,000 MWd/MTU and with maximum initial fuel enrichments of up to 5 wt. % U-235. The Type 2 basket also incorporates the redesigned hold down ring.

The OS197FC-B is essentially the same as the OS197FC except that the lid and bottom have been modified to introduce air cooling design features to accommodate a higher decay heat load (>22 kW). The design of the OS197FC TC is identical to the design of OS197/OS197H TC except that the OS197FC TC has a modified top lid. For the shielding analysis OS197FC-B TC is used to bound the OS197/OS197H TC also because the design features in the TC radial direction are identical for all three TCs; and OS197FC top axial geometry bounds other TCs.

There are a total of ten possible heat load zoning configurations (HLZCs) for the 61BTH Type 1 and Type 2 DSCs. Five out of ten total DSC HLZCs are for Type 2 DSC only. The remaining five can be used with either DSC type; however, certain restrictions apply for Type 1 DSC in some cases. DSC HLZCs are depicted in Figures T.2-1 through Figure T.2-8, Figure T.2-10, and Figure T.2-11 of Chapter T.2.

The fuel qualification tables shown in Table T.2-5 through Table T.2-10, Table T.2-16 and Table T.2-17 are developed for the design basis heavy metal loading of 0.198 MTU with SAS2H/ORIGEN-S modules of SCALE 4.4 [5.1] and for the heavy metal loading of 0.170 MTU with SAS2H/ORIGEN-S modules of SCALE 5.0 [5.20]. Section *7.2.3.2* of Chapter *7* provides the methods for determining minimum required cooling times using fitting equations or linear interpolation for a given MTU between 0.170 MTU and 0.198 MTU.

performed until all implicitness in the coupling of cells, directions, groups, and source regeneration is resolved.

ANISN coupled with the CASK-81 (22 neutron, 18 gamma-ray) energy group, coupled cross-section library [5.5] and the ANSI/ANS-6.1.1-1977 flux-to-dose conversion factors [5.10] is chosen to generate the ANISN dose rates used to determine the relative strength of the various source terms from fuel assemblies and determine the design basis source terms for the HSM and TC. These design basis source terms are used with MCNP models of the 61BTH system to calculate the bounding system dose rates. ANISN provides an efficient method to select the design basis source terms.

The surface dose rates are calculated using ANISN models to perform the evaluation for the fuel assembly parameters in the fuel qualification table. The ANISN model used to generate the relative dose rates on the TC is similar to a cut through the center of the MCNP4C2 OS197FC-B TC side model used for the shielding evaluation. Figure T.5-2 provides a sketch for the ANISN model of the OS197FC TC centerline. A sample ANISN input file is included in Section T.5.5.5.

With the exception of the fuel region, the material densities used in the ANISN models are the same as those used in the MCNP models as provided in Table T.5-19. The ANISN and MCNP number densities in the fuel region differ because in the MCNP models, the basket is modeled explicitly, while in the ANISN models the basket is homogenized with the fuel. The ANISN number densities for the fuel/basket region are provided in Table T.5-20.

To reduce the number of ANISN calculations required, a "response function" is developed using ANISN. Separate response functions are developed for all the radial heat zones shown on Figure T.5-2*b*. It allows estimation of the relative contribution to the dose rate due to individual decay HLZC used.

To generate a neutron response function, the neutron radiation source for the ANISN model corresponds to a single particle emitted per second for each fuel assembly. The radius of the entire homogenized source region in the ANISN model is 71.58 cm. The axial extent of the gamma source region includes the bottom nozzle, active fuel, plenum and top nozzle zones. The total length of these zones is 447.55 cm. For the neutron ANISN models, the axial zone of the source corresponds to the active fuel region only, which has a length of 365.76 cm.

For the gamma response function, a separate ANISN model is executed with a single gamma emitted per second in each of the 18 CASK-81 gamma energy groups. The ANISN source volume and number of assemblies are used to calculate the ANISN source strength in units of particles per sec per unit volume. The neutron response function is generated in a similar fashion to the gamma response function, although only one ANISN input file is required because the neutron spectrum is adequately represented by the ^{244}Cm spectrum provided in Table T.5-21. The dose rate from secondary capture gammas is calculated in addition to the neutron dose rate. This method allows for the calculation of the neutron and capture gamma dose rate due to individual radial zones on the surface of the TC or HSM knowing only the magnitude of the neutron source.

Response functions are generated for each radial fuel zone shown on Figure T.5-2*b*. An effective compartment unit cell is derived by preserving the total fuel compartment area in the cask. This effective unit cell dimension is 6.26 inches. The one dimensional methodology employed in ANISN is not capable of accurately modeling the two dimensional nature of the radial zone distribution of the fuel compartments. To alleviate this issue, modified zone radii are employed so that the two dimensional shielding features of the radial zones are accounted for. Effective zone radii are assumed that represent the cylindrical regions such that the thickness of the shielding material the particle radiation traverses is preserved and hence would adequately simulate penetration of radiation to the surface of the HSM or transfer cask through each radial zone. The effective zone radii used in the ANISN models are shown on Figure T.5-2.

In order to preserve the volumetric source strength throughout the source regions, adjustment factors are applied to the calculated ANISN response functions. These adjustment factors are equal to the actual total compartment area divided by the ANISN zone area that represents such compartment in ANISN models.

As shown in Figure T.5-2*b*, radial zone 4 contains 12 assemblies that shield the inner zones only at the 0, 90, 180 and 270 degree corners of the cask. However at the 45, 135, 225 and 315 degree corners radial zone 4 does not shield the inner zones. Therefore, radial zone 4 is treated as void in the calculation of zones 1 through 3 response functions.

Response functions as well as MCNP calculations performed demonstrate that dose rates on or near HSM surfaces are dominated by gamma radiation. The gamma component is larger than the neutron component by a factor of 10 to 100. That implies the burnup, enrichment and cooling time combination resulting in the highest gamma radiation only dose rate when using HSM response functions will be bounding for HSM dose rates.

Therefore, it is appropriate to use transfer cask gamma response functions when determining burnup/enrichment/cooling time combinations related to HSM dose rates.

The response functions for the OS197FC TC are provided in Table T.5-22 through Table T.5-25. These response functions are used to compute the dose rate for each entry in the fuel qualification tables. For each qualification table, the burnup/enrichment/cooling time combination that results in the highest dose rate is selected as the design basis source.

An example of an ANISN response function evaluation is given in Table T.5-29 for radial source zone 2. Note the example is applicable for definition of bounding burnup/enrichment/cooling time combinations related to the transfer cask dose rates. The maximum dose rate for each table corresponds to the design basis source for that decay heat and shielding configuration.

Further, note that the values presented in Table T.5-29 are based on decay heat values rounded to the nearest 0.1 year and not the final decay heat values as presented in the fuel qualification tables, which have been conservatively rounded up to the nearest 0.5 year, as the design basis sources were selected prior to the rounding process.

T.5.2.5 Reconstituted Fuel

As explained in Section T.5.2, each fuel assembly may have up to 10 solid stainless steel rods that replace fuel rods. Reconstituted fuel assemblies typically generate lower decay heat than a standard assembly because fuel is replaced with steel. However, the reconstituted fuel produces higher dose rates due to the irradiated stainless steel that contains a strong ^{60}Co source. As the half-life of ^{60}Co is 5.27 years, after 10 years the ^{60}Co activity in the stainless steel rods is reduced to approximately a factor of four and the reconstituted assembly no longer generates higher dose rates than an equivalent standard fuel assembly. To bound this effect, the fuel qualification tables require an additional 5 years of cooling time for reconstituted fuel assemblies.

To validate this approach SAS2H runs are generated for reconstituted fuel assemblies. Dose rates are estimated using the response functions for radial zone number 4 (see Figure T.5-2*b*) shown in Table T.5-25. This zone is analyzed because it contributes the largest to the total dose rate at the side of the transfer cask when the 61BTH DSC is loaded according to HLZC #6.

The SAS2H model for reconstituted fuel is very similar to the model for standard fuel assemblies. The following changes are implemented to generate the SAS2H model for reconstituted fuel. First, the number of fuel rods is decreased from 49 to 39. Second, the power is adjusted to maintain the desired burnup corresponding to the initial heavy metal loading of 0.198 MTU*39/49, or 0.158 MTU. Lastly, using the material masses shown in Table T.5-6 the SAS2H light elements are modified to account for the 10 fuel rods that have been replaced with stainless steel rods.

It is assumed that reconstituted fuel is irradiated during the second and third cycles because the first cycle will always correspond to fresh fuel that cannot be loaded with reconstituted rods. To accurately model this behavior, two SAS2H models are generated for a subset of burnup and enrichment combinations used to generate the fuel qualification table for the 0.54 kW/assembly fuel assemblies in HLZC #6 (radial zone 4, *see Figure T.5-2b*). The first SAS2H model is for only one cycle of irradiation of 10 reconstituted rods, while the second model is for three cycles of irradiation of 10 reconstituted rods. By subtracting the single cycle source term of the reconstituted rods from the total source term (fuel and reconstituted rods) corresponding to three cycles, the effective source term of the reconstituted fuel assembly is generated (three irradiation cycles of fuel and two irradiation cycles of reconstituted fuel).

This source term is used with the response function shown in Table T.5-25 to calculate dose rates due to the reconstituted fuel assembly. If the dose rate of the reconstituted fuel assembly exceeds the dose rates due to the design basis source term of the standard fuel assembly, the cooling time of the reconstituted fuel assembly is increased until the design basis source term is bounding. The reconstituted fuel assembly was analyzed for all burnups at the lowest and highest enrichment to evaluate the cooling time increase as a function of enrichment. When the reconstituted fuel is examined in this fashion, no more than 5 additional years of cooling time is required for reconstituted fuel to be bounded by the design basis source. In most cases, the increase in cooling time is from 1 to 3 years.

Reconstituted fuel may contain up to 10 stainless steel rods that have been irradiated or an unlimited number of lower enriched UO_2 rods or Zircaloy rods or unirradiated stainless steel rods

that replace fuel rods. All replacement rods shall be of similar OD and length such that the equivalent amount of water is displaced as the original fuel rod in the fuel assembly matrix. The lower enriched UO_2 rods are of similar design and behavior as the standard rods aside from the uranium enrichment. The reconstituted rods can be at any location in the fuel assemblies and the reconstituted assemblies can be placed anywhere in the basket.

Fuel assemblies reconstituted with Zircaloy replacement rods are bounded by the design basis source terms because Zircaloy has a low ^{59}Co content and therefore results in a much lower source term that the rod it replaces. Lower enriched UO_2 rods reduce the fuel assembly average initial enrichment. Using this reduced assembly average enrichment with the fuel qualification tables accurately addresses the actual source term for the reconstituted assembly. Finally, unirradiated stainless steel replacement rods contribute no source term and are therefore bounded by the intact fuel assembly source term on which the shielding analysis is based.

Table T.5-10
Gamma and Neutron Source Term for 0.48 kW Fuel in TC for HLZC 6, HSM Model 80 and 102 for *the Modeled HLZC (Figure T.5-1)*
(25 GWd/MTU, 1.0 wt. % U-235 and 3.2-Year Cooled Fuel)

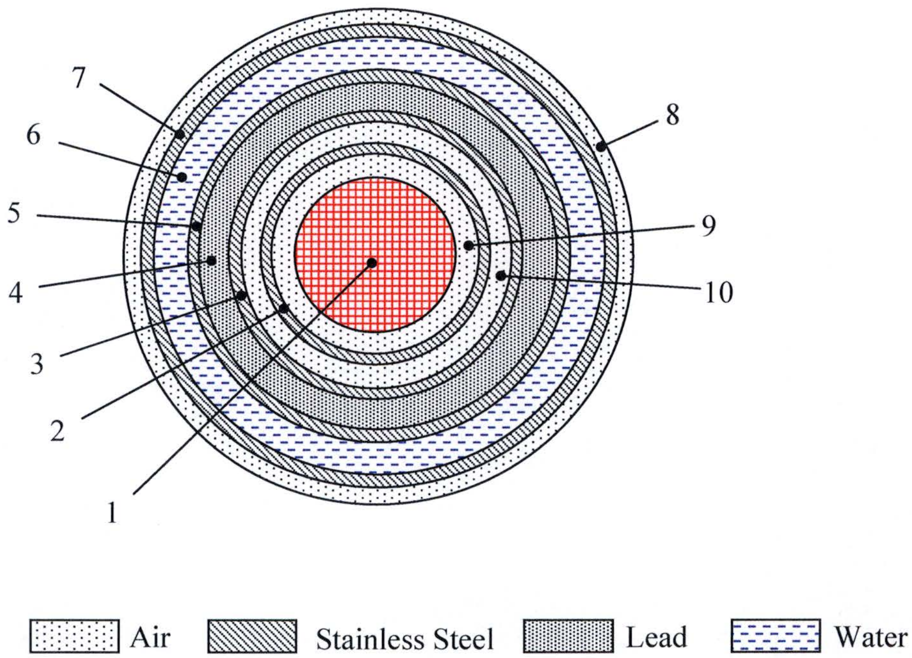
E_{lower} (MeV)		E_{upper} (MeV)	Bottom Region (γ/s/assembly)	Fuel Region (γ/s/assembly)	Plenum Region (γ/s/assembly)	Top Region (γ/s/assembly)
0	to	0.05	1.5767e+11	1.0846e+15	1.9068e+11	1.2116e+11
0.05	to	0.1	1.6981e+10	2.4167e+14	5.6723e+09	1.2771e+10
0.1	to	0.2	5.1010e+09	2.1043e+14	9.0221e+09	4.0617e+09
0.2	to	0.3	2.6492e+08	5.9161e+13	5.3713e+08	2.1288e+08
0.3	to	0.4	5.0740e+08	4.5265e+13	1.9215e+09	4.3552e+08
0.4	to	0.6	5.3991e+09	4.1178e+14	4.0981e+10	5.2686e+09
0.6	to	0.8	2.8120e+09	8.1035e+14	2.1314e+10	2.7711e+09
0.8	to	1.0	1.0518e+11	1.4113e+14	4.5006e+10	4.6043e+10
1.0	to	1.33	4.9362e+12	7.2668e+13	1.4864e+12	3.7075e+12
1.33	to	1.66	1.3940e+12	2.3412e+13	4.1975e+11	1.0470e+12
1.66	to	2.0	1.0611e+05	1.3819e+12	4.3329e+04	1.0363e+05
2.0	to	2.5	3.3081e+07	3.3957e+12	9.9618e+06	2.4847e+07
2.5	to	3.0	5.1296e+04	1.1210e+11	1.5446e+04	3.8527e+04
3.0	to	4.0	1.4138e-12	1.3964e+10	4.5348e-16	1.0104e-11
4.0	to	5.0	0	3.7908e+06	0	0
5.0	to	6.5	0	1.5214e+06	0	0
6.5	to	8.0	0	2.9846e+05	0	0
8.0	to	10.0	0	6.3370e+04	0	0
Total Gamma			6.6241e+12	3.1054e+15	2.2213e+12	4.9472e+12
Total Neutron			1.10e+8 n/s/assembly			

Table T.5-16
Gamma and Neutron Source Term for 0.54 kW Fuel in HSM-H for HLZC 6, HSM Model 80 and 102 for *the Modeled HLZC (Figure T.5-1)*
(25 GWd/MTU, 0.9 wt. % U-235 and 3.0-Year Cooled Fuel)

E_{lower} (MeV)		E_{upper} (MeV)	Bottom Region (γ/s/assembly)	Fuel Region (γ/s/assembly)	Plenum Region (γ/s/assembly)	Top Region (γ/s/assembly)
0	to	0.05	1.6853e+11	1.2121e+15	2.1150e+11	1.2917e+11
0.05	to	0.1	1.7923e+10	2.7252e+14	5.9980e+09	1.3438e+10
0.1	to	0.2	5.3997e+09	2.3891e+14	9.6161e+09	4.2887e+09
0.2	to	0.3	2.8124e+08	6.7134e+13	5.7783e+08	2.2547e+08
0.3	to	0.4	5.3938e+08	5.1646e+13	2.0501e+09	4.6187e+08
0.4	to	0.6	5.7892e+09	4.5751e+14	4.3741e+10	5.6293e+09
0.6	to	0.8	3.0299e+09	8.4881e+14	2.2863e+10	2.9703e+09
0.8	to	1.0	1.2517e+11	1.5349e+14	5.3430e+10	5.4651e+10
1.0	to	1.33	5.2088e+12	7.8190e+13	1.5639e+12	3.9003e+12
1.33	to	1.66	1.4710e+12	2.5486e+13	4.4164e+11	1.1014e+12
1.66	to	2.0	2.1615e+05	1.6212e+12	8.9902e+04	2.1136e+05
2.0	to	2.5	3.49098+07	4.0106e+12	1.0482e+07	2.6139e+07
2.5	to	3.0	5.4129e+04	1.3173e+11	1.6252e+04	4.0531e+04
3.0	to	4.0	1.5221e-12	1.6406e+10	4.9681e-16	1.0817e-11
4.0	to	5.0	0	4.1984e+06	0	0
5.0	to	6.5	0	1.6850e+06	0	0
6.5	to	8.0	0	3.3055e+05	0	0
8.0	to	10.0	0	7.0184e+04	0	0
Total Gamma			7.0065e+12	3.4116e+15	2.3553e+12	5.2126e+12
Total Neutron			1.22e+8 n/s/assembly			

Table T.5-18
Gamma and Neutron Source Term for 0.393 kW Fuel in HSM Model 80 and Model 102 for *the Modeled HLZC (Figure T.5-1)* (62 GWd/MTU, 2.6 wt. % U-235 and 21.4-Year Cooled Fuel)

