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June 28, 2023
E-62384

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852

Subject: Application for Amendment 4 to NUHOMS® EOS Certificate of Compliance No. 1042, Revision 2 (Docket 72-1042, CAC No. 001028, EPID: L-2022-LLA-0017) – Supplemental Responses to Request for Supplemental Information

References: [1] Letter E-61991, dated March 30, 2023, from Prakash Narayanan, Application for Amendment 4 to NUHOMS® EOS Certificate of Compliance No. 1042, Revision 1 (Docket 72-1042)

[2] Letter from Christian Jacobs to Prakash Narayanan, "Acceptance Review of TN Americas LLC Application for Certificate of Compliance No. 1042, Amendment No. 4, to NUHOMS® EOS System (Docket No. 72-1042, CAC No. 001028, EPID: L-2022-LLA-0017) – Request for Supplemental Information," dated January 30, 2023

[3] Letter E-59796, dated September 29, 2022, from Prakash Narayanan, Application for Amendment 4 to NUHOMS® EOS Certificate of Compliance No. 1042, Revision 0 (Docket 72-1042)

As a follow-up to Reference [1], the NRC and TN held a conference call on May 16, 2023, for the purpose of discussing certain responses to the Request for Supplemental Information (RSI).

This submittal provides supplemental responses to the RSI forwarded by Reference [1]. Enclosure 2 herein provides a proprietary version of the supplemental responses to specific RSI items. Enclosure 3 provides a public version of these responses. Each supplemental RSI response has a section stating the impact of the response on the application, both Technical Specifications (TS) and updated final safety analysis report (UFSAR), indicating which sections, tables, etc., have been changed.

Enclosure 4 provides a listing of the CoC 1042 Amendment 4, Revision 2 TS changes, along with a justification, resulting from these RSI responses. Enclosure 5 provides a list of changed TS and UFSAR pages. Enclosure 6 provides a complete update to the TS, denoted as "Revision 2 to Amendment 4 Proposed Technical Specifications."

Enclosure 7 provides the UFSAR changed pages associated with this Revision 2 to the application for Amendment 4. Enclosure 8 provides the public version of the Enclosure 7 UFSAR changed pages.

For the UFSAR, pages affected by Amendment 4, Revision 2 are provided. Each page includes a footer annotated as “72-1042 Amendment 4, Revision 2, June 2023” with changes indicated by italicized text and revision bars. The new changes associated with each RSI response are further annotated with gray shading and an indication of which RSI is associated with the changes. Note that for Chapter 3.9.8, the complete chapter is being provided for ease of review of the supplemental responses and their associated FSAR changes.

For the TS, Amendment 4 changes on Revision 2 pages are indicated by italicized text, revision bars, and gray shading and an indication of which RSI response is associated with the changes to distinguish them from the changes proposed in Revision 0 and Revision 1 of the Amendment 4 application.

Enclosure 9 provides several supporting calculations relating to the supplemental RSI responses. Since Enclosure 9 contains entirely proprietary information, no public version is provided.

Certain portions of this submittal include proprietary information, which may not be used for any purpose other than to support the NRC staff’s review of the application. In accordance with 10 CFR 2.390, TN Americas LLC is providing an affidavit (Enclosure 1), specifically requesting that this proprietary information be withheld from public disclosure. The submittal also includes security-related information.

TN Americas LLC looks forward to working with the NRC staff on this amendment application. We are prepared to meet with the staff to resolve any questions the staff might have. Should the NRC staff require additional information to support review of this application, please do not hesitate to contact Mr. Glenn Mathues at 410-910-6538, or by email at Glenn.Mathues@orano.group.

Sincerely,

A. Prakash

Prakash Narayanan
Chief Technical Officer

cc: Chris Jacobs (NRC), Senior Project Manager, Storage and Transportation Licensing Branch, Division of Fuel Management

Enclosures:

1. Affidavit Pursuant to 10 CFR 2.390
2. RSIs and Responses (Proprietary)
3. RSIs and Responses (Public)
4. List of New CoC 1042 Amendment 4, Revision 2 Technical Specification Changes and Justifications
5. List of Changed TS and UFSAR Pages Involved in CoC 1042 Amendment 4, Revision 2
6. Proposed Technical Specifications, CoC 1042 Amendment 4, Revision 2
7. CoC 1042 Amendment 4, Revision 2 UFSAR Changed Pages (Proprietary)
8. CoC 1042 Amendment 4, Revision 2 UFSAR Changed Pages (Public)
9. Supporting Calculations (Proprietary)

AFFIDAVIT PURSUANT TO 10 CFR 2.390

TN Americas LLC)
State of Maryland) SS.
County of Howard)

I, Prakash Narayanan, depose and say that I am Chief Technical Officer of TN Americas LLC, duly authorized to execute this affidavit, and have reviewed or caused to have reviewed the information that is identified as proprietary and referenced in the paragraph immediately below. I am submitting this affidavit in conformance with the provisions of 10 CFR 2.390 of the Commission's regulations for withholding this information.

The information for which proprietary treatment is sought is contained in the following enclosures, as listed below:

- Enclosure 2 – RSIs and Responses
- Enclosure 7 – Portions of certain updated final safety analysis report (UFSAR) chapters
- Enclosure 9 – Supporting Calculations

These documents have been appropriately designated as proprietary.

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

Pursuant to the provisions of paragraph (b) (4) of Section 2.390 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure, included in the above referenced document, should be withheld.

1) The information sought to be withheld from public disclosure involves portions of certain RSI responses, portions of the UFSAR, and supporting calculations, all related to the design of the NUHOMS® EOS System, which are owned and have been held in confidence by TN Americas LLC, or were provided in confidence to TN Americas LLC and have been held in confidence.

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

3) Public disclosure of the information is likely to cause substantial harm to the competitive position of TN Americas LLC, because the information consists of descriptions of the design and analysis of dry spent fuel storage systems, the application of which provide a competitive economic advantage. The availability of such information to competitors would enable them to modify their product to better compete with TN Americas LLC, take marketing or other actions to improve their product's position or impair the position of TN Americas LLC's product, and avoid developing similar data and analyses in support of their processes, methods, or apparatus.

Further the deponent sayeth not.

A. Prakash
Prakash Narayanan
Chief Technical Officer, TN Americas LLC

Subscribed and sworn before me this 20th day of June 2023.

Notary Public

My Commission Expires 03/04/2024

SHAWN ROBERT STAUB
NOTARY PUBLIC
COMM. EXP. MARCH 09, 2024
FREDERICK COUNTY, MD

Enclosure 2 to E-62384

RSIs and Responses

(Proprietary)

Withheld Pursuant to 10 CFR 2.390

Proprietary Information on Pages 1 through 3
Withheld Pursuant to 10 CFR 2.390

RSI 3-2:

Provide descriptions of the basic installed configurations of an EOS-HSM-SC, e.g., single, one-row array, or two-row array that are documented in the SAR. Indicate in the SAR section 3.9.8 which HSM-SC configuration is being evaluated for each structural compliance check, noting whether that configuration bounds all possible configurations and a rationale behind these statements.

SAR and technical specification (TS) sections provide seemingly conflicting information regarding the expected installation configuration. This conflict creates doubt as to whether the most conservative configuration has been evaluated. A list of noted general conflicts follows: 1) TS sections 4.5.1 and 5.1.2.b only mention rear shield wall, 2) SAR section 1.1 mentions rear and end shear walls, but also states that empty interior modules can be employed in lieu of shield walls, 3) SAR section 1.2.1.3 mentions rear and end walls, but also states that end walls will be employed between modules, 4) SAR section 3.9.8.1 mentions rear and end walls. Furthermore, the stability analyses, (e.g., SAR sections 2.3.4, 3.6.2 and 3.9.7), seem to consider several different variations: a) one end wall is present, b) one end wall is present and reevaluation is performed omitting it, and c) end and rear walls are present.

This information is necessary to demonstrate compliance with 10 CFR 72.236(b), (d) and (l).