E_{lower} (MeV)		E_{upper} (MeV)	Bottom Region (γ/s/assembly)	Fuel Region (γ/s/assembly)	Plenum Region (γ/s/assembly)	Top Region (γ/s/assembly)
0.00e+00	to	5.00e-02	2.4047e+10	4.9243e+14	8.8167e+09	1.7549e+10
5.00e-02	to	1.00e-01	2.8985e+09	9.5577e+13	8.6231e+08	2.1273e+09
1.00e-01	to	2.00e-01	7.2167e+08	6.3759e+13	3.7845e+08	5.3503e+08
2.00e-01	to	3.00e-01	3.6074e+07	1.9274e+13	2.0567e+07	2.6817e+07
3.00e-01	to	4.00e-01	5.0988e+07	1.2624e+13	5.4327e+07	3.8645e+07
4.00e-01	to	6.00e-01	1.2510e+08	1.2432e+13	9.1227e+08	1.1895e+08
6.00e-01	to	8.00e-01	7.8537e+07	7.3583e+14	4.7218e+08	1.3197e+08
8.00e-01	to	1.00e+00	5.1503e+07	7.8680e+12	1.1111e+07	9.5887e+07
1.00e+00	to	1.33e+00	8.4517e+11	1.6306e+13	2.4839e+11	6.2027e+11
1.33e+00	to	1.66e+00	2.3868e+11	2.3903e+12	7.0145e+10	1.7516e+11
1.66e+00	to	2.00e+00	7.3831e+00	3.2435e+10	5.8513e+01	7.5403e+00
2.00e+00	to	2.50e+00	5.6641e+06	1.7533e+09	1.6646e+06	4.1569e+06
2.50e+00	to	3.00e+00	8.7828e+03	1.9620e+08	2.5812e+03	6.4457e+03
3.00e+00	to	4.00e+00	1.1536e-11	4.9170e+07	6.6224e-15	6.4875e-11
4.00e+00	to	5.00e+00	0	1.6551e+07	1.4013e-45	0
5.00e+00	to	6.50e+00	0	6.6430e+06	0	0
6.50e+00	to	8.00e+00	0	1.3032e+06	0	0
8.00e+00	to	1.00e+01	0	2.7671e+05	0	0
Total Gamma:			1.1119e+12	1.4585e+15	3.3006e+11	8.1606e+11
Total Neutrons, n/(sec*FA)			4.80e+8			



Item No.	Nomenclature or Description	Material	Inner Radius (cm)	Outer Radius (cm)
1a	*Active Fuel Region, Zone 1*	*Active Fuel*	*0*	*25.1*
1b	*Active Fuel Region, Zone 2*	*Active Fuel*	*25.1*	*46.4*
1c	*Active Fuel Region, Zone 3*	*Active Fuel*	*46.4*	*60.6*
1d	*Active Fuel Region, Zone 4*	*Active Fuel or Air*	*60.6*	*71.58*
2	DSC Cylindrical Shell, 0.49" thk.	SS 304	84.15	85.42
3	TC Inner Liner Plate, 1/2" thk.	SS 304	86.36	87.63
4	TC Lead Gamma Shield	Lead	87.63	96.67
5	TC Structural Shell	SS 304	96.67	100.48
6	Neutron Shielding Material	Water	100.48	108.11
7	Neutron Shield Panel, 3/16" thk.	SS 304	108.11	108.59
8	Air Outside of TC	Air	108.59	Any
9	Air Cavity Between Active Fuel and DSC Structural Shell	Air	72.10	84.09
10	Air Cavity Between DSC and TC	Air	85.33	86.36

Figure T.5-2
ANISN OS197 TC Model

			4	4	4			
	3	3	3	3	3	3	3	
	3	2	2	2	2	2	3	
4	3	2	1	1	1	2	3	4
4	3	2	1	1	1	2	3	4
4	3	2	1	1	1	2	3	4
	3	2	2	2	2	2	3	
	3	3	3	3	3	3	3	
			4	4	4			

Figure T.5-2b
Heat Load Radial Zones for ANISN Models

Note: In the steps that follow, actions pertaining to the removable holddown ring also apply to the removable type top grid assembly.

11. a. For DSCs with removable hold down rings, test fit the hold down ring into the canister. Examine the hold down ring to ensure a proper fit. Remove hold down ring. (Note this step may be completed earlier and hold down ring may be left in place while testing the top shield plug fit-up.)

    b. Place the top shield plug onto the DSC. Examine the top shield plug to ensure a proper fit. If using the rigging cables under the yoke to install the shield plug, attach the rigging cables to the shield plug and adjust the rigging cables as necessary to obtain even cable tension. Remove top shield plug and hold down ring, if present. (Note this step may be complete earlier.)

12. Position the cask lifting yoke above the transfer cask and engage the cask lifting trunnions.

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

14. Provide for later connection to a water draining/pumping device to the siphon port of the DSC and position any connecting hose such that the hose will not interfere with loading (yoke, fuel, shield plug, rigging, etc.). A flowmeter or other suitable means for measuring the amount of water removed must be provided for at a suitable location as part of this connection.

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

16. 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.

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

    b. Fill the TC liquid neutron shield *with demineralized water* as required by licensee ALARA requirements and crane capacity limits. This step may be completed at any time prior to immersion of the TC/DSC into the pool.

18. Prior to the cask being lowered into the fuel pool, the water level in the pool should be adjusted as necessary to accommodate the TC/DSC volume. If the water placed in the DSC cavity was obtained from the fuel pool, a level adjustment may not be necessary.

Any changes on this page are a part of CoC 1004 renewal.

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

21. *If this is the final loading, fully drain the liquid neutron shield.*

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

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

24. Ensure the HSM or HSM-H maximum air exit temperature requirements of Technical Specification 3.1.4 are met.

T.8.1.7 Monitoring Operations

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

2. Perform one of the two alternate daily surveillance activities listed below:

   a. A daily visual surveillance of the HSM air inlets and outlets to insure that no debris is obstructing the HSM vents in accordance with Technical Specification 5.2.5.a requirements.

   b. A temperature measurement of the thermal performance, for each HSM, on a daily basis in accordance with Technical Specification 5.2.5.b requirements.

T.9 Acceptance Tests and Maintenance Program

Background for this particular UFSAR chapter:

Beginning with CoC 1004 Amendment 10, which was incorporated into UFSAR Revision 11, Chapter T.9, "Acceptance Tests and Maintenance Program," contained information which was incorporated by reference into the Technical Specifications (TS) associated with a particular amendment. It is known that certain general licensees reconcile the CoC 1004 UFSAR revisions provided to them to their loaded systems, pursuant to 10 CFR 72.48 and 10 CFR 72.212. In doing so they sometimes find the changed UFSAR portions incorporated by reference into the TS to be impossible to reconcile because the 10 CFR 72.48 regulation does not allow proposed activities which involve changes to the TS.

In order to facilitate this reconciliation process by general licensees, the following statements are provided, addressing the licensing basis for certain amendments, as they relate to certain UFSAR chapters which contain TS incorporated by reference. Additionally, so that the actual information is contained in the current CoC 1004 UFSAR, to facilitate the reconciliation by general licensees, the UFSAR Revision 11, 12, 13, and 14 versions of Chapter T.9 are inserted and annotated in this part of the UFSAR. For clarity, this includes annotating the version of Chapter T.9 directly associated with the latest UFSAR revision in which a change to Chapter T.9 occurred.

- Systems loaded to CoC 1004 Amendment 10 have Technical Specifications incorporated by reference from UFSAR Revisions 11 and 12 in Chapter T.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to systems loaded to Amendment 10.

- Systems loaded to CoC 1004 Amendment 11 have Technical Specifications incorporated by reference from UFSAR Revision 13 Chapter T.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to Amendment 11.

- Note that CoC 1004 Amendment 12 was submitted and docketed, associated with a U.S. Department of Energy project, but due to a lack of review funding the NRC returned it without a review.

- Systems loaded to CoC 1004 Amendment 13 have Technical Specifications incorporated by reference from UFSAR Revisions 14 and 15 Chapter T.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to Amendment 13.

- Systems loaded to CoC 1004 Amendment 14 have Technical Specifications incorporated by reference by FCN 721004-1575, which will be incorporated into UFSAR Revision*s* 16 *and 17* Chapter T.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to Amendment 14.

T.9 Acceptance Tests and Maintenance Program

T.9.1 Acceptance Tests

The pre-operational testing requirements for the NUHOMS® system are given in Chapter 9.0, with the exceptions described in the following sections. The NUHOMS®-61BTH DSC has been enhanced to provide leaktight confinement and the basket includes an updated poison plate design. Additional acceptance testing of the NUHOMS®-61BTH DSC welds and of the poison plates are described.

T.9.1.1 Visual Inspection

Visual inspections are performed at the fabricator's facility to ensure that the DSC, the Transfer Cask and the HSM conform to the drawings and specifications. The visual inspections include weld, dimensional, surface finish, and cleanliness inspections. Visual inspections specified by codes applicable to a component are performed in accordance with the requirements and acceptance criteria of those codes.

All weld inspection is performed using qualified processes and qualified personnel according to the applicable code requirements, e.g., ASME or AWS. Non-destructive examination (NDE) requirements for welds are specified on the drawings provided in Chapter T.1; acceptance criteria are as specified by the governing code. NDE personnel are qualified in accordance with SNT-TC-1A [9.2].

The confinement welds on the DSC are inspected in accordance with ASME B&PV Code Subsection NB [9.1] including alternatives to ASME Code specified in Section T.3.1.2.3.

DSC non-confinement welds are inspected to the NDE acceptance criteria of ASME B&PV Code Subsection NG or NF, based on the applicable code for the components welded.

T.9.1.2 Structural

The DSC confinement boundary except the inner top cover/shield plug to the DSC shell weld is pressure tested at the fabricator's shop in accordance with ASME Article NB-6300. The test pressure is set between 14.5 to 16.0 psig for 61BTH DSC with Type 1 basket for future 10CFR71 application. This bounds the 1.1xDSC design pressure of 10 psig. The test pressure is set between 18.5 to 20.0 psig for 61BTH DSC with Type 2 basket for future 10CFR71 application. This bounds the 1.1xDSC design pressure of 15 psig.

The inner top cover/shield plug to the DSC shell weld is also pressure tested using a test pressure of between 14.5 to 16.0 psig for 61BTH DSC with Type 1 basket and between 18.5 to 20.0 psig for 61BTH DSC with Type 2 basket. This pressure test is performed at the field after the fuel assemblies are loaded in the DSC. This test is in accordance with the alternatives to the ASME Code specified in Section T.3.1.2.3.

HSM-H reinforcement and concrete are tested as described in Section 3.4.2.

T.9.1.3 Leak Tests

DSC confinement welds in the DSC shell and bottom are leak tested at the fabricator's shop to an acceptance criterion of 1×10^{-7} ref cm^3/s, i.e., "leaktight" as defined in ANSI N14.5 [9.4]. Personnel performing the leak test are qualified in accordance with SNT-TC-1A [9.2].

The weld between the DSC shell and inner top cover and the siphon/vent cover welds are also leak tested to an acceptance criteria of 1×10^{-7} ref cm^3/s in the field after the fuel assemblies are loaded in the canister.

T.9.1.4 Components

The Standardized NUHOMS® system does not include any components such as valves, rupture discs, pumps, or blowers. No other components of the NUHOMS® system require testing, except as discussed in this chapter.

T.9.1.5 Shielding Integrity

The Transfer Cask poured lead shielding integrity will be confirmed via gamma scanning prior to first use. The detector and examination grid will be matched to provide coverage of the entire lead-shielded surface area. For example, for a 6" × 6" grid, the detector will encompass a 6" × 6" square. The acceptance criterion is attenuation greater than or equal to that of a test block matching the cask through-wall configuration with lead and steel thicknesses equal to the design minima less 5%.

The radial neutron shielding is provided by filling the neutron shield shell with water during operations. No testing is necessary. The neutron shield material in the lid and bottom end is a proprietary polymer resin. The shielding performance of the resin will be assured by written procedures controlling temperature, measuring, and mixing of the components, degassing of the resin, and verification of the mass or volume of resin installed.

The gamma and neutron shielding materials of the storage system itself are limited to concrete HSM components and steel shield plugs in the DSC. The integrity of these shielding materials is ensured by the control of their fabrication in accordance with the appropriate ASME, ASTM or ACI criteria. No additional acceptance testing is required.

T.9.1.6 Thermal Acceptance

No thermal acceptance testing is required to verify the performance of each storage unit other than that specified in the Technical Specifications for initial loading.

The heat transfer analysis for the basket includes credit for the thermal conductivity of neutron-absorbing materials, as specified in Section T.4.3. Because these materials do not have publicly documented values for thermal conductivity, testing of such materials will be performed in accordance with Section T.9.1.7.6.

All changes on this page are AMD 11

T.9.1.7 Poison Acceptance

CAUTION

Sections T.9.1.7.1 through T.9.1.7.4 below are incorporated by reference into the NUHOMS® CoC 1004 Technical Specifications 4.1 (Note 4) and shall not be deleted or altered in any way without approval from the NRC. The text of these sections is shown in bold type to distinguish it from other sections.

The neutron absorber used for criticality control in the DSC basket may consist any of the following types of material:

(a) Borated *a*luminum

(b) Boron carbide / *a*luminum metal matrix composite (MMC)

(c) *BORAL*®

The 61BTH DSC safety analyses do not rely upon the tensile strength of these materials. 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 three types of materials is given in Table T.9-1.

References to metal matrix composites throughout this chapter are not intended to refer to *BORAL*®, which is described later in this section.

T.9.1.7.1 Borated Aluminum

See the Caution in Section T.9.1.7 before deletion or modification to this section.

The material is produced by direct chill (DC) or permanent mold casting with boron precipitating *primarily* as a uniform fine dispersion of discrete AlB_2 or TiB_2 particles in the matrix of aluminum or aluminum alloy *(other boron compounds, such as AlB_{12}, can also occur)*. 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. 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 T.9.1.7.7. 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.

All changes on this page are AMD 13

T.9.1.7.2 **Boron Carbide / Aluminum Metal Matrix Composites (MMC)**

See the Caution in Section T.9.1.7 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, *molten metal infiltration,* or thermal spray techniques. The boron carbide content shall not exceed 40% by volume. The boron carbide content for MMCs with an integral aluminum cladding *or produced by molten metal infiltration* 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.

At least 50% by weight of the B_4C particles in MMCs shall be smaller than 40 microns. No more than 10% of the particles shall be over 60 microns.

Prior to use in the 61BTH DSC, MMCs shall pass the qualification testing specified in Section T.9.1.7.8, and shall subsequently be subject to the process controls specified in Section T.9.1.7.9.

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 T.9.1.7.7. 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.

T.9.1.7.3 **BORAL®**

See the Caution in Section T.9.1.7 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. Before rolling, at least 80% by weight of the B_4C particles in BORAL® shall be smaller than 200 microns. The nominal boron carbide content shall be limited to 65% (+ 2% tolerance limit) of the core by weight.

This version of Chapter T.9 is associated with CoC 1004 Amendment 14 and is from UFSAR Revision 17. Please see Page T.9 Introduction - 1 for a discussion as to why certain versions of Chapter T.9 are being maintained in the UFSAR.

All changes on this page are AMD 13

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.

T.9.1.7.4 Visual Inspections of Neutron Absorbers

See the Caution in Section T.9.1.7.7 before deletion or modification to this section.

Neutron absorbers shall be 100% visually inspected in accordance with the Certificate Holder's QA procedures. Blisters shall be treated as non-conforming. *For clad MMCs and f*or 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. *Material that does not meet these criteria shall be reworked, repaired, or scrapped.*

T.9.1.7.5 Other Visual Inspections Criteria (non-Technical Specifications)

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" [9.5]. Local or cosmetic conditions such as scratches, nicks, die lines, inclusions, abrasion, isolated pores, or discoloration are acceptable.

T.9.1.7.6 Thermal Conductivity Testing

*Acceptance t*esting shall conform to ASTM E1225[1], ASTM E1461[2], or equivalent method, performed at room temperature on coupons taken from the rolled or extruded production material. Initial sampling shall be one test per lot, and may be reduced if the first five tests meet the specified minimum thermal conductivity. *For cast products, the lot shall be defined by the heat or ingot. For other products, the lot shall be defined as material produced in a single production campaign using the same heat or lots of aluminum and boron carbide feed materials.*

If a thermal conductivity test result is below the specified minimum, at least four additional tests shall be performed on the material from that lot. If the mean value of those tests, including the original test, falls below the specified minimum, the associated lot shall be rejected.

1 ASTM E1225, "Thermal Conductivity of Solids by Means of the Guarded-Comparative-Longitudinal Heat Flow Technique"

2 ASTM E1461, "Thermal Diffusivity of Solids by the Flash Method"

After twenty five tests of a single type of material, with the same aluminum alloy matrix, the same boron content, and the same primary boron phase, e.g., B_4C, TiB_2, or AlB_2, if the mean value of all the test results less two standard deviations meets the specified thermal conductivity, no further testing of that material is required. This exemption may also be applied to the same type of material if the matrix of the material changes to a more thermally conductive alloy (e.g., from 6000 to 1000 series aluminum), or if the boron content is reduced without changing the boron phase.

The measured thermal conductivity values shall satisfy the minimum required conductivities as specified in Section T.4.3.

In cases where the specified thickness of the neutron absorber may vary, the equations introduced in Section T.4.3 shall be used to determine the minimum required effective thermal conductivity.

The thermal conductivity test requirement does not apply to aluminum that is paired with the neutron absorber.

T.9.1.7.7 Specification for Acceptance Testing of Neutron Absorber *Content*

Acceptance testing for neutron absorber content shall be performed by either neutron transmission or by B-10 volume density measurement.

CAUTION

Portions of T.9.1.7.7 are incorporated by reference into the NUHOMS® CoC 1004 Technical Specification 4.1 (Note 4) and shall not be deleted or altered in any way without approval from the NRC. The text of this section is shown in bold type to distinguish it from other sections.

T.9.1.7.7.1 Specification for Acceptance Testing of Neutron Absorbers by Neutron Transmission

a) 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 up to 1.1 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 B10 at that energy.

All changes on this page are AMD 13

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.

b) The following illustrates one acceptable method and is intended to be utilized as an example. Therefore, the following text is not part of the Technical Specifications. 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 [9.6].