Original Response to RSI 3-2:

The HSM-SC, as with the HSM-RC, can be arranged either in a single-row array, or in back-to-back double row arrays. In either configuration, end shield walls are installed at each end of a module array to provide the required missile and shielding protection. During installation, however, two or more empty modules can be substituted for the end walls until the array is fully built. Because of this allowance, end shield walls are omitted from TS Section 4.5.1. The “thick concrete side walls between EOS-HSMs” described in UFSAR Section 1.2.1.3 refer to the wall of the HSM base itself, not end (side) shield walls. Independent side shield walls are generally not installed between modules within a given array. However, in certain instances, where the complete array is not built in one phase, the general licensees may prefer to install an end (side) wall in lieu of empty HSMs and complete the array later by adding HSMs at a later date. Only in single-row arrays are rear shield walls installed along the back of each module. There are no rear shield walls installed between modules of a back-to-back double row array.

All the structural analyses in UFSAR Section 3.9.8 consider an individual module as a conservative estimate of the response of the EOS-HSM-SC structural elements under the postulated static and dynamic loads for any EOS-HSM-SC array configuration. As with the HSM-RC structural analyses, the only checks that consider the shield walls are the tornado missile evaluation (end and rear shield walls), and stability checks (end shield wall only). It is clear that either end or rear shield walls may be subject to impacts from tornado missiles and, therefore, must be evaluated. Following the previously approved method of evaluation for the HSM-RC, all the stability evaluations in UFSAR Section 3.9.8.11 conservatively consider a single module with one end shield wall and ignore the rear shield wall and corner block because there never exists a freestanding, loaded HSM with nothing on either side.

UFSAR Section 2.3.4 has been revised to remove mention of stability evaluations with no shield wall, and instead state that the seismic stability response of a single, freestanding HSM with an end shield wall is considered.

Original Impact:

UFSAR Section 2.3.4 has been revised as described in the response.

Supplemental Response to RSI 3-2:

The original responses to RSI 3-2 incorrectly stated that ALL EOS-HSM-SC stability analyses considered only a single end shield wall. The evaluations of overturning due to tornado wind and missile impact, flood loads, and seismic loads conservatively consider a single end shield wall. The evaluations of sliding due to the same loads consider two end shield walls as the minimum configuration of a single HSM-SC, with the exception of the static sliding analysis due to seismic load, which is not sensitive to the weight of the HSM-SC or its contents. UFSAR Sections 2.3.1.2, 2.3.4, 3.9.7.1.8.1.4, 3.9.7.1.8.2.1, 3.9.7.1.8.2.2, 3.9.7.1.8.3.2, 3.9.8.7, 3.9.8.11.2, 3.9.8.11.3, 3.9.8.11.4, and 12.3.3 have been updated to reflect this.

UFSAR Section 3.6.2 has been updated to clarify that 135 kips DSC weight is considered for stress analyses, while stability analysis consider a range of DSC weights.

Calculation EOS01-0268 Revision 1, documenting the stability evaluation for the HSM-SC, is included in Enclosure 9 of this submittal.

Supplemental Impact:

UFSAR Sections 2.3.1.2, 2.3.4, 3.6.2, 3.9.7.1.8.1.4, 3.9.7.1.8.2.1, 3.9.7.1.8.2.2, 3.9.7.1.8.3.2, 3.9.8.7, 3.9.8.11.2, 3.9.8.11.3, 3.9.8.11.4, and 12.3.3 have been updated as described in the response.

Proprietary Information on Pages 6 and 7
Withheld Pursuant to 10 CFR 2.390

RSI 3-6:

Provide stability analysis information for the NUHOMS EOS HSM-SC and document in the SAR.

SAR section 3.9.8.11 addresses the stability analyses for tornado wind and missile impact, flood, seismic, and interaction with adjacent horizontal storage modules. The description of the stability analyses in this section references a corresponding analysis described in SAR section 3.9.7 for the NUHOMS EOS HSM-RC, often simply stating a resulting factor of safety for each analysis or that the HMS-RC results are bounding. Referencing the previous analysis may be sufficient to describe certain aspects of the analysis, such as the methodology, if they are identical to those used to analyze the HSM-SC. However, this approach does not highlight how aspects of the analysis that are unique to the HSM-SC (e.g., horizontal storage module (HSM) configuration and self-weight) are considered. It also does not document the numerical analysis results that form the basis of the reported factor of safety for each loading condition.