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 T.9.1.7.7 a) 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. Edge effects due to manufacturing operations such as shearing, deburring, and chamfering need not be included in this determination.

Non-conforming material shall be evaluated for acceptance in accordance with the Certificate Holder's QA procedures.

T.9.1.7.7.2 *Specification for Acceptance Testing of Neutron Absorbers by B-10 Volume Density Measurement*

a) B-10 volume density measurement 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, as long as it results in accumulating material that is uniform for sampling purposes.

The sampling rate for B-10 volume density measurements shall be such that there is at least one density measurement for each 2000 square inches of final product in each lot.

Areal density is determined by measuring the B-10 volume density in test samples and converting the measured values to areal density. The method of measurement of B-10 volume density shall be subject to approval by the certificate holder. The method of measurement of B-10 volume density shall be qualified against neutron transmission testing. Results of the two test methods shall be compared and a penalty shall be derived to account for the performance based results of neutron transmission testing.

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.

b) The following illustrates one acceptable method and is intended to be utilized as an example. Therefore, the following text is not part of the Technical Specifications. The acceptance criterion for individual plates is determined from a statistical analysis of the test results for their lot. The B-10 areal densities are determined by volume density as described above. The lower tolerance limit of B-10 volume density is then determined, defined as the mean value of B-10 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 [9.6]. Finally, the minimum specified value of B-10 areal density is divided by the lower tolerance limit of B-10 volume density to arrive at the minimum plate thickness that provides the specified B-10 areal density.

Any plate that is thinner than the statistically derived minimum thickness from T.9.1.7.7.2 a) or the minimum design thickness, whichever is greater, shall be treated as nonconforming, with the following exception. Local depressions are acceptable, as 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

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90% of the minimum design thickness. Edge effects due to manufacturing operations such as shearing, deburring, and chamfering need not be included in this determination.

Non-conforming material shall be evaluated for acceptance in accordance with the certificate holder's QA procedures.

T.9.1.7.8 Specification for Qualification Testing of Metal Matrix Composites

CAUTION

Portions of Section T.9.1.7.8.4 and Section T.9.1.7.8.5 are incorporated by reference into the NUHOMS® CoC 1004 Technical Specification 4.1 (Note 4) and shall not be deleted or altered in any way without approval from the NRC. The text of this section is shown in bold type to distinguish it from other sections.

T.9.1.7.8.1 Applicability and Scope

Metal matrix composites (MMCs) acceptable for use in the 61BTH DSC are described in Section T.9.1.7.2.

Prior to initial use in a spent fuel dry storage or 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 T.9.1.7.9 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.

T.9.1.7.8.2 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 storage/ transport system. This is demonstrated by the tests in Section T.9.1.7.8.4. It must have a uniform distribution of boron carbide. This is demonstrated by the tests in Section T.9.1.7.8.5.

T.9.1.7.8.3 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 storage, about 10^{15} neutrons/cm^2.

Thermal damage and corrosion (hydrogen generation) testing shall be performed unless such tests on materials of the same chemical composition have already been performed and found acceptable. The following paragraphs illustrate two cases where such testing is not required.

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

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842°F, well above the basket temperature under normal conditions of storage or transport[3].

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[4].

T.9.1.7.8.4 **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[5]) 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[6]. 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 %.

c) __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 storage. *An example of such a test would be: (1) immerse a specimen at least 6 x 6 inches in water under pressure ≥30 psig for at least 24 hours, (2) place the specimen in a vacuum furnace preheated to at least 300°F and evacuate the furnace. Acceptance criterion: no blistering or delamination of the cladding.*

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3 Sung, C., "Microstructural Observation of Thermally Aged and Irradiated Aluminum/Boron Carbide (B_4C) Metal Matrix Composite by Transmission and Scanning Electron Microscope," 1998.

4 Boralyn testing submitted to the NRC under docket 71-1027, 1998.

5 ASTM B557 Standard Test Methods of Tension Testing Wrought and Cast Aluminum and Magnesium-Alloy Products.

6 ASTM E290, Standard Methods for Bend Testing of Materials for Ductility

T.9.1.7.8.5 **Required Tests and Examinations to Demonstrate B10 Uniformity**

Uniformity of the boron distribution shall be verified either by:

a) **Neutron radioscopy or radiography (ASTM E94[7], E142[8], and E545[9]) 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, the boron carbide weight fraction, *or the boron 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 T.9.1.7.7, or by chemical analysis for boron carbide *or boron* content in the composite.**

T.9.1.7.8.6 Qualification Report

Qualification report shall be prepared by, or subject to approval by the Certificate Holder.

T.9.1.7.9 Specification for Process Controls for Metal Matrix Composites

CAUTION

Sections T.9.1.7.9.1 and T.9.1.7.9.2 are incorporated by reference into the NUHOMS® CoC 1004 Technical Specification 4.1 (Note 4) and shall not be deleted or altered in any way without approval from the NRC. The text of this section is shown in bold type to distinguish it from other sections.

T.9.1.7.9.1 **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 T.9.1.7.8 is required, depending on the characteristics of the material that could be affected by the process change.

T.9.1.7.9.2 **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, reduce the mechanical strength or ductility of the MMC.

7 ASTM E94, Recommended Practice for Radiographic Testing

8 ASTM E142, Controlling Quality of Radiographic Testing

9 ASTM E545, Standard Method for Determining Image Quality in Thermal Neutron Radiographic Testing

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T.9.1.7.9.3 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 T.9.1.7.9.2.

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 *(d50)* 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.

T.9.2 Maintenance Program

The NUHOMS®-61BTH system is a totally passive system and therefore will require little, if any, maintenance over the lifetime of the ISFSI. Typical NUHOMS®-61BTH system maintenance tasks will be performed in accordance with the UFSAR.

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T.9.3 References

9.1 ASME Boiler and Pressure Vessel Code, Section III, *2004* Edition with *2006* Addenda.

9.2 SNT-TC-1A, "American Society for Nondestructive Testing, Personnel Qualification and Certification in Nondestructive Testing," 1992.

9.3 *Deleted.*

9.4 ANSI N14.5-1997, "American National Standard for Leakage Tests on Packages for Shipment of Radioactive Materials," February 1998.

9.5 "Aluminum Standards and Data, 2003," The Aluminum Association.

9.6 Natrella, "Experimental Statistics," Dover, 2005.

9.7 *Deleted.*

9.8 *Deleted.*

9.9 *Deleted.*

9.10 *Deleted.*

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Table T.9-1
B10 Specification for the NUHOMS® 61BTH Poison Plates

Basket Type	*Specified Minimum B10 Areal Density for Borated Aluminum/MMC for 90% Credit (g/cm²)*	*Specified Minimum B10 Areal Density for BORAL® for 75% Credit (g/cm²)*
Type 1 DSC		
A	*0.021*	*0.025*
B	*0.032*	*0.038*
C	*0.040*	*0.048*
D	*0.048*	*0.058*
E	*0.055*	*0.066*
F	*0.062*	*0.075*
Type 2 DSC		
A	*0.022*	*0.027*
B	*0.032*	*0.038*
C	*0.042*	*0.050*
D	*0.048*	*0.058*
E	*0.055*	*0.066*
F	*0.062*	*0.075*

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Table T.9-2
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Table T.9-3
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The OS200 Transfer Cask (TC), used to transfer the 32PTH1 DSC, is a modified version of the OS197 TC described in the UFSAR, with a slightly larger TC cavity diameter of 70.5" and a minimum TC cavity length of 199.25". An alternate option, designated as OS200FC TC, is provided with an optional modified top lid to allow air circulation through the TC/DSC annulus during transfer operations at certain heat loads when time limits for transfer operations cannot be satisfied. This OS200FC TC is very similar to the OS197FC TC described in Appendix P of the UFSAR, except it is larger in diameter and longer in length. The two alternate NUHOMS®-32PTH1 System configurations are summarized below:

System Configuration	32PTH1 DSC Type	Basket Type	Max. Heat Load (kW) per DSC	Transfer Cask	Storage Module
1	32PTH1-S or 32PTH1-M or 32PTH1-L	1A, 1B, 1C, 1D or 1E	40.8	OS200FC	HSM-H
			31.2	OS200	
2	32PTH1-S or 32PTH1-M or 32PTH1-L	2A, 2B, 2C, 2D or 2E	31.2	OS200FC	
			24.0	OS200	

The NUHOMS®-32PTH1 system provides structural integrity, confinement, shielding, criticality control and passive heat removal independent of any other facility structures or components.

The format of this Appendix follows the guidance provided in NRC Regulatory Guide 3.6 1 [1.1]. The analysis presented in this Appendix shows that the NUHOMS®-32PTH1 system meets all the requirements of 10CFR72 [1.2]. A separate analysis will be submitted to address the safety related aspects of transporting spent fuel in the NUHOMS®-32PTH1 DSC in accordance with 10CFR71 [1.3].

Several sections of this Appendix have been identified as "No change". For these sections, the description or analysis presented in the corresponding sections of the UFSAR for the Standardized NUHOMS® system is also applicable to the 32PTH1 system. In addition, Tables and Figures presented in the UFSAR which remain unchanged due to the addition of the 32PTH1 system to the Standardized NUHOMS® system are not repeated in this Appendix.

Note: References to sections or chapters within this Appendix are identified with a prefix U (e.g., Section U.2.3 or Chapter U.2). References to sections or chapters of the UFSAR outside of this Appendix (main body of the UFSAR) are identified with the applicable UFSAR section or chapter number (e.g., Section 2.3 or Chapter 2) or Appendix (e.g., Appendix P). The references used in this Appendix are identified as [X.X] (e.g., [1.1] is Reference 1.1 at the end of Chapter U.1).

Aging Management Program Requirements

AMP requirements for use of the 32PTH1 System during the period of extended storage operations are contained in Section 12.3. Applicable TLAAs performed for the initial CoC 1004 renewal application are provided in Section 12.2.

Any changes on this page are a part of CoC 1004 renewal.

8 7 6 5 4 3 2 1

H G F E D C B A

Proprietary and Security Related Information for Drawing NUH32PTH1-1006-SAR, Rev. 1 Withheld Pursuant to 10 CFR 2.390

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8 7 6 5 4 3 2 1

H G F E D C B A

Proprietary and Security Related Information for Drawing NUH32PTH1-1007-SAR, Rev. 1 Withheld Pursuant to 10 CFR 2.390

H G F E D C B A

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U.2.3 Safety Protection Systems

U.2.3.1 General

The NUHOMS®-32PTH1 DSC is designed to provide storage of spent fuel for at least 40 years.[1] The DSC cavity is inerted and backfilled with helium and the internal pressure is always above atmospheric during the storage period as a precaution against in-leakage of air, which could be harmful to the fuel. Since the confinement vessel consists of a steel cylinder with an integrally welded bottom closure, and a seal welded top closure that is verified to be leak tight after loading, the DSC cavity gas cannot escape.

Renewal

Only those features that are not addressed in the existing UFSAR, Chapter 3, or have been revised, are addressed in this Section. Those features include the thermal and nucleonic performance of the poison plates, and their acceptance. The quality category classification for the various NUHOMS®system components is described in Section 3.4. The quality categories for the 32PTH1 system are summarized in Table U.2-19. The detailed quality category of components of the NUHOMS®-32PTH1 DSC and the OS200TC that are "Important to Safety" and "Not Important to Safety" are also shown on the drawings listed in Section U.1.5. For the HSM-HS, the components that are "Important to Safety" are unchanged from those listed for the Horizontal Storage Module in Table 3.3-1 and discussed in Section 3.3, "Safety Protection System."

U.2.3.2 Protection By Multiple Confinement Barriers and Systems

The NUHOMS®-32PTH1 DSC provides a leak tight confinement of the spent fuel. Although similar to the existing NUHOMS®-24P DSC, sealing of the NUHOMS®-32PTH1 DSC involves leak testing to the criteria of ANSI N14.5 [2.4] after loading and sealing the canister, as described in Chapter U.7.

U.2.3.3 Protection By Equipment and Instrumentation Selection

No change to Section 3.3.3.

U.2.3.4 Nuclear Criticality Safety

U.2.3.4.1 Control Methods for Prevention of Criticality

The design criterion for criticality is that an upper subcritical limit (USL) of 0.95 minus benchmarking bias and modeling bias will be maintained for all postulated arrangements of fuel within the DSC. The intact fuel assemblies are assumed to stay within their basket compartment based on the DSC and basket geometry.

[1] *With NRC approval of the CoC 1004 renewal application, the license is extended to a total of 60 years. The TLAAs identified as #1, #4, and #5 in Section 12.2 performed for the renewal of this design conservatively used a service life of 100 years.* 72.48

The control method used to prevent criticality is incorporation of poison material in the basket material, soluble boron in the pool and favorable geometry. The quantity and distribution of boron in the poison material is controlled by specific manufacturing and acceptance criteria of the poison plates. The acceptance criteria of the plates is described in Chapter U.9.

The basket has been designed to assure an ample margin of safety against criticality under the conditions of fresh fuel in a DSC flooded with borated pool water. The method of criticality control is in accordance with the requirements of 10CFR72.124 [2.10].

U.3.6.4 Failed Fuel Cans

Up to four FFCs with failed fuel may be loaded in the 32PTH1F basket with the remainder cells loaded with intact or damaged PWR fuel assemblies with or without control components (CCs). Up to 16 FFCs with failed fuel may be loaded in the 32PTH1F basket with the remainder cells empty or loaded with dummy fuel assemblies.

The failed fuel assemblies are to be placed in individual FFCs in cells located at the corners of the interior 4x4 compartment cells of the 32PTH1F basket, as described in Chapter U.2, Figure U.2-5 or in a checkerboard loading as shown in Figure U.2-3. The design of the FFC for the 32PTH1F basket is similar to the already licensed FFC for the 24PTHF basket, as discussed in Section P.3.6.4. Each FFC is constructed of sheet metal and is provided with a welded bottom closure and a removable top closure. The top end of the FFC is reinforced with an oversleeve welded to the sheet metal liner to facilitate lifting of the FFC with the enclosed failed fuel *or the sheet metal liner is of sufficient thickness to take the shear at the lifting slots for lifting the loaded FFC.* The failed fuel *may be* housed in a secondary container, such as rod storage basket. Minor basket modifications *may be* required in order to accommodate the thickened top end of the FFCs in the fuel compartments. These consist of reducing the height of the basket compartment tubes by 3.5 inches and adjusting the top basket plates for proper fit-up with the FFC top end. The FFC is provided with screens *and/or drain holes* at the bottom and at the top to contain fuel and allow filling/drainage of water from the FFC during loading operations. Drawings NUH32PTH1-1006-SAR and NUH32PTH-1007-SAR show the FFC design and the associated basket modifications, respectively.

The maximum fuel assembly load applied to each associated basket compartment location bounds the load due to the FFC. Therefore, the 32PTH1 basket analyses with intact fuel are applicable when the basket is loaded with failed fuel. The FFC is protected by the basket fuel compartment tubes and its only function is to confine the failed fuel and allow its retrievability under normal and off-normal conditions.

The FFC is evaluated for a load of 1.5g, which bounds the loads associated with lifting, handling and other normal and off-normal loads. The controlling stresses due to the 1.5g loading are compared to normal condition allowable stresses based on NF criteria [3.3]. Thermal loads for the FFC are not considered based on the following: (1) Subsection NF does not require evaluation of internal thermal stresses; (2) during lifting and handling, when primary stresses in the FFC are largest, there are no significant thermal gradients; (3) the more significant thermal gradients occur when the FFC is in the horizontal position when the transfer stresses occur, which are much lower than the lifting and handling stresses; and (4) similar thermal gradients and stresses occur in the basket, and are already qualified. The maximum allowable stresses based on a conservative temperature of 750 °F, are shown in the following table:

FFC Allowable Stresses

Stress Category	Maximum Allowable Stress (ksi)
Tensile / Combined	Min (S_m; S_y) = 15.6
Bending	1.5 × S_m = 23.4

Conservative hand calculations based on [3.12] demonstrate that maximum handling stresses meet the allowable stress criteria. The controlling stresses and comparison to allowable stresses are summarized below:

FFC Summary of Stresses

Location	Type of Stress	Calculated Stress (ksi)	Allowable Stress (ksi)
FFC Wall	Tensile	3.81	15.6
Bottom Lid	Bending	13.28	23.4
FFC Liner to Oversleeve Weld	Shear	3.72	6.9
FFC Liner (Loaded FFC)	*Shear (Lifting Slots)*	*5.4*	*9.36*

Based on the summary above, the FFC meets the normal allowable stress criteria for a conservative lift and handling load of 1.5g. Therefore, the structural integrity and retrievability of the FFC is ensured.

An alternate design for the FFC bottom lid is also included on Drawing NUH32PTH1-1006-SAR which includes a threaded feature in the bottom lid which enables lifting and handling of the empty FFC. The empty FFC is evaluated for a load of 1.5g, which bounds the loads associated with lifting, handling and other normal and off-normal loads. The bottom lid is conservatively assumed to be loaded by the total weight of the empty FFC (200 lbs). The maximum bending and shear stresses are taken from Section NF-3221.1 [3.3].

The calculated bending stress in the bottom lid is bounded by the case where the FFC is loaded and the shear stresses at the bottom lid threads are below the allowable limits as shown below:

FFC Allowable Stresses

Location	*Stress Type*	*Calculated Stress (ksi)*	*Allowable Stress (ksi)*
Bottom Lid (Empty)	*Bending (Threads)*	*1.1*	*9.36*

12. Place the top shield plug onto the DSC. Examine the top shield plug to ensure a proper fit. Optionally, the top shield plug once fitted, may be removed and disconnected from the yoke. It may be installed later once the DSC is loaded and prior to removing it from the pool.

13. Position the cask lifting yoke above the transfer cask and engage the cask lifting trunnions and the rigging cables to the DSC top shield plug. Adjust the rigging cables as necessary to obtain even cable tension.

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

15. Provide for later connection to the vacuum drying system (VDS) or an optional water draining/pumping device to the siphon port of the DSC and position any connecting hose such that the hose will not interfere with loading (yoke, fuel, shield plug, rigging, etc.). A flowmeter or other suitable means for measuring the amount of water removed must be installed at a suitable location as part of this connection.

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

17. 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.

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

    b. Fill the TC liquid neutron shield *with demineralized water* as required by licensee ALARA requirements and crane capacity limits. This step may be completed at any time prior to immersion of the TC/DSC into the pool.

19. Prior to the cask being lowered into the fuel pool, 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.

U.8.1.2 <u>DSC Fuel Loading</u>

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 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 demineralized water.

3. Place the cask in the designated location of the fuel pool.

14. Recheck all alignment marks in accordance with the Technical Specification 5.3.3 limits and ready all systems for DSC transfer.

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

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

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

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

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

20. Install the HSM door using a portable crane and secure it in place. Door may be welded for security. Verify that the HSM dose rates are compliant with the limits specified in Technical Specifications 5.4.1 and 5.4.2.

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

22. *If this is the final loading, fully drain the liquid neutron shield.*

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

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

25. Ensure the HSM-H maximum air exit temperature requirements of Technical Specification 3.1.4 are met.

U.8.1.7 Monitoring Operations

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

2. Perform **one** of the two alternate daily surveillance activities listed below:

   a. A daily visual surveillance of the HSM air inlets and outlets to insure that no debris is obstructing the HSM vents in accordance with Technical Specification 5.2.5.a requirements.

   b. A temperature measurement of the thermal performance, for each HSM, on a daily basis in accordance with Technical Specification 5.2.5.b requirements.

U.9 Acceptance Tests and Maintenance Program

Background for this particular UFSAR chapter:

Beginning with CoC 1004 Amendment 10, which was incorporated into UFSAR Revision 11, Chapter U.9, "Acceptance Tests and Maintenance Program," contained information which was incorporated by reference into the Technical Specifications (TS) associated with a particular amendment. It is known that certain general licensees reconcile the CoC 1004 UFSAR revisions provided to them to their loaded systems, pursuant to 10 CFR 72.48 and 10 CFR 72.212. In doing so they sometimes find the changed UFSAR portions incorporated by reference into the TS to be impossible to reconcile because the 10 CFR 72.48 regulation does not allow proposed activities which involve changes to the TS.

In order to facilitate this reconciliation process by general licensees, the following statements are provided, addressing the licensing basis for certain amendments, as they relate to certain UFSAR chapters which contain TS incorporated by reference. Additionally, so that the actual information is contained in the current CoC 1004 UFSAR, to facilitate the reconciliation by general licensees, the UFSAR Revision 11, 12, 13, and 14 versions of Chapter U.9 are inserted and annotated in this part of the UFSAR. For clarity, this includes annotating the version of Chapter U.9 directly associated with the latest UFSAR revision in which a change to Chapter U.9 occurred.

- Systems loaded to CoC 1004 Amendment 10 have Technical Specifications incorporated by reference from UFSAR Revisions 11 and 12 in Chapter U.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to systems loaded to Amendment 10.

- Systems loaded to CoC 1004 Amendment 11 have Technical Specifications incorporated by reference from UFSAR Revision 13 Chapter U.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to Amendment 11.

- Note that CoC 1004 Amendment 12 was submitted and docketed, associated with a U.S. Department of Energy project, but due to a lack of review funding the NRC returned it without a review.

- Systems loaded to CoC 1004 Amendment 13 have Technical Specifications incorporated by reference from UFSAR Revisions 14 and 15 Chapter U.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to Amendment 13.

- Systems loaded to CoC 1004 Amendment 14 have Technical Specifications incorporated by reference by FCN 721004-1575, which will be incorporated into UFSAR Revision*s* 16 *and 17* Chapter U.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to Amendment 14.

U.9 Acceptance Tests and Maintenance Program

U.9.1 Acceptance Tests

The pre-operational testing requirements for the NUHOMS® system are given in Chapter 9.0, with the exceptions described in the following sections. The NUHOMS®-32PTH1 DSC has been enhanced to provide leaktight confinement and the basket includes an updated poison plate design. Additional acceptance testing of the NUHOMS®-32PTH1 DSC welds and of the poison plates are described.

U.9.1.1 Visual Inspection

Visual inspections are performed at the fabricator's facility to ensure that the DSC, the Transfer Cask and the HSM conform to the drawings and specifications. The visual inspections include weld, dimensional, surface finish, and cleanliness inspections. Visual inspections specified by codes applicable to a component are performed in accordance with the requirements and acceptance criteria of those codes.

All weld inspection is performed using qualified processes and qualified personnel according to the applicable code requirements, e.g., ASME or AWS. Non-destructive examination (NDE) requirements for welds are specified on the drawings provided in Chapter U.1; acceptance criteria are as specified by the governing code. NDE personnel are qualified in accordance with SNT-TC-1A [9.2].

The confinement welds on the DSC are inspected in accordance with ASME B&PV Code Subsection NB [9.1] including alternatives to ASME Code specified in Section U.3.1.2.3.

DSC non-confinement welds are inspected to the NDE acceptance criteria of ASME B&PV Code Subsection NG or NF, based on the applicable code for the components welded.

U.9.1.2 Structural

The DSC confinement boundary except the inner top cover/shield plug to the DSC shell weld is pressure tested at the fabricator's shop in accordance with ASME Article NB-6300. The test pressure is set between 21.5 to 23.0 psig for 32PTH1 DSC for future 10CFR71 application. This bounds the 1.1xDSC design pressure of 15 psig.

The inner top cover/shield plug to the DSC shell weld is also pressure tested using a test pressure between 21.5 to 23.0 psig for 32PTH1 DSC at the field after the fuel assemblies are loaded in the DSC. This test is in accordance with the alternatives to the ASME Code specified in Section U.3.1.2.3.

HSM-H reinforcement and concrete are tested as described in Section U.3.4.2.

U.9.1.3 Leak Tests

DSC confinement welds in the DSC shell and bottom are leak tested at the fabricator's shop to an acceptance criterion of $1x10^{-7}$ ref cm^3/s, i.e., "leaktight" as defined in ANSI N14.5 [9.4].

Personnel performing the leak test are qualified in accordance with SNT-TC-1A [9.2].

The weld between the DSC shell and inner top cover/shield plug and the siphon/vent cover welds are also leak tested to an acceptance criteria of 1 x 10^{-7} ref cm^3/s in the field after the fuel assemblies are loaded in the canister.

U.9.1.4 Components

The NUHOMS® System does not include any components such as valves, rupture discs, pumps, or blowers. No other components of the NUHOMS® System require testing, except as discussed in this chapter.

U.9.1.5 Shielding Integrity

The Transfer Cask poured lead shielding integrity will be confirmed via gamma scanning prior to first use. The detector and examination grid will be matched to provide coverage of the entire lead-shielded surface area. For example, for a 6" × 6" grid, the detector will encompass a 6" × 6" square. The acceptance criterion is attenuation greater than or equal to that of a test block matching the cask through-wall configuration with lead and steel thicknesses equal to the design minima less 5%.

The radial neutron shielding is provided by filling the neutron shield shell with water during operations. No testing is necessary. The neutron shield material in the lid and bottom end is a proprietary polymer resin. The shielding performance of the resin will be assured by written procedures controlling temperature, measuring, and mixing of the components, degassing of the resin, and verification of the mass or volume of resin installed.

The gamma and neutron shielding materials of the storage system itself are limited to concrete HSM components and steel shield plugs in the DSC. The integrity of these shielding materials is ensured by the control of their fabrication in accordance with the appropriate ASME, ASTM or ACI criteria. No additional acceptance testing is required.

U.9.1.6 Thermal Acceptance

No thermal acceptance testing is required to verify the performance of each storage unit other than that specified in the Technical Specifications for initial loading.

The heat transfer analysis for the basket includes credit for the thermal conductivity of neutron-absorbing materials, as specified in Section U.4.3. Because these materials do not have publicly documented values for thermal conductivity, testing of such materials will be performed in accordance with Section U.9.1.7.6.

This version of Chapter U.9 is associated with CoC 1004 Amendment 14 and is from UFSAR Revision 17. Please see Page U.9 Introduction - 1 for a discussion as to why certain versions of Chapter U.9 are being maintained in the UFSAR.

All changes on this page are AMD 11

U.9.1.7 Poison Acceptance

CAUTION

Sections U.9.1.7.1 through U.9.1.7.4 below are incorporated by reference into the NUHOMS® CoC 1004 Technical Specifications 4.1 (Note 5) and shall not be deleted or altered in any way without approval from the NRC. The text of these sections is shown in bold type to distinguish it from other sections.

The neutron absorber used for criticality control in the DSC basket may consist any of the following types of material:

(a) Borated *a*luminum

(b) Boron carbide / *a*luminum metal matrix composite (MMC)

(c) *BORAL®*

The 32PTH1 DSC safety analyses do not rely upon the tensile strength of these materials. 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 for these materials is given in Table U.9-1.

References to metal matrix composites throughout this chapter are not intended to refer to *BORAL®*, which is described later in this section.

U.9.1.7.1 **Borated Aluminum**

See the Caution in Section U.9.1.7 before deletion or modification to this section.

The material is produced by direct chill (DC) or permanent mold casting with boron precipitating *primarily* as a uniform fine dispersion of discrete AlB_2 or TiB_2 particles in the matrix of aluminum or aluminum alloy *(other boron compounds, such as AlB_{12}, can also occur)*. 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. 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 U.9.1.7.7. 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.

U.9.1.7.2 Boron Carbide / Aluminum Metal Matrix Composites (MMC)

All changes on this page are AMD 13

See the Caution in Section U.9.1.7 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, *molten metal infiltration,* or thermal spray techniques. The boron carbide content shall not exceed 40% by volume. The boron carbide content for MMCs with an integral aluminum cladding *or produced by molten metal infiltration* 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.

At least 50% by weight of the B_4C particles in MMCs shall be smaller than 40 microns. No more than 10% of the particles shall be over 60 microns.

Prior to use in the 32PTH1 DSC, MMCs shall pass the qualification testing specified in Section U.9.1.7.8, and shall subsequently be subject to the process controls specified in Section U.9.1.7.9.

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 U.9.1.7.7. 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.

U.9.1.7.3 BORAL®

See the Caution in Section U.9.1.7 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. Before rolling, at least 80% by weight of the B_4C particles in BORAL® shall be smaller than 200 microns. 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.

All changes on this page are AMD 13

U.9.1.7.4 **Visual Inspections of Neutron Absorbers**

See the Caution in Section U.9.1.7 before deletion or modification to this section.

Neutron absorbers shall be 100% visually inspected in accordance with the Certificate Holder's QA procedures. Blisters shall be treated as non-conforming. *For clad MMCs and f*or 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. *Material that does not meet these criteria shall be reworked, repaired, or scrapped.*

U.9.1.7.5 Other Visual Inspections Criteria (non-Technical Specifications)

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" [9.5]. Local or cosmetic conditions such as scratches, nicks, die lines, inclusions, abrasion, isolated pores, or discoloration are acceptable.

U.9.1.7.6 Thermal Conductivity Testing

*Acceptance t*esting shall conform to ASTM E1225[1], ASTM E1461[2], or equivalent method, performed at room temperature on coupons taken from the rolled or extruded production material. Initial sampling shall be one test per lot, and may be reduced if the first five tests meet the specified minimum thermal conductivity. *For cast products, the lot shall be defined by the heat or ingot. For other products, the lot shall be defined as material produced in a single production campaign using the same heat or lots of aluminum and boron carbide feed materials.*

If a thermal conductivity test result is below the specified minimum, at least four additional tests shall be performed on the material from that lot. If the mean value of those tests, including the original test, falls below the specified minimum, the associated lot shall be rejected.

After twenty five tests of a single type of material, with the same aluminum alloy matrix, the same boron content, and the same primary boron phase, e.g., B_4C, TiB_2, or AlB_2, if the mean value of all the test results less two standard deviations meets the specified thermal conductivity, no further testing of that material is required. This exemption may also be applied to the same type of material if the matrix of the material changes to a more thermally conductive alloy (e.g., from 6000 to 1000 series aluminum), or if the boron content is reduced without changing the boron phase.

The measured thermal conductivity values shall satisfy the minimum required conductivities as

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1 ASTM E1225, "Thermal Conductivity of Solids by Means of the Guarded-Comparative-Longitudinal Heat Flow Technique."

2 ASTM E1461, "Thermal Diffusivity of Solids by the Flash Method."

specified in Section U.4.3.

In cases where the specified thickness of the neutron absorber may vary, the equations introduced in Section U.4.3 shall be used to determine the minimum required effective thermal conductivity.

The thermal conductivity test requirement does not apply to aluminum that is paired with the neutron absorber.

U.9.1.7.7 Specification for Acceptance Testing of Neutron Absorber *Content*

Acceptance testing for neutron absorber content shall be performed by either neutron transmission or by B-10 volume density measurement.

CAUTION

Portions of Section U.9.1.7.7 are incorporated by reference into the NUHOMS® CoC 1004 Technical Specification 4.1 (Note 5) and shall not be deleted or altered in any way without approval from the NRC. The text of this section is shown in bold type to distinguish it from other sections.

U.9.1.7.7.1 Specification for Acceptance Testing of Neutron Absorbers by Neutron Transmission

a) 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 up to 1.1 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 B10 at that energy.

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.

b) The following illustrates one acceptable method and is intended to be utilized as an example. Therefore, the following text is not part of the Technical Specifications. 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 [9.6].

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 U.9.1.7.7 a) 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. Edge effects due to manufacturing operations such as shearing, deburring, and chamfering need not be included in this determination.

Non-conforming material shall be evaluated for acceptance in accordance with the Certificate Holder's QA procedures.

U.9.1.7.7.2 *Specification for Acceptance Testing of Neutron Absorbers by B-10 Volume Density Measurement*

a) B-10 volume density measurement 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, as long as it

results in accumulating material that is uniform for sampling purposes.

The sampling rate for B-10 volume density measurements shall be such that there is at least one density measurement for each 2000 square inches of final product in each lot.

Areal density is determined by measuring the B-10 volume density in test samples and converting the measured values to areal density. The method of measurement of B-10 volume density shall be subject to approval by the certificate holder. The method of measurement of B-10 volume density shall be qualified against neutron transmission testing. Results of the two test methods shall be compared and a penalty shall be derived to account for the performance based results of neutron transmission testing.

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.

b) The following illustrates one acceptable method and is intended to be utilized as an example. Therefore, the following text is not part of the Technical Specifications. The acceptance criterion for individual plates is determined from a statistical analysis of the test results for their lot. The B-10 areal densities are determined by volume density as described above. The lower tolerance limit of B-10 volume density is then determined, defined as the mean value of B-10 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 [9.6]. Finally, the minimum specified value of B-10 areal density is divided by the lower tolerance limit of B-10 volume density to arrive at the minimum plate thickness that provides the specified B-10 areal density.

Any plate that is thinner than the statistically derived minimum thickness from U.9.1.7.7.2 a) or the minimum design thickness, whichever is greater, shall be treated as nonconforming, with the following exception. Local depressions are acceptable, as 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. Edge effects due to manufacturing operations such as shearing, deburring, and chamfering need not be included in this determination.

Non-conforming material shall be evaluated for acceptance in accordance with the certificate holder's QA procedures.

U.9.1.7.8 <u>Specification for Qualification Testing of Metal Matrix Composites</u>

CAUTION

Portions of Section U.9.1.7.8.4, and Section U.9.1.7.8.5, are incorporated by reference into the NUHOMS® CoC 1004 Technical Specification 4.1 (Note 5) and shall not be deleted or altered in any way without approval from the NRC. The text of this section is shown in bold type to distinguish it from other sections.

All changes on this page are AMD 13

U.9.1.7.8.1 Applicability and Scope

Metal matrix composites (MMCs) acceptable for use in the 32PTH1 DSC are described in Section U.9.1.7.2.

Prior to initial use in a spent fuel dry storage or 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 U.9.1.7.9 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.

U.9.1.7.8.2 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 storage/ transport system. This is demonstrated by the tests in Section U.9.1.7.8.4. It must have a uniform distribution of boron carbide. This is demonstrated by the tests in Section U.9.1.7.8.5.

U.9.1.7.8.3 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 storage, about 10^{15} neutrons/cm^2.

Thermal damage and corrosion (hydrogen generation) testing shall be performed unless such tests on materials of the same chemical composition have already been performed and found acceptable. The following paragraphs illustrate two cases where such testing is not required.

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 below842°F, well above the basket temperature under normal conditions of storage or transport[3].

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[4].

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[3] Sung, C., "Microstructural Observation of Thermally Aged and Irradiated Aluminum/Boron Carbide (B_4C) Metal Matrix Composite by Transmission and Scanning Electron Microscope," 1998.

[4] Boralyn testing submitted to the NRC under docket 71-1027, 1998.

U.9.1.7.8.4 **Required Qualification Tests and Examinations to Demonstrate Mechanical Integrity**

All changes on this page are AMD 13

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[5]) 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[6]. 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 %.

c) 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 storage. *An example of such a test would be: (1) immerse a specimen at least 6 x 6 inches in water under pressure ≥30 psig for at least 24 hours, (2) place the specimen in a vacuum furnace preheated to at least 300 °F and evacuate the furnace. Acceptance criterion: no blistering or delamination of the cladding.*

U.9.1.7.8.5 **Required Tests and Examinations to Demonstrate B10 Uniformity**

Uniformity of the boron distribution shall be verified either by:

a) Neutron radioscopy or radiography (ASTM E94[7], E142[8], and E545[9]) 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,

[5] ASTM B557 Standard Test Methods of Tension Testing Wrought and Cast Aluminum and Magnesium-Alloy Products.
[6] ASTM E290, Standard Methods for Bend Testing of Materials for Ductility.
[7] ASTM E94, Recommended Practice for Radiographic Testing.
[8] ASTM E142, Controlling Quality of Radiographic Testing.
[9] ASTM E545, Standard Method for Determining Image Quality in Thermal Neutron Radiographic Testing.

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 U.9.1.7.7, or by chemical analysis for boron carbide content in the composite.

All changes on this page are AMD 13

U.9.1.7.8.6 *Qualification Report*

Qualification *reports* shall be *prepared by, or* subject to approval by the Certificate Holder.

U.9.1.7.9 Specification for Process Controls for Metal Matrix Composites

CAUTION

Sections U.9.1.7.9.1 and U.9.1.7.9.2 are incorporated by reference into the NUHOMS® CoC 1004 Technical Specification 4.1 (Note 5) and shall not be deleted or altered in any way without approval from the NRC. The text of this section is shown in bold type to distinguish it from other sections.

U.9.1.7.9.1 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 U.9.1.7.8 is required, depending on the characteristics of the material that could be affected by the process change.

U.9.1.7.9.2 **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, reduce the mechanical strength or ductility of the MMC.

U.9.1.7.9.3 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 U.9.1.7.9.2.

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 *(d50)* 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.

All changes on this page are AMD 13

This version of Chapter U.9 is associated with CoC 1004 Amendment 14 and is from UFSAR Revision 17. Please see Page U.9 Introduction - 1 for a discussion as to why certain versions of Chapter U.9 are being maintained in the UFSAR.

U.9.2 Maintenance Program

The NUHOMS®-32PTH1 system is a totally passive system and therefore will require little, if any, maintenance over the lifetime of the ISFSI. Typical NUHOMS®-32PTH1 system maintenance tasks will be performed in accordance with the UFSAR.

This version of Chapter U.9 is associated with CoC 1004 Amendment 14 and is from UFSAR Revision 17. Please see Page U.9 Introduction - 1 for a discussion as to why certain versions of Chapter U.9 are being maintained in the UFSAR.

All changes on this page are AMD 13

U.9.3 References

9.1 ASME Boiler and Pressure Vessel Code, Section III, 1998 Edition *through* 2000 Addenda.

9.2 SNT-TC-1A, "American Society for Nondestructive Testing, Personnel Qualification and Certification in Nondestructive Testing," 1992.

9.3 Deleted.

9.4 ANSI N14.5-1997, "American National Standard for Leakage Tests on Packages for Shipment of Radioactive Materials," February 1998.

9.5 "Aluminum Standards and Data, 2003" The Aluminum Association.

9.6 Natrella, "Experimental Statistics," Dover, 2005.

9.7 Deleted.

9.8 Deleted.

9.9 Deleted.

9.10 Deleted.

This version of Chapter U.9 is associated with CoC 1004 Amendment 14 and is from UFSAR Revision 17. Please see Page U.9 Introduction - 1 for a discussion as to why certain versions of Chapter U.9 are being maintained in the UFSAR.

All changes on this page are AMD 11

Table U.9-1
B10 Specification for the NUHOMS® 32PTH1 Poison Plates

Poison Type	32PTH1 Basket Type	Minimum Poison Loading (B10 mg/cm²)	% Credit Used in Criticality Analysis
Borated Aluminum /MMC	1A or 2A	7	90
	1B or 2B	15	
	1C or 2C	20	
	1D or 2D	32	
	1E or 2E	50	
BORAL®	1A or 2A	9	75
	1B or 2B	19	
	1C or 2C	25	
	1D or 2D	N/A	
	1E or 2E	N/A	

V.1 General Discussion

Appendix V to the NUHOMS® Updated Final Safety Analysis Report (UFSAR) addresses the Important to Safety aspects of adding the HSM Model 202 to the Standardized NUHOMS® system described in the UFSAR. The HSM Model 202, which is based on the HSM-H (described in Appendix P), is added to the UFSAR as an alternative to the HSM Model 80, Model 102, and Model 152. The primary reason for adding a fourth HSM design (Model 202) is to include an HSM design that offers even greater biological shielding compared to Models 80 and 102, and greater heat rejection capabilities than those currently available in Models 80/102/152.

The Model 202 is a "one size fits all" module, which can accommodate both PWR (187") and BWR (197") length Dry Shielded Canisters (DSCs). The varying lengths of the DSCs are accommodated through the use of rail spacers. Similar to the design basis, function, and operation of the HSM Models 80/102/152, the Model 202 provides an independent, passive system with heat removal capacity sufficient to ensure that peak cladding temperatures during long term storage of spent fuel assemblies remain below acceptable limits to assure fuel cladding integrity.

The format of this appendix follows the guidance provided in NRC Regulatory Guide 3.61 [1.1]. The analyses presented in this appendix demonstrates that the HSM Model 202 system meets all the requirements of 10 CFR 72 [1.2].

Several sections of this appendix have been identified as "No Change." For these sections, the description or analysis presented in the corresponding sections of the UFSAR for the Standardized NUHOMS® system is also applicable to the HSM Model 202. In addition, tables and figures presented in the UFSAR which remain unchanged due to the addition of the HSM Model 202 to the Standardized NUHOMS® system are not repeated in this appendix.

NOTE: References to sections or chapters within this appendix are identified with a prefix V (e.g., Section V.2.3 or Chapter V.2). References to sections or chapters of the UFSAR outside of this appendix (i.e., main body of the UFSAR) are identified with the applicable UFSAR section or chapter number (e.g., Section 2.3 or Chapter 2). The references used in this appendix are identified as [X.X] (e.g., [1.1] is reference 1.1 at the end of Chapter V.1).

Aging Management Program Requirements

AMP requirements for use of the HSM Model 202 during the period of extended storage operations are contained in Section 12.3. Applicable TLAAs performed for the initial CoC 1004 renewal application are provided in Section 12.2.

V.1.1 Introduction

This appendix adds the HSM Model 202 to the NUHOMS® system. Only those features that are being revised or added to the NUHOMS® system are addressed and evaluated in this appendix. Sections of this appendix which are not affected by the addition of the HSM Model 202 are indicated in this appendix with "No Change." The various DSCs and Transfer Cask (TC) in the Standardized NUHOMS® system remain unchanged.

The HSM Model 202 is based on the HSM-H, which is currently qualified to store only 24PTH DSCs. The HSM Model 202 is qualified to store payloads with a maximum decay heat load of 24.0 kW, similar to the Standardized HSM Models 80 and Model 102. The HSM Model 202 is being added to the UFSAR as an alternative to the HSM Model 80/102/152. The primary reason

W.1 General Description

Appendix W to the NUHOMS® updated final safety analysis report (UFSAR) addresses the important to safety aspects of adding the OS197L TC to the standardized NUHOMS® system described in the UFSAR. The OS197L TC is added to the UFSAR as an alternative to the OS197 and OS197H TCs. The primary reason for adding the OS197L TC design is to include a reduced weight transfer cask that can be used to transfer specific payloads at facilities.

The format of this appendix follows the guidance provided in NRC Regulatory Guide 3.61 [1.1]. The analyses presented in this Appendix demonstrate that the OS197L TC system meets all the requirements of 10 CFR 72 [1.2].

Several sections of this appendix have been identified as "No Change." For these sections, the description or analysis presented in the identified sections of the UFSAR for the standardized NUHOMS® system is also applicable to the OS197L TC. In addition, tables and figures presented in the UFSAR which remain unchanged due to the addition of the OS197L TC to the standardized NUHOMS® system are not repeated in this appendix. Table W.1-2 provides a summary of the sections of the main body of the UFSAR applicable to the OS197 TC and addresses the impact of the OS197L TC on these sections.

Note: References to sections or chapters within this appendix are identified with a prefix W (e.g., Section W.2.3 or Chapter W.2). References to sections or chapters of the UFSAR outside of this appendix (i.e., main body of the UFSAR) are identified with the applicable UFSAR section, chapter number or appendix number (e.g., Section 2.3, Chapter 2 or Appendix K). The references used in this appendix are identified as [X.X] (e.g., [1.1] is Reference 1.1 at the end of Chapter W.1).

OS197 and OS197H TCs in the remainder of this appendix will be referred to as OS197 TC.

Aging Management Program Requirements

AMP requirements for use of the OS197L TC during the period of extended storage operations are contained in Section 12.3. Applicable TLAAs performed for the initial CoC 1004 renewal application are provided in Section 12.2.

W.1.1 Introduction

As stated in Section 1.3.2.1, the body of this UFSAR is dedicated to four on-site transfer cask types: the standardized cask, NUHOMS®-OS197, NUHOMS®-OS197H, and OS200 TCs. The purpose of this appendix is to provide the safety analysis of the design of a fifth type of on-site transfer cask, designated as the NUHOMS® OS197L TC, for use with the standardized NUHOMS® system.

W.1.2 General Description of the NUHOMS® OS197L TC

The OS197L TC on-site transfer cask is designed to accommodate fuel transfer needs of plants where the payload is limited to a maximum of 13.0 kW. The major differences between the OS197L TC and the OS197 casks are:

- reduced cask weight;

W.8 Operating Systems

The following is a description of the operational sequences for use of the OS197L TC. In general, the steps are similar to those for the OS197 TC, described in detail in Appendix K.8 or M.8 of the UFSAR. This chapter consolidates these procedures and includes the differences in operational steps when using OS197L TC relative to the OS197 TC. Figures are provided to illustrate the differences in operational steps.

Notes: A general licensee shall meet the requirements of applicable Technical Specifications (such as 4.4.1 – 4.4.4) prior to the use of OS197L TC for onsite transfer of an authorized payload.

The generic term "DSC" used throughout this chapter may be the 61BT or 32PT DSC. The term "cask" or "TC" is used for the OS197L TC.

Discussion of Similarities and Differences Between Use of the OS197 TC and OS197L TC Systems:

Placement of the DSC into the OS197L TC and preparations for placement of the TC into the fuel pool are the same as for the OS197 TC. The DSC/TC annulus is filled with clean water and sealed with the annulus seal. The TC neutron shield is also filled with clean *demineralized* water. The DSC may be filled with fuel pool water either prior to lowering OS197L TC into the pool, or the OS197L TC lowered to within a few feet of submergence and the DSC filled at that time. The OS197L TC with DSC is then lowered to the fuel pool bottom and landed, and the yoke removed. Sequence 1 below shows the cask as it enters the pool.

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head above the level of water in the TC/DSC annulus. This is an optional arrangement, which provides additional assurance that contaminated water from the fuel pool will not enter the TC/DSC annulus, provided a positive head is maintained at all times.

12. If not done previously, place the top shield plug onto the DSC and examine the top shield plug to ensure a proper fit. The top shield plug, once fitted is removed and disconnected from the yoke.

13. Position the cask lifting yoke above the transfer cask and engage the cask lifting trunnions and the rigging cables to the DSC top shield plug. Adjust the rigging cables as necessary to obtain even cable tension.

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

15. Provide for later connection to the vacuum drying system (VDS) or an optional water draining/pumping device to the siphon port of the DSC and position any connecting hose such that the hose will not interfere with loading (yoke, fuel, shield plug, rigging, etc.). A flowmeter or other suitable means for measuring the amount of water removed must be installed at a suitable location as part of this water removal system.

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

17. 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.

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

    b. Fill the TC liquid neutron shield *with demineralized water*. This step may be completed at any time prior to immersion of the TC/DSC into the pool.

19. Prior to the cask being lowered into the fuel pool, 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.

W.8.1.2 <u>DSC Fuel Loading</u>

Note: The licensee shall verify that the lifting device used for handling the OS197L TC meets the requirements of the sites lifting program. Licensee shall use remote operations and optical targeting system and other mitigating ALARA practices when handling the bare OS197L TC when loaded with fuel as required by the sites ALARA program and the Radiation Protection Program requirements of Technical Specification 5.2.4.a.

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.

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21. Install the HSM door using a portable crane or other suitable lifting device and secure it in place. Door may be welded for security. Verify that the HSM dose rates are compliant with the limits specified in Technical Specifications 5.4.1 and 5.4.2.

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

23. *If this is the final loading, fully drain the liquid neutron shield.*

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

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

26. Ensure the HSM maximum air exit temperature requirements of Technical Specification 3.1.4 are met.

W.8.1.7 Monitoring Operations

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

2. Perform one of the two alternate daily surveillance activities listed below:

   a. A daily visual surveillance of the HSM air inlets and outlets to insure that no debris is obstructing the HSM vents in accordance with Technical Specification 5.2.5a requirements.

   b. A temperature measurement of the thermal performance, for each HSM, on a daily basis in accordance with Technical Specification 5.2.5b requirements.

W.8.2 Procedures for Unloading the Cask

The operational differences specified above for loading operations when using OS197L TC (relative to the use of OS197 TC described in Chapter 5) will also apply for unloading operations.

W.8.3 Identification of Subjects for Safety Analysis

There is no change relative to Section 5.1.3 regarding criticality control, chemical safety, operational shutdown modes and maintenance techniques.

In addition to the typical instrumentation listed in Table 5.1-1 of Section 5.1.3, the use of OS197L TC shall require optical targets and instruments to implement specific remote crane operations described in Section W.8.1 above.

The NUHOMS®-69BTH system provides structural integrity, confinement, shielding, criticality control and passive heat removal independent of any other facility structures or components.

The format of this appendix follows the guidance provided in the NRC Regulatory Guide 3.61 [1.1]. The analysis presented in this appendix shows that the NUHOMS®-69BTH system meets all the requirements of 10 CFR 72 [1.2]. A separate analysis [1.7] has been submitted to address the safety related aspects of transporting spent fuel in the NUHOMS®-69BTH DSC in accordance with 10 CFR 71 [1.3].

Several sections of this appendix have been identified as "No change." For these sections, the applicable sections of the UFSAR are specified.

References to sections or chapters within this appendix are identified with a prefix Y (e.g., Section Y.2.3 or Appendix Y.2). References to sections or chapters of the UFSAR outside of this appendix (main body or other appendices of the UFSAR) are identified with the applicable UFSAR section or chapter number (e.g., Section 2.3 or Chapter 2) or appendix (e.g., Appendix K). The references used in this appendix are identified as [X.X] (e.g., [1.1] is reference 1.1 at the end of Appendix Y.1).

Aging Management Program Requirements

AMP requirements for use of the 69BTH System during the period of extended storage operations are contained in Section 12.3. Applicable TLAAs performed for the initial CoC 1004 renewal application are provided in Section 12.2.

Y.2.3 Safety Protection Systems

Y.2.3.1 General

The NUHOMS®-69BTH system is designed to provide storage of spent fuel for at least 40 years.*(1)* The DSC cavity is inerted and backfilled with helium and the internal pressure is always above atmospheric during the storage period as a precaution against in-leakage of air, which could be harmful to the fuel. Since the confinement vessel consists of a steel cylinder with an integrally welded bottom closure, and a seal welded top closure that is verified to be leak tight after loading, the DSC cavity gas cannot escape.

Renewal

Only those features that are not addressed in Chapter 3, or have been revised, are addressed in this section. Those features include the thermal and neutronic performance of the poison plates, and their acceptance. The quality category classification for the various NUHOMS® system components is described in Chapter 3, Section 3.4. The quality categories for the 69BTH system are summarized in Table Y.2-22. The detailed quality category of components of the NUHOMS®-69BTH DSC and OS200 FC TC that are "important to safety" and "not important to safety" are also shown on the drawings listed in Appendix Y, Section Y.1.5.

Y.2.3.2 Protection by Multiple Confinement Barriers and Systems

The NUHOMS®-69BTH DSC provides a leak tight confinement of the spent fuel. Similar to the existing NUHOMS®-61BT DSC, sealing of the NUHOMS®-69BTH DSC involves leak testing to the criteria of ANSI N14.5 [2.3] after loading and sealing the canister, as described in Appendix Y.7.

Y.2.3.3 Protection by Equipment and Instrumentation Selection

No change to Chapter 3, Section 3.3.3.

Y.2.3.4 Nuclear Criticality Safety

Y.2.3.4.1 Control Methods for Prevention of Criticality

The design criterion for criticality is that an upper subcritical limit (USL) of 0.95 minus benchmarking bias and modeling bias will be maintained for all postulated arrangements of fuel within the DSC. The fuel assemblies are assumed to stay within their basket compartment based on the DSC and basket geometry.

The control method used to prevent criticality is incorporation of neutron absorber material in the basket material and favorable geometry. The quantity and distribution of boron in the poison material is controlled by specific manufacturing and acceptance criteria of the poison plates. The acceptance criteria of the neutron absorber materials is described in Appendix Y.9.

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[1] *With NRC approval of the CoC 1004 renewal application, the license is extended to a total of 60 years. The TLAAs identified as #1, #4, and #5 in Section 12.2 performed for the renewal of this design conservatively used a service life of 100 years.* 72.48

The basket has been designed to assure an ample margin of safety against criticality under the conditions of fresh fuel in a DSC flooded with pool water. The method of criticality control is in accordance with the requirements of 10 CFR 72.124 [2.5].

Y.5.1 Discussion and Results

All 69BTH DSC shielding analyses using MCNP Code are performed for a hypothetical shielding configuration in which the bounding radiological sources terms for the 69BTH DSC are used for the OS200/OS200FC and HSM-H/HSM-HS as appropriate.

Table Y.5-1 summarizes the maximum and average dose rates for the NUHOMS®-69BTH design basis DSC loaded into the NUHOMS® HSM-HS.

Table Y.5-2 summarizes the maximum and average dose rates for the NUHOMS®-69BTH design basis DSC loaded into the NUHOMS® HSM-HS with the optional dose reduction hardware shielding improvements.

Table Y.5-3 provides a summary of the dose rates on and around the OS200FC TC for transfer of the 69BTH design basis DSC under normal, off-normal and accident conditions.

Table Y.5-4 provides a summary of the dose rates on and around the OS200FC TC for decontamination and welding operations for the 69BTH design basis DSC.

A discussion of the method used to determine the design basis fuel source terms is included in Section Y.5.2. The shielding material densities are given in Section Y.5.3. Decay heat and radiological source terms are calculated with the SAS2H/ORIGEN-S modules of SCALE 4.4 [5.1] for the design basis heavy metal weight of 0.198 MTU. The shielding evaluation is performed with the MCNP Computer Code Version 5 [5.3] with the ENDF/B-VI cross section library. Sample input files used for calculating neutron and gamma source terms and dose rates are included in Section Y.5.6.

The fuel qualification tables shown in Table Y.2-5 through Table Y.2-17b are developed for the design basis heavy metal loading of 0.198 MTU with SAS2H/ORIGEN-S modules of SCALE 4.4 [5.1] and for the heavy metal loading of 0.170 MTU with SAS2H/ORIGEN-S modules of SCALE 5.0 [5.14]. Section *7.2.3.2* of Chapter *7* provides the methods for determining minimum required cooling times using fitting equations or linear interpolation for a given MTU between 0.170 MTU and 0.198 MTU.

11. a. Test fit the hold down ring into the canister. Examine the hold down ring to ensure a proper fit. Remove hold down ring. (Note this step may be completed earlier and hold down ring may be left in place while testing the top shield plug fit-up.)

    b. Place the top shield plug onto the DSC. Examine the top shield plug to ensure a proper fit. If using the rigging cables under the yoke to install the shield plug, attach the rigging cables to the shield plug and adjust the rigging cables as necessary to obtain even cable tension. Remove top shield plug and hold down ring, if present. (Note this step may be completed earlier.) Alternately, if compatible with the fuel handling tools, the hold down ring may remain in the basket during loading the SFAs in subsequent steps.

12. Position the cask lifting yoke above the transfer cask and engage the cask lifting trunnions.

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

14. Provide for later connection to a water draining/pumping device to the siphon port of the DSC and position any connecting hose such that the hose will not interfere with loading (yoke, fuel, shield plug, rigging, etc.). A flowmeter or other suitable means for measuring the amount of water removed must be provided for at a suitable location as part of this connection.

15. Fill the TC liquid neutron shield *with demineralized water,* as required. This step may be completed at any time prior to immersion of the TC/DSC into the pool.

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

17. 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 ensure that they are properly positioned on the cask trunnions.

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

19. Prior to the cask being lowered into the fuel pool, the water level in the pool should be adjusted, as necessary, to accommodate the TC/DSC volume. If the water placed in the DSC cavity was obtained from the fuel pool, a level adjustment may not be necessary.

Y.8.1.2 DSC Fuel Loading

1. Lift the TC/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 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

Any changes on this page are a part of CoC 1004 renewal.

Y.9 Acceptance Tests and Maintenance Program

Background for this particular UFSAR chapter:

Beginning with CoC 1004 Amendment 13, which was incorporated into UFSAR Revision 14, Chapter Y.9, "Acceptance Tests and Maintenance Program," contained information which was incorporated by reference into the Technical Specifications (TS) associated with a particular amendment. It is known that certain general licensees reconcile the CoC 1004 UFSAR revisions provided to them to their loaded systems, pursuant to 10 CFR 72.48 and 10 CFR 72.212. In doing so they sometimes find the changed UFSAR portions incorporated by reference into the TS to be impossible to reconcile because the 10 CFR 72.48 regulation does not allow proposed activities which involve changes to the TS.

In order to facilitate this reconciliation process by general licensees, the following statements are provided, addressing the licensing basis for certain amendments, as they relate to certain UFSAR chapters which contain TS incorporated by reference. Additionally, so that the actual information is contained in the current CoC 1004 UFSAR, to facilitate the reconciliation by general licensees, the UFSAR Revision 14 and 15 versions of Chapter Y.9 are inserted and annotated in this part of the UFSAR. For clarity, this includes annotating the version of Chapter Y.9 directly associated with the latest UFSAR revision in which a change to Chapter Y.9 occurred.

- Systems loaded to CoC 1004 Amendment 13 have Technical Specifications incorporated by reference from UFSAR Revisions 14 and 15 Chapter Y.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to Amendment 13.

- Systems loaded to CoC 1004 Amendment 14 have Technical Specifications incorporated by reference by FCN 721004-1575, which will be incorporated into UFSAR Revision*s* 16 *and 17* Chapter Y.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to Amendment 14.

Y.9 Acceptance Tests and Maintenance Program

Y.9.1 Acceptance Tests

The pre-operational testing requirements for the Standardized NUHOMS® system are given in Chapter 9, with the exceptions described in the following sections. The NUHOMS®-69BTH DSC has been enhanced to provide leaktight confinement and the basket includes an updated poison plate design. Additional acceptance testing of the NUHOMS®-69BTH DSC welds and of the poison plates are described.

Y.9.1.1 Visual Inspection

Visual inspections are performed at the fabricator's facility to ensure that the DSC, the Transfer Cask and the HSM conform to the drawings and specifications. The visual inspections include weld, dimensional, surface finish, and cleanliness inspections. Visual inspections specified by codes applicable to a component are performed in accordance with the requirements and acceptance criteria of those codes.

All weld inspection is performed using qualified processes and qualified personnel according to the applicable code requirements, e.g., ASME or AWS. Non-destructive examination (NDE) requirements for welds are specified on the drawings provided in Appendix Y.1; acceptance criteria are as specified by the governing code. NDE personnel are qualified in accordance with SNT-TC-1A [9.2].

The confinement welds on the DSC are inspected in accordance with ASME B&PV Code Subsection NB [9.1] including alternatives to ASME Code specified in Section Y.3.1.2.3.

DSC non-confinement welds are inspected to the NDE acceptance criteria of ASME B&PV Code Subsection NG or NF, based on the applicable code for the components welded.

Y.9.1.2 Structural

The DSC confinement boundary except the inner top cover/shield plug to the DSC shell weld is pressure tested at the fabricator's shop in accordance with ASME Article NB-6300. The test pressure is set between 16.5 to 18.0 psig for the 69BTH DSC, which bounds the 1.1xDSC design pressure of 15 psig.

The inner top cover/shield plug to the DSC shell weld is also pressure tested between 16.5 to 18.0 psig for 69BTH DSC. This pressure test is performed at the field after the fuel assemblies are loaded in the DSC. This test is in accordance with the alternatives to the ASME Code specified in Section Y.3.1.2.3.

HSM-H reinforcement and concrete are tested as described in Chapter 3, Section 3.4.2.

Y.9.1.3 Leakage Tests

The DSC canister confinement boundary is tested using two procedures described below. Personnel performing the leakage test are qualified in accordance with SNT-TC-1A [9.2].

Procedure 1 is accomplished during fabrication:

Upon completion of all canister shell welding and attachment of the inner bottom cover plate to the shell, a temporary seal plate is placed over the open end of the DSC. A bag or other enclosure is placed around the outside of the entire DSC and it is filled with helium. The DSC cavity is evacuated and a helium leakage test is performed using a port in the seal plate. This test is used to show that the entire DSC confinement boundary tested is leak tight ($1x10^{-7}$ ref cm^3/s).

Procedure 2 of the testing occurs after the DSC has been loaded with fuel assemblies:

The DSC cavity has been dried, back filled with helium and the inner top cover plate and the vent and drain port cover plates have been welded in place. After these welds are completed, a temporary test cover is installed or the outer top cover plate is welded in place with at least the root pass of the full weld. The cavity between inner top cover plate and the temporary test cover or outer top cover plate is evacuated and a helium leakage test is performed using a test port in the temporary test cover or in the outer top cover plate. The leakage test thus includes the weld attaching the inner top cover plate to the canister shell, the vent and drain port cover plate welds and the base metal of the inner top cover plate and vent and drain port cover plates. The vent and drain ports are filled with helium prior to welding the vent and drain port covers. This test verifies that the tested welds and cover plates are leak tight ($1x10^{-7}$ ref cm^3/s).

Y.9.1.4 Components

The Standardized NUHOMS® system does not include any components such as valves, rupture discs, pumps, or blowers. No other components of the NUHOMS® system require testing, except as discussed in this chapter.

Y.9.1.5 Shielding Integrity

The Transfer Cask poured lead shielding integrity will be confirmed via gamma scanning prior to first use. The detector and examination grid will be matched to provide coverage of the entire lead-shielded surface area. For example, for a 6″ × 6″ grid, the detector will encompass a 6″ × 6″ square. The acceptance criterion is attenuation greater than or equal to that of a test block matching the cask through-wall configuration with lead and steel thicknesses equal to the design minima less 5%.

The radial neutron shielding is provided by filling the neutron shield shell with water during operations. No testing is necessary. The neutron shield material in the lid and bottom end is a proprietary polymer resin. The shielding performance of the resin will be assured by written procedures controlling temperature, measuring, and mixing of the components, degassing of the resin, and verification of the mass or volume of resin installed. The gamma and neutron

shielding materials of the storage system itself are limited to concrete HSM components and steel shield plugs in the DSC. The integrity of these shielding materials is ensured by the control of their fabrication in accordance with the appropriate ASME, ASTM or ACI criteria. No additional acceptance testing is required.

Y.9.1.6 Thermal Acceptance

No thermal acceptance testing is required to verify the performance of each storage unit other than that specified in the Technical Specifications for initial loading.

The heat transfer analysis for the basket includes credit for the thermal conductivity of neutron-absorbing materials, as specified in Section Y.4.3. Because these materials do not have publicly documented values for thermal conductivity, testing of such materials will be performed in accordance with Section Y.9.1.7.6.

Y.9.1.7 Poison Acceptance

CAUTION

Sections Y.9.1.7.1 through Y.9.1.7.4 below are incorporated by reference into the NUHOMS® CoC 1004 Technical Specification 4.1 (Note 6) and shall not be deleted or altered in any way without approval from the NRC. The text of these sections is shown in bold type to distinguish it from other sections.

The neutron absorber used for criticality control in the DSC basket may consist any of the following types of material:

(a) Borated aluminum

(b) Boron carbide/aluminum metal matrix composite (MMC)

(c) BORAL®

The 69BTH DSC safety analyses do not rely upon the tensile strength of these materials. 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 three types of materials is given in Table Y.9-1.

References to metal matrix composites throughout this chapter are not intended to refer to BORAL®, which is described later in this section.

Y.9.1.7.1 **Borated Aluminum**

See the Caution in Section Y.9.1.7 before deletion or modification to this section.

The material is produced by direct chill (DC) or permanent mold casting with boron precipitating primarily as a uniform fine dispersion of discrete AlB_2 or TiB_2 particles in the matrix of aluminum or aluminum alloy (other boron compounds, such as AlB_{12}, can also occur). 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. 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 Y.9.1.7.7. 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.

Y.9.1.7.2 **Boron Carbide / Aluminum Metal Matrix Composites (MMCs)**

See the Caution in Section Y.9.1.7 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, molten metal infiltration, or thermal spray techniques. The boron carbide content shall not exceed 40% by volume. The boron carbide content for MMCs with an integral aluminum cladding or produced by molten metal infiltration 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.

At least 50% by weight of the B_4C particles in boron carbide shall be smaller than 40 microns. No more than 10% of the particles shall be over 60 microns.

Prior to use in the 69BTH DSC, MMCs shall pass the qualification testing specified in Section Y.9.1.7.8, and shall subsequently be subject to the process controls specified in Section Y.9.1.7.9.

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 Y.9.1.7.7. 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.

Y.9.1.7.3 **BORAL®**

See the Caution in Section Y.9.1.7 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. Before rolling, at least 80% by weight of the B_4C particles in BORAL® shall be smaller than 200 microns. 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.

Y.9.1.7.4 **Visual Inspections of Neutron Absorbers**

See the Caution in Section Y.9.1.7 before deletion or modification to this section.

Neutron absorbers shall be 100% visually inspected in accordance with the Certificate Holder's QA procedures. Blisters shall be treated as non-conforming. For clad MMCs and 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. Material that does not meet these criteria shall be reworked, repaired, or scrapped.

Y.9.1.7.5 Other Visual Inspections Criteria (non-Technical Specifications)

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" [9.5]. Local or cosmetic conditions such as scratches, nicks, die lines, inclusions, abrasion, isolated pores, or discoloration are acceptable.

Y.9.1.7.6 Thermal Conductivity Testing

Acceptance testing shall conform to ASTM E1225[1], ASTM E1461[2], or equivalent method, performed at room temperature on coupons taken from the rolled or extruded production material. Initial sampling shall be one test per lot, and may be reduced if the first five tests meet the specified minimum thermal conductivity. For cast products, the lot shall be defined by the heat or ingot. For other products, the lot shall be defined as material produced in a single production campaign using the same heat or lots of aluminum and boron carbide feed materials.

1 ASTM E1225, "Thermal Conductivity of Solids by Means of the Guarded-Comparative-Longitudinal Heat Flow Technique"

2 ASTM E1461, "Thermal Diffusivity of Solids by the Flash Method"

If a thermal conductivity test result is below the specified minimum, at least four additional tests shall be performed on the material from that lot. If the mean value of those tests, including the original test, falls below the specified minimum, the associated lot shall be rejected.

After twenty five tests of a single type of material, with the same aluminum alloy matrix, the same boron content, and the same primary boron phase, e.g., B_4C, TiB_2, or AlB_2, if the mean value of all the test results less two standard deviations meets the specified thermal conductivity, no further testing of that material is required. This exemption may also be applied to the same type of material if the matrix of the material changes to a more thermally conductive alloy (e.g., from 6000 to 1000 series aluminum), or if the boron content is reduced without changing the boron phase.

The measured thermal conductivity values shall satisfy the minimum required conductivities as specified in Section Y.4.3

In cases where the specified thickness of the neutron absorber may vary, the equations introduced in Section Y.4.3 shall be used to determine the minimum required effective thermal conductivity.

The thermal conductivity test requirement does not apply to aluminum that is paired with the neutron absorber.

Y.9.1.7.7 Specification for Acceptance Testing of Neutron Absorber *Content*

Acceptance testing for neutron absorber content shall be performed by either neutron transmission or by B-10 volume density measurement.

CAUTION

Portions of Section Y.9.1.7.7 are incorporated by reference into the NUHOMS® CoC 1004 Technical Specification 4.1 (Note 6) and shall not be deleted or altered in any way without approval from the NRC. The text of this section is shown in bold type to distinguish it from other sections.

Y.9.1.7.7.1 Specification for Acceptance Testing of Neutron Absorbers by Neutron Transmission

a) 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 up to 1.1 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 B10 at that energy.

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.

b) The following illustrates one acceptable method and is intended to be utilized as an example. Therefore, the following text is not part of the Technical Specifications. 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 [9.6].

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 Y.9.1.7.7a) 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.

Y.9.1.7.7.2 Specification for Acceptance Testing of Neutron Absorbers by B-10 Volume Density Measurement

a) B-10 volume density measurement 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, as long as it results in accumulating material that is uniform for sampling purposes.

The sampling rate for B-10 volume density measurements shall be such that there is at least one density measurement for each 2000 square inches of final product in each lot.

Areal density is determined by measuring the B-10 volume density in test samples and converting the measured values to areal density. The method of measurement of B-10 volume density shall be subject to approval by the certificate holder. The method of measurement of B-10 volume density shall be qualified against neutron transmission testing. Results of the two test methods shall be compared and a penalty shall be derived to account for the performance based results of neutron transmission testing.

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.

b) The following illustrates one acceptable method and is intended to be utilized as an example. Therefore, the following text is not part of the Technical Specifications. The acceptance criterion for individual plates is determined from a statistical analysis of the test results for their lot. The B-10 areal densities are determined by volume density as described above. The lower tolerance limit of B-10 volume density is then determined, defined as the mean value of B-10 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 [9.6]. Finally, the minimum specified value of B-10 areal density is divided by the lower tolerance limit of B-10 volume density to arrive at the minimum plate thickness that provides the specified B-10 areal density.

Any plate that is thinner than the statistically derived minimum thickness from Y.9.1.7.7.2 a) or the minimum design thickness, whichever is greater, shall be treated as nonconforming, 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. Edge effects due to manufacturing operations such as shearing, deburring, and chamfering need not be included in this determination.

Non-conforming material shall be evaluated for acceptance in accordance with the Certificate Holder's QA procedures.

Y.9.1.7.8 Specification for Qualification Testing of Metal Matrix Composites

> ***CAUTION***
>
> *Portions of Section Y.9.1.7.8.4, and all of Section Y.9.1.7.8.5, are incorporated by reference into the NUHOMS® CoC 1004 Technical Specification 4.1 (Note 6) and shall not be deleted or altered in any way without approval from the NRC. The text of this section is shown in bold type to distinguish it from other sections.*

Y.9.1.7.8.1 Applicability and Scope

MMCs acceptable for use in the 69BTH DSC are described in Section Y.9.1.7.2.

Prior to initial use in a spent fuel dry storage or 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 Y.9.1.7.9 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.

Y.9.1.7.8.2 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 storage/ transport system. This is demonstrated by the tests in Section Y.9.1.7.8.4. It must have a uniform distribution of boron carbide. This is demonstrated by the tests in Section Y.9.1.7.8.5.

Y.9.1.7.8.3 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 storage, 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 and corrosion (hydrogen generation) testing shall be performed unless such tests on materials of the same chemical composition have already been performed and found acceptable. The following paragraphs illustrate two cases where such testing is not required.

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 storage or transport[3].

Corrosion testing is not required for full density 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[4].

Y.9.1.7.8.4 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[5]) 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[6]. 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 %.**

c) **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 storage. An example of such a test would be: (1) immerse a specimen at least 6 x 6 inches in water under pressure ≥30 psig for at least 24 hours, (2) place the specimen in a vacuum furnace preheated to at least 300 °F and evacuate the furnace. Acceptance criterion: no blistering or delamination of the cladding.

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3 Sung, C., "Microstructural Observation of Thermally Aged and Irradiated Aluminum/Boron Carbide (B_4C) Metal Matrix Composite by Transmission and Scanning Electron Microscope," 1998.

4 Boralyn testing submitted to the NRC under docket 71-1027, 1998.

5 ASTM B557, Standard Test Methods of Tension Testing Wrought and Cast Aluminum and Magnesium-Alloy Products.

6 ASTM E290, Standard Methods for Bend Testing of Materials for Ductility

This version of Chapter Y.9 is associated with CoC 1004 Amendment 14 and is from UFSAR Revision 17. Please see Page Y.9 Introduction - 1 for a discussion as to why certain versions of Chapter Y.9 are being maintained in the UFSAR.

Y.9.1.7.8.5 **Required Tests and Examinations to Demonstrate B10 Uniformity**

Uniformity of the boron distribution shall be verified either by:

a) Neutron radioscopy or radiography (ASTM E94[7], E142[8], and E545[9]) 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, *or the boron 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 Y.9.1.7.7, or by chemical analysis for boron carbide *or boron* content in the composite.

Y.9.1.7.8.6 Qualification Report

Qualification report shall be prepared by, or subject to approval by the Certificate Holder.

Y.9.1.7.9 Specification for Process Controls for Metal Matrix Composites

CAUTION

Sections Y.9.1.7.9.1 and Y.9.1.7.9.2 are incorporated by reference into the NUHOMS® CoC 1004 Technical Specification 4.1 (Note 6) and shall not be deleted or altered in any way without approval from the NRC. The text of this section is shown in bold type to distinguish it from other sections.

Y.9.1.7.9.1 **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 Y.9.1.7.8 is required, depending on the characteristics of the material that could be affected by the process change.

Y.9.1.7.9.2 **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, reduce the mechanical strength or ductility of the MMC.

7 ASTM E94, Recommended Practice for Radiographic Testing

8 ASTM E142, Controlling Quality of Radiographic Testing

9 ASTM E545, Standard Method for Determining Image Quality in Thermal Neutron Radiographic Testing

Y.9.1.7.9.3 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 Y.9.1.7.9.2.

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 (d50) 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.

Y.9.2 Maintenance Program

The NUHOMS®-69BTH system is a totally passive system and therefore will require little, if any, maintenance over the lifetime of the ISFSI. Typical NUHOMS®-69BTH system maintenance tasks will be performed in accordance with the UFSAR.

Y.9.3 References

9.1 ASME Boiler and Pressure Vessel Code, Section III, 2004 Edition through 2006 Addenda.

9.2 SNT-TC-1A, "American Society for Nondestructive Testing, Personnel Qualification and Certification in Nondestructive Testing," 1992.

9.3 Not Used.

9.4 ANSI N14.5-1997, "American National Standard for Leakage Tests on Packages for Shipment of Radioactive Materials," February 1998.

9.5 "Aluminum Standards and Data, 2003," The Aluminum Association.

9.6 Natrella, "Experimental Statistics," Dover, 2005.

Table Y.9-1
B10 Specification for the NUHOMS®-69BTH Poison Plates

Poison Type	Basket Type	Specified Minimum B10 Areal Density for 90% Credit (g/cm^2)	% Credit Used in Criticality Analysis
Borated Aluminum Alloy / MMC	A	0.021	90
	B	0.031	
	C	0.039	
	D	0.046	
	E	0.053	
	F	0.061	
BORAL®	A	0.025	75
	B	0.037	
	C	0.047	
	D	0.055	
	E	0.064	
	F	0.073	

System Configuration	DSC Type	Basket Option	Neutron Absorber Plate Type	Max. Heat Load per DSC	Transfer Cask	Storage Module
1	37PTH-S	Option 1 paired Al/poison, Options 2 & 3 single poison plate	Borated aluminum, or MMC, or Boral®	22.0 kW	OS200 or OS200FC	HSM-H or HSM-HS
2	37PTH-M			30.0 kW	OS200FC	HSM-H or HSM-HS

The NUHOMS®-37PTH system provides structural integrity, confinement, shielding, criticality control and passive heat removal independent of any other facility structures or components.

The format of this appendix follows the guidance provided in NRC Regulatory Guide 3.61 [1.1]. The analysis presented in this appendix shows that the NUHOMS®-37PTH system meets all the requirements of 10 CFR 72 [1.2]. A separate analysis [1.8] has been submitted to address the safety related aspects of transporting spent fuel in the NUHOMS®-37PTH DSC in accordance with 10 CFR 71 [1.3].

Several sections of this appendix have been identified as "No change." For these sections, the applicable sections of the UFSAR are specified.

References to sections or chapters within this appendix are identified with a prefix Z (e.g., Section Z.2.3 or Appendix Z.2). References to sections or chapters of the UFSAR outside of this appendix (main body of the UFSAR) are identified with the applicable UFSAR section or chapter number (e.g., Section 2.3 or Chapter 2) or Appendix (e.g., Appendix P). The references used in this appendix are identified as [X.X] (e.g., [1.1] is reference 1.1 at the end of Appendix Z.1).

Aging Management Program Requirements

AMP requirements for use of the 37PTH System during the period of extended storage operations are contained in Section 12.3. Applicable TLAAs performed for the initial CoC 1004 renewal application are provided in Section 12.2.

Z.2.3 Safety Protection Systems

Z.2.3.1 General

The NUHOMS®-37PTH DSC is designed to provide storage of spent fuel for at least 40 years.(1) The DSC cavity is inerted and backfilled with helium and the internal pressure is always above atmospheric during the storage period as a precaution against in-leakage of air, which could be harmful to the fuel. Since the confinement vessel consists of a steel cylinder with an integrally welded bottom closure, and a seal welded top closure that is verified to be leak tight after loading, the DSC cavity gas cannot escape.

Renewal

Only those features that are not addressed in Chapter 3, or have been revised, are addressed in this Section. Those features include the thermal and neutronic performance of the poison plates, and their acceptance. The quality category classification for the various NUHOMS® System components is described in Chapter 3, Section 3.4. The quality categories for the 37PTH system are summarized in Table Z.2-18. The detailed quality category of components of the NUHOMS®-37PTH DSC and the OS200TC that are "Important to Safety" and "Not Important to Safety" are also shown on the drawings listed in Section Z.1.5. For the HSM-H/HSM-HS, the components that are "Important to Safety" are unchanged from those listed in Table 3.3-1 and discussed in Section 3.3 of Chapter 3, "Safety Protection System."

Z.2.3.2 Protection by Multiple Confinement Barriers and Systems

The NUHOMS®-37PTH DSC provides a leak tight confinement of the spent fuel. Although similar to the existing NUHOMS®-24P DSC, sealing of the NUHOMS®-37PTH DSC involves leak testing to the criteria of ANSI N14.5 [2.4] after loading and sealing the canister, as described in Appendix Z.7.

Z.2.3.3 Protection by Equipment and Instrumentation Selection

No change to Chapter 3, Section 3.3.3.

Z.2.3.4 Nuclear Criticality Safety

Z.2.3.4.1 Control Methods for Prevention of Criticality

The design criterion for criticality is that an upper subcritical limit (USL) of 0.95 minus benchmarking bias and modeling bias will be maintained for all postulated arrangements of fuel within the DSC. The intact fuel assemblies are assumed to stay within their basket compartment based on the DSC and basket geometry.

The control method used to prevent criticality is incorporation of poison material in the basket material, soluble boron in the pool and favorable geometry. The quantity and distribution of boron in the poison material is controlled by specific manufacturing and acceptance criteria of the poison plates and PRAs. The acceptance criteria of the plates and PRAs is described in Appendix Z.9.

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[1] *With NRC approval of the CoC 1004 renewal application, the license is extended to a total of 60 years. The TLAAs identified as #1, #4, and #5 in Section 12.2 performed for the renewal of this design conservatively used a service life of 100 years.* 72.48

The basket has been designed to assure an ample margin of safety against criticality under the conditions of fresh fuel in a DSC flooded with borated pool water. The method of criticality control is in accordance with the requirements of 10 CFR 72.124 [2.10].

limiting features listed in Appendix Z.2 bound the specific manufacturer's replacement fuel. The limiting parameters are the design basis radiological and decay heat source terms.

The design-basis fuel source terms, based on 0.490 MTU of heavy metal weight, for this evaluation are defined as the source terms from fuel with the burnup/initial enrichment/cooling time combination given in Appendix Z.2, Tables Z.2-6 through Z.2-11 and located in the basket as shown in Appendix Z.2, Figures Z.2-2 and Z.2-3 that give the maximum dose rate on the surface of the HSM and/or TC. This approach is consistent with the method used to generate the fuel qualification tables for the Standardized NUHOMS®-24P and -52B DSC designs as described in Chapter 7, Section 7.2.3, 32PT DSC design as described in Appendix M, NUHOMS®-24PTH DSC design described in Appendix P, or NUHOMS®-32PTH DSC design described in Appendix U. The design basis fuel source terms in conjunction with the design basis CC source terms (Table Z.5-13) are used to calculate dose rates for the NUHOMS®-37PTH System.

The fuel qualification tables shown in Table Z.2-6 through Table Z.2-11 are developed for the design basis heavy metal loading of 0.490 MTU with SAS2H/ORIGEN-S modules of SCALE 4.4 [5.1] and for the heavy metal loading of 0.400 MTU with SAS2H/ORIGEN-S modules of SCALE 5.0 [5.17]. Section *7.2.3.2* of Chapter *7* provides the methods for determining minimum required cooling times using fitting equations or linear interpolation for a given MTU between 0.400 MTU and 0.490 MTU.

The enveloping heat load zoning configuration (HLZC) utilized in the shielding evaluation is shown in Figure Z.5-1. This HLZC produces the highest dose rates on the surfaces of the HSM-H and OS200 TC as compared to the allowable HLZCs because the highest source fuel assemblies are on the outer periphery of the basket region where self-shielding due to adjacent assemblies is limited. This results in a shielding analysis corresponding to a total of 31.2 kW decay heat per DSC which is conservative because the total decay heat in 37PTH DSC is limited to 30 kW. These bounding gamma and neutron source terms are then used in the radiation shielding models to conservatively calculate dose rates on and around the NUHOMS®-37PTH System.

The bounding burnup, minimum initial enrichment, and cooling time combinations for the fuel assemblies used in the shielding analyses of the 37PTH DSC in the HSM-H and the OS200 TC are as follows:

37PTH DSC in HSM-H:

- Zones 1 and 2: 40 GWD/MTU, 1.5 wt % ^{235}U, 40.2 years cooled, 0.40 kW/FA
- Zone 3: 16 GWD/MTU, 0.7 wt % ^{235}U, 3.1 years cooled, 0.70 kW/FA
- Zone 4: 26 GWD/MTU, 1.5 wt % ^{235}U, 3.1 years cooled, 1.2 kW/FA

37PTH DSC in OS200:

- Zones 1 and 2: 40 GWD/MTU, 1.5 wt % ^{235}U, 40.2 years cooled, 0.40 kW/FA
- Zone 3: 41 GWD/MTU, 1.5 wt % ^{235}U, 15.3 years cooled, 0.70 kW/FA

Zone 4: 41 GWD/MTU, 1.5 wt % ^{235}U, 5.7 years cooled, 1.2 kW/FA. For dry cask and dry DSC.

head above the level of water in the TC/DSC annulus. This is an optional arrangement, which provides additional assurance that contaminated water from the fuel pool will not enter the TC/DSC annulus, provided a positive head is maintained at all times.

12. Place the top shield plug onto the DSC. Examine the top shield plug to ensure a proper fit. Optionally, the top shield plug once fitted, may be removed and disconnected from the yoke. It may be installed later once the DSC is loaded and prior to removing it from the pool.

13. Position the cask lifting yoke above the transfer cask and engage the cask lifting trunnions and the rigging cables to the DSC top shield plug. Adjust the rigging cables as necessary to obtain even cable tension.

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

15. Provide for later connection to the vacuum drying system (VDS) or an optional water draining/pumping device to the siphon port of the DSC and position any connecting hose such that the hose will not interfere with loading (yoke, fuel, shield plug, rigging, etc.). A flowmeter or other suitable means for measuring the amount of water removed must be installed at a suitable location as part of this connection.

16. Fill the TC liquid neutron shield *with demineralized water,* as required. This step may be completed at any time prior to immersion of the TC/DSC into the pool.

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

18. 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 ensure that they are properly positioned on the cask trunnions.

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

20. Prior to the cask being lowered into the fuel pool, 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.

Z.8.1.2 DSC Fuel Loading

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 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 demineralized water. Prior to submerging the top of the cask, verify correct connections of the annulus seal and annulus pressurization tank if used.

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

14. Recheck all alignment marks in accordance with the Technical Specification 5.3.3 limits and ready all systems for DSC transfer.

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

    CAUTION: Verify that the applicable time limits of Technical Specification 3.1.3 are met if loading a 37PTH DSC with heat load greater than 22.0 kW.

16. Disengage the ram grapple mechanism away from the DSC grapple ring.

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

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

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

20. After inserting the DSC axial retainer, the transfer trailer may be moved as necessary to install the HSM door. Install the HSM door using a portable crane and secure it in place. Door may be welded for security. Verify that the HSM dose rates are compliant with the limits specified in Technical Specification 5.4.

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

22. *If this is the final loading, fully drain the liquid neutron shield.*

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

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

25. Ensure the HSM maximum air exit temperature requirements of Technical Specification 3.1.4 are met.

Z.8.1.7 Monitoring Operations

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

2. Perform one of the two alternate daily surveillance activities listed below:

    a. A daily visual surveillance of the HSM air inlets and outlets to ensure that no debris is obstructing the HSM vents in accordance with Technical Specification 5.2.5a requirements.

Any changes on this page are a part of CoC 1004 renewal.

b. A temperature measurement of the thermal performance, for each HSM, on a daily basis in accordance with Technical Specification 5.2.5b requirements.

Z.9 Acceptance Tests and Maintenance Program

Background for this particular UFSAR chapter:

Beginning with CoC 1004 Amendment 13, which was incorporated into UFSAR Revision 14, Chapter Z.9, "Acceptance Tests and Maintenance Program," contained information which was incorporated by reference into the Technical Specifications (TS) associated with a particular amendment. It is known that certain general licensees reconcile the CoC 1004 UFSAR revisions provided to them to their loaded systems, pursuant to 10 CFR 72.48 and 10 CFR 72.212. In doing so they sometimes find the changed UFSAR portions incorporated by reference into the TS to be impossible to reconcile because the 10 CFR 72.48 regulation does not allow proposed activities which involve changes to the TS.

In order to facilitate this reconciliation process by general licensees, the following statements are provided, addressing the licensing basis for certain amendments, as they relate to certain UFSAR chapters which contain TS incorporated by reference. Additionally, so that the actual information is contained in the current CoC 1004 UFSAR, to facilitate the reconciliation by general licensees, the UFSAR Revision 14 and 15 versions of Chapter Z.9 are inserted and annotated in this part of the UFSAR. For clarity, this includes annotating the version of Chapter Z.9 directly associated with the latest UFSAR revision in which a change to Chapter Z.9 occurred.

- Systems loaded to CoC 1004 Amendment 13 have Technical Specifications incorporated by reference from UFSAR Revisions 14 and 15 Chapter Z.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to Amendment 13.
- Systems loaded to CoC 1004 Amendment 14 have Technical Specifications incorporated by reference by FCN 721004-1575, which will be incorporated into UFSAR Revision*s* 16 *and 17* Chapter Z.9. Changes made to that chapter in subsequent UFSAR revisions do not apply to Amendment 14.

This version of Chapter Z.9 is associated with CoC 1004 Amendment 14 and is added from UFSAR Revision 17. Please see Page Z.9 Introduction - 1 for a discussion as to why certain versions of Chapter Z.9 are being maintained in the UFSAR.

Z.9 Acceptance Tests and Maintenance Program

Z.9.1 Acceptance Tests

The pre-operational testing requirements for the Standardized NUHOMS® system are given in Chapter 9, with the exceptions described in the following sections. The NUHOMS®-37PTH DSC has been enhanced to provide leaktight confinement and the basket includes an updated poison plate design. Additional acceptance testing of the NUHOMS®-37PTH DSC welds and of the poison plates are described.

Z.9.1.1 Visual Inspection

Visual inspections are performed at the fabricator's facility to ensure that the DSC, the transfer cask and the HSM conform to the drawings and specifications. The visual inspections include weld, dimensional, surface finish, and cleanliness inspections. Visual inspections specified by codes applicable to a component are performed in accordance with the requirements and acceptance criteria of those codes.

All weld inspection is performed using qualified processes and qualified personnel according to the applicable code requirements, e.g., ASME or AWS. Non-destructive examination (NDE) requirements for welds are specified on the drawings provided in Appendix Z.1; acceptance criteria are as specified by the governing code. NDE personnel are qualified in accordance with SNT-TC-1A [9.2].

The confinement welds on the DSC are inspected in accordance with ASME B&PV Code Subsection NB [9.1] including alternatives to ASME Code specified in Section Z.3.1.2.3.

DSC non-confinement welds are inspected to the NDE acceptance criteria of ASME B&PV Code Subsection NG or NF, based on the applicable code for the components welded.

Z.9.1.2 Structural

The DSC confinement boundary except the inner top cover/shield plug to the DSC shell weld is pressure tested at the fabricator's shop in accordance with ASME Article NB-6300. The test pressure is set between 16.5 to 18.0 psig for 37PTH DSC, which bounds the 1.1xDSC design pressure of 15 psig.

The inner top cover/shield plug to the DSC shell weld is also pressure tested between 16.5 to 18.0 psig for 37PTH DSC. This pressure test is performed at the field after the fuel assemblies are loaded in the DSC. This test is in accordance with the alternatives to the ASME Code specified in Section Z.3.1.2.3.

HSM-H reinforcement and concrete are tested as described in Chapter 3, Section 3.4.2.

Z.9.1.3 Leakage Tests

The DSC canister confinement boundary is tested using two procedures described below. Personnel performing the leakage test are qualified in accordance with SNT-TC-1A [9.2].

Procedure 1 is accomplished during fabrication:

Upon completion of all canister shell welding and attachment of the inner bottom cover plate to the shell, a temporary seal plate is placed over the open end of the DSC. A bag or other enclosure is placed around the outside of the entire DSC and it is filled with helium. The DSC cavity is evacuated and a helium leakage test is performed using a port in the seal plate. This test is used to show that the entire DSC confinement boundary tested is leak tight ($1x10^{-7}$ ref cm^3/s).

Procedure 2 of the testing occurs after the DSC has been loaded with fuel assemblies:

The DSC cavity has been dried, back filled with helium and the inner top cover plate and the vent and drain port cover plates have been welded in place. After these welds are completed, a temporary test cover is installed or the outer top cover plate is welded in place with at least the root pass of the full weld. The cavity between inner top cover plate and the temporary test cover or outer top cover plate is evacuated and a helium leakage test is performed using a test port in the temporary test cover or in the outer top cover plate. The leakage test thus includes the weld attaching the inner top cover plate to the canister shell, the vent and drain port cover plate welds and the base metal of the inner top cover plate and vent and drain port cover plates. The vent and drain ports are filled with helium prior to welding the vent and drain port covers. This test verifies that the tested welds and cover plates are leak tight ($1x10^{-7}$ ref cm^3/s).

Z.9.1.4 Components

The Standardized NUHOMS® system does not include any components such as valves, rupture discs, pumps, or blowers. No other components of the NUHOMS® system require testing, except as discussed in this chapter.

Z.9.1.5 Shielding Integrity

The transfer cask poured lead shielding integrity will be confirmed via gamma scanning prior to first use. The detector and examination grid will be matched to provide coverage of the entire lead-shielded surface area. For example, for a 6″ × 6″ grid, the detector will encompass a 6″ × 6″ square. The acceptance criterion is attenuation greater than or equal to that of a test block matching the cask through-wall configuration with lead and steel thicknesses equal to the design minima less 5%.

The radial neutron shielding is provided by filling the neutron shield shell with water during operations. No testing is necessary. The neutron shield material in the lid and bottom end is a proprietary polymer resin. The shielding performance of the resin will be assured by written

procedures controlling temperature, measuring, and mixing of the components, degassing of the resin, and verification of the mass or volume of resin installed.

The gamma and neutron shielding materials of the storage system itself are limited to concrete HSM components and steel shield plugs in the DSC. The integrity of these shielding materials is ensured by the control of their fabrication in accordance with the appropriate ASME, ASTM or ACI criteria. No additional acceptance testing is required.

Z.9.1.6 Thermal Acceptance

No thermal acceptance testing is required to verify the performance of each storage unit other than that specified in the Technical Specifications for initial loading.

The heat transfer analysis for the basket includes credit for the thermal conductivity of neutron-absorbing materials, as specified in Section Z.4.3. Because these materials do not have publicly documented values for thermal conductivity, testing of such materials will be performed in accordance with Section Z.9.1.7.6.

Z.9.1.7 Poison Acceptance

CAUTION

Sections Z.9.1.7.1 through Z.9.1.7.4 below are incorporated by reference into the NUHOMS® CoC 1004 Technical Specification 4.1 (Note 7) and shall not be deleted or altered in any way without approval from the NRC. The text of these sections is shown in bold type to distinguish it from other sections.

The neutron absorber used for criticality control in the DSC basket may consist any of the following types of material:

(a) Borated aluminum

(b) Boron carbide/aluminum metal matrix composite (MMC)

(c) BORAL®

The 37PTH DSC safety analyses do not rely upon the tensile strength of these materials. 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 three types of materials is 0.0020 g/cm^2 for Borated Aluminum and MMC, and 0.0025 g/cm^2 for BORAL®.

References to metal matrix composites throughout this chapter are not intended to refer to BORAL®, which is described later in this section.

Z.9.1.7.1 **Borated Aluminum**

See the Caution in Section Z.9.1.7 before deletion or modification to this section.

The material is produced by direct chill (DC) or permanent mold casting with boron precipitating primarily as a uniform fine dispersion of discrete AlB2 or TiB2 particles in the matrix of aluminum or aluminum alloy (other boron compounds, such as AlB12, can also occur). For extruded products, the TiB2 form of the alloy shall be used. For rolled products, either the AlB2, the TiB2, 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. 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 Z.9.1.7.7. 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.

Z.9.1.7.2 **Boron Carbide/Aluminum Metal Matrix Composites (MMCs)**

See the Caution in Section Z.9.1.7 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, molten metal infiltration, or thermal spray techniques. The boron carbide content shall not exceed 40% by volume. The boron carbide content for MMCs with an integral aluminum cladding or produced by molten metal infiltration 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.

At least 50% by weight of the B4C particles in boron carbide shall be smaller than 40 microns. No more than 10% of the particles shall be over 60 microns.

Prior to use in the 37PTH DSC, MMCs shall pass the qualification testing specified in Section Z.9.1.7.8, and shall subsequently be subject to the process controls specified in Section Z.9.1.7.9.

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 Z.9.1.7.7. 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.

Z.9.1.7.3 **BORAL®**

See the Caution in Section Z.9.1.7 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. Before rolling, at least 80% by weight of the B_4C particles in BORAL® shall be smaller than 200 microns. 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.

Z.9.1.7.4 **Visual Inspections of Neutron Absorbers**

See the Caution in Section Z.9.1.7 before deletion or modification to this section.

Neutron absorbers shall be 100% visually inspected in accordance with the Certificate Holder's QA procedures. Blisters shall be treated as non-conforming. For clad MMCs and 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. Material that does not meet these criteria shall be reworked, repaired, or scrapped.

Z.9.1.7.5 Other Visual Inspections Criteria (non-Technical Specifications)

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" [9.5]. Local or cosmetic conditions such as scratches, nicks, die lines, inclusions, abrasion, isolated pores, or discoloration are acceptable.

Z.9.1.7.6 Acceptance Testing

Acceptance testing shall conform to ASTM E1225[1], ASTM E1461[2], or equivalent method, performed at room temperature on coupons taken from the rolled or extruded production material. Initial sampling shall be one test per lot, and may be reduced if the first five tests meet the specified minimum thermal conductivity. For cast products, the lot shall be defined by the

[1] ASTM E1225, "Thermal Conductivity of Solids by Means of the Guarded-Comparative-Longitudinal Heat Flow Technique"
[2] ASTM E1461, "Thermal Diffusivity of Solids by the Flash Method"

heat or ingot. For other products, the lot shall be defined as material produced in a single production campaign using the same heat or lots of aluminum and boron carbide feed materials.

If a thermal conductivity test result is below the specified minimum, at least four additional tests shall be performed on the material from that lot. If the mean value of those tests, including the original test, falls below the specified minimum, the associated lot shall be rejected.

After twenty five tests of a single type of material, with the same aluminum alloy matrix, the same boron content, and the same primary boron phase, e.g., B_4C, TiB_2, or AlB_2, if the mean value of all the test results less two standard deviations meets the specified thermal conductivity, no further testing of that material is required. This exemption may also be applied to the same type of material if the matrix of the material changes to a more thermally conductive alloy (e.g., from 6000 to 1000 series aluminum), or if the boron content is reduced without changing the boron phase.

The measured thermal conductivity values shall satisfy the minimum required conductivities as specified in Section Z.4.3

In cases where the specified thickness of the neutron absorber may vary, the equations introduced in Section Z.4.3 shall be used to determine the minimum required effective thermal conductivity.

The thermal conductivity test requirement does not apply to aluminum that is paired with the neutron absorber.

Z.9.1.7.7 Specification for Acceptance Testing of Neutron Absorber *Content*

Acceptance testing for neutron absorber content shall be performed by either neutron transmission or by B-10 volume density measurement.

CAUTION

Portions of Section Z.9.1.7.7 are incorporated by reference into the NUHOMS® CoC 1004 Technical Specification 4.1 (Note 7) and shall not be deleted or altered in any way without approval from the NRC. The text of this section is shown in bold type to distinguish it from other sections.

Z.9.1.7.7.1 *Specification for Acceptance Testing of Neutron Absorbers by Neutron Transmission*

a) 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 up to 1.1 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 B10 at that energy.

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.

b) The following illustrates one acceptable method and is intended to be utilized as an example. Therefore, the following text is not part of the Technical Specifications. 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 [9.6].

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 Z.9.1.7.7 a) 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.

This version of Chapter Z.9 is associated with CoC 1004 Amendment 14 and is added from UFSAR Revision 17. Please see Page Z.9 Introduction - 1 for a discussion as to why certain versions of Chapter Z.9 are being maintained in the UFSAR.

Non-conforming material shall be evaluated for acceptance in accordance with the Certificate Holder's QA procedures.

Z.9.1.7.7.2 *Specification for Acceptance Testing of Neutron Absorbers by B-10 Volume Density Measurement*

a) B-10 volume density measurement 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, as long as it results in accumulating material that is uniform for sampling purposes.

The sampling rate for B-10 volume density measurements shall be such that there is at least one density measurement for each 2000 square inches of final product in each lot.

Areal density is determined by measuring the B-10 volume density in test samples and converting the measured values to areal density. The method of measurement of B-10 volume density shall be subject to approval by the certificate holder. The method of measurement of B-10 volume density shall be qualified against neutron transmission testing. Results of the two test methods shall be compared and a penalty shall be derived to account for the performance based results of neutron transmission testing.

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.

b) The following illustrates one acceptable method and is intended to be utilized as an example. Therefore, the following text is not part of the Technical Specifications. The acceptance criterion for individual plates is determined from a statistical analysis of the test results for their lot. The B-10 areal densities are determined by volume density as described above. The lower tolerance limit of B-10 volume density is then determined, defined as the mean value of B-10 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 [9.6]. Finally, the minimum specified value of B-10 areal density is divided by the lower tolerance limit of B-10 volume density to arrive at the minimum plate thickness that provides the specified B-10 areal density.

Any plate that is thinner than the statistically derived minimum thickness from Z.9.1.7.7.2 a) or the minimum design thickness, whichever is greater, shall be treated as nonconforming, 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. Edge effects due to manufacturing operations such as shearing, deburring, and chamfering need not be included in this determination.

Non-conforming material shall be evaluated for acceptance in accordance with the certificate holder's QA procedures.

Z.9.1.7.8 Specification for Qualification Testing of Metal Matrix Composites

CAUTION

Portions of Section Z.9.1.7.8.4, and all of Section Z.9.1.7.8.5, are incorporated by reference into the NUHOMS® CoC 1004 Technical Specification 4.1 (Note 7) and shall not be deleted or altered in any way without approval from the NRC. The text of this section is shown in bold type to distinguish it from other sections.

Z.9.1.7.8.1 Applicability and Scope

Metal matrix composites (MMCs) acceptable for use in the 37PTH DSC are described in Section Z.9.1.7.2.

Prior to initial use in a spent fuel dry storage or 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 Z.9.1.7.9 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.

Z.9.1.7.8.2 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 storage/ transport system. This is demonstrated by the tests in Section Z.9.1.7.8.4. It must have a uniform distribution of boron carbide. This is demonstrated by the tests in Section Z.9.1.7.8.5.

Z.9.1.7.8.3 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 storage, about 10^{15} neutrons/cm^2.

This version of Chapter Z.9 is associated with CoC 1004 Amendment 14 and is added from UFSAR Revision 17. Please see Page Z.9 Introduction - 1 for a discussion as to why certain versions of Chapter Z.9 are being maintained in the UFSAR.

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 and corrosion (hydrogen generation) testing shall be performed unless such tests on materials of the same chemical composition have already been performed and found acceptable. The following paragraphs illustrate two cases where such testing is not required.

This version of Chapter Z.9 is associated with CoC 1004 Amendment 14 and is added from UFSAR Revision 17. Please see Page Z.9 Introduction - 1 for a discussion as to why certain versions of Chapter Z.9 are being maintained in the UFSAR.

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 storage or transport[3].

Corrosion testing is not required for full density 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[4].

Z.9.1.7.8.4 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[5]) 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[6]. 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 %.**

c) **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 storage. An example

3 Sung, C., "Microstructural Observation of Thermally Aged and Irradiated Aluminum/Boron Carbide (B_4C) Metal Matrix Composite by Transmission and Scanning Electron Microscope," 1998.

4 Boralyn testing submitted to the NRC under docket 71-1027, 1998.

5 ASTM B557, Standard Test Methods of Tension Testing Wrought and Cast Aluminum and Magnesium-Alloy Products.

6 ASTM E290, Standard Methods for Bend Testing of Materials for Ductility

of such a test would be: (1) immerse a specimen at least 6 x 6 inches in water under pressure ≥30 psig for at least 24 hours, (2) place the specimen in a vacuum furnace preheated to at least 300°F and evacuate the furnace. Acceptance criterion: no blistering or delamination of the cladding.

Z.9.1.7.8.5 **Required Tests and Examinations to Demonstrate B10 Uniformity**

Uniformity of the boron distribution shall be verified either by:

a) Neutron radioscopy or radiography (ASTM E94[7], E142[8], and E545[9]) 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, the boron carbide weight fraction, *or the boron 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 Z.9.1.7.7, or by chemical analysis for boron carbide *or boron* content in the composite.

Z.9.1.7.8.6 Qualification Report

Qualification report shall be prepared by, or subject to approval by the Certificate Holder.

Z.9.1.7.9 Specification for Process Controls for Metal Matrix Composites

CAUTION

Sections Z.9.1.7.9.1 and Z.9.1.7.9.2 are incorporated by reference into the NUHOMS® CoC 1004 Technical Specification 4.1 (Note 7) and shall not be deleted or altered in any way without approval from the NRC. The text of this section is shown in bold type to distinguish it from other sections.

Z.9.1.7.9.1 **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 Z.9.1.7.8 is required, depending on the characteristics of the material that could be affected by the process change.

7 ASTM E94, Recommended Practice for Radiographic Testing

8 ASTM E142, Controlling Quality of Radiographic Testing

9 ASTM E545, Standard Method for Determining Image Quality in Thermal Neutron Radiographic Testing

This version of Chapter Z.9 is associated with CoC 1004 Amendment 14 and is added from UFSAR Revision 17. Please see Page Z.9 Introduction - 1 for a discussion as to why certain versions of Chapter Z.9 are being maintained in the UFSAR.

Z.9.1.7.9.2 **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, reduce the mechanical strength or ductility of the MMC.

Z.9.1.7.9.3 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 Z.9.1.7.9.2.

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 (d50) 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.

Z.9.1.7.10 B_4C Linear Density Testing for Poison Rod Assemblies (PRAs)

The PRAs are shown in Figure Z.1-1, and additional physical requirements are listed in Table Z.2-5a. The B_4C poison is inserted into the stainless steel tubes shown in Figure Z.1-1. Table Z.2-5a specifies the minimum B_4C content per unit length in the axial direction of the rods for the various PRA designs. The minimum B_4C content per unit length is consistent with the criticality analysis (Section Z.6) with an additional 25% margin.

Pellets or powder representing each powder lot shall be tested per ASTM C751 [9.7] or ASTM C750 (Type 2) [9.8] (or equivalent). Density and diameter shall be measured to verify conformance to the specification requirements.

Deviations from the specified dimensions or density may be accepted, as long as the resulting minimum B_4C mass per unit length is maintained.

Justification for Durability of B_4C Pellets:

B_4C is essentially inert and will not be attacked even by hot hydrofluoric or nitric acids [9.9]. It is insoluble in water [9.10], resistant to steam at temperatures of 200 to 300 °C [9.10] and has a melting point of 2450°C [9.11]. Mechanically, B_4C is extremely hard (Mohs hardness of 9.3 vs. 10 for diamond) and is used in abrasion- and wear-resistant applications and in bullet-proof tiles.

It has a compressive strength of 398,000 psi. In the PRAs, the B_4C pellets are sealed within stainless steel. With this configuration, there is nothing that could cause the material to degrade.

In the unlikely event that a pellet was to crack or break, the total mass would be confined by the steel to the same dimensions.

The irradiation-induced swelling is due to neutron capture by the ^{10}B isotope. Using data from [9.12] and by determining the neutron absorption in the B_4C (^{10}B capture) from the shielding analyses, the swelling is determined to be negligible ≈ 0.00002 %. Finally, according to [9.12], the first intergranular cracks do not start to appear until fluences are 5.5 orders of magnitude greater than those calculated for 50 years operation.

This version of Chapter Z.9 is associated with CoC 1004 Amendment 14 and is added from UFSAR Revision 17. Please see Page Z.9 Introduction - 1 for a discussion as to why certain versions of Chapter Z.9 are being maintained in the UFSAR.

Z.9.2 Maintenance Program

The NUHOMS®-37PTH system is a totally passive system and therefore will require little, if any, maintenance over the lifetime of the ISFSI. Typical NUHOMS®-37PTH system maintenance tasks will be performed in accordance with the UFSAR.

This version of Chapter Z.9 is associated with CoC 1004 Amendment 14 and is added from UFSAR Revision 17. Please see Page Z.9 Introduction - 1 for a discussion as to why certain versions of Chapter Z.9 are being maintained in the UFSAR.

Z.9.3 References

9.1 ASME Boiler and Pressure Vessel Code, Section III, 2004 Edition through 2006 Addenda.

9.2 SNT-TC-1A, "American Society for Nondestructive Testing, Personnel Qualification and Certification in Nondestructive Testing," 1992.

9.3 Not Used.

9.4 ANSI N14.5-1997, "American National Standard for Leakage Tests on Packages for Shipment of Radioactive Materials," February 1998.

9.5 "Aluminum Standards and Data, 2003," The Aluminum Association.

9.6 Natrella, "Experimental Statistics," Dover, 2005.

9.7 ASTM C751, "Standard Specification for Nuclear-Grade Boron Carbide Pellets."

9.8 ASTM C750, "Standard Specification for Nuclear-Grade Boron Carbide Powder."

9.9 The Merck Index, 9th edition, Merck & Co., 1976.

9.10 Grant (ed.), Hackh's Chemical Dictionary, 4th edition, McGraw-Hill, 1969.

9.11 Lipp, A., "Boron Carbide: Production, Properties, Application," Reprint from Technische Rundschau, Nos. 14, 28, 33 (1995) and 7 (1966).

9.12 *Stoto, T. et al., "Swelling and Microcracking of Boron Carbide Subjected to Fast Neutron Irradiations," Journal of Applied Physics, Vol. 68, No.7, October 1, 1990, pp. 3198-3206.*