The staff notes that the design basis tornado wind and missile evaluation results presented in SAR section 3.9.8.11.2 show sliding occurring for a single HSM-SC. SAR section 3.9.8.11.5 states that the results are conservative when the interaction of adjacent modules is considered. Provide justification for not meeting the guidance provided in table 4-3 of NUREG-2215, which requires a safety factor of 1.1, and how this safety factor is met with a multi-module configuration.

SAR sections 2.3.4 and 3.9.8.9 reference CoC No. 1029 (for the Advanced NUHOMS Horizontal Modular Storage System) as the basis for the stability evaluation methodology employed for the HSM-SC dynamic analyses. The methodology is not easily identifiable by external reference and its content should appear in this SAR for configuration control purposes.

The information in SAR section 3.9.8.11 is insufficient for the staff to begin its review of the stability of the HSM-SC. The staff notes that section 4.5.4.1 of NUREG-2215 discusses the information necessary for the review of hand calculations like those typically used for stability analyses.

This information is necessary to demonstrate compliance with 10 CFR 72.236(b), (d) and (l).

Original Response to RSI 3-6:

The stability analyses performed for the HSM-SC are identical methodologically to those performed for the HSM-RC and detailed in UFSAR Section 3.9.7. There are no aspects of the stability analysis that are unique to the HSM-SC. The assumptions, load combinations, and configurations considered are the same except as noted in UFSAR Section 3.9.8.11.1. The only distinctions are numerical (weight, for example), but the same formulae presented in UFSAR Section 3.9.7.1.8 are applied to produce the factors of safety presented for the HSM-SC.

The cases that simply state that the HSM-RC analysis is bounding were not explicitly recalculated. Both the dynamic and time-dependent overturning analysis of tornado wind concurrent with massive missile impact loading performed for the HSM-RC resulted in a large safety factor (over 20 for the dynamic analysis, and over 6 for the time-dependent analysis). The interior and exterior dimensions of the HSM-SC compared to the HSM-RC are negligibly different, and the minimum HSM-SC weight accounting for the minimum concrete weight density is heavier compared to the HSM-RC. Similarly, the end shield wall used for the HSM-SC is considered similar in dimensions and weight to the end shield walls used for the HSM-RC. Finally, the maximum weight of the DSC for the HSM-SC is the same as used for the HSM-RC. The increased weight of the HSM-SC increases the stabilizing moment. The change in CG height of the HSM-SC compared to the HSM-RC is considered negligible. Due to the large safety factors calculated for these cases in the HSM-RC with the same methodology, it was concluded that the HSM-SC has similar safety factors and is therefore acceptable.

The value of 1.09 inches of sliding presented in UFSAR Section 3.9.8.11.2 represents a conservative theoretical maximum sliding case including a safety factor of 1.1 for a single HSM-SC module with one shield wall. In actual scenarios, this sliding distance could not be achieved because of energy absorption due to contact with the adjacent module as described in UFSAR Section 3.9.7.1.8.4 for the HSM-RC. Thus, the maximum displacement described in UFSAR Section 3.9.8.11.2 is conservative and bounding.

The statements in UFSAR Sections 2.3.4 and 3.9.8.9 that reference the CoC 1029 [1] dynamic analysis methodology concern the use of LS-DYNA for non-linear, dynamic seismic stability analyses of the HSM as described in Section 11.2.1.2.1 and Appendix B.11.2.1.2.1 of the CoC 1029 UFSAR. As discussed in response to RAI 3-1 for Amendment 0 to CoC 1042 [2], this is similar to the approach presented in Sections 2.3.4 and 3.9.4.9.2 of the UFSAR and Item 5 of Section 4.5.3 of Technical Specification for the HSM-RC wherein a provision for dynamic analyses has been provided if necessary. It is only the case that should such analyses be required to meet site specific requirements, and/or at sites where the response spectra at the base of the HSM are larger than analyzed herein, they must be performed in accordance with the previously accepted methodology documented in the CoC 1029 UFSAR utilizing the provisions of 10 CFR 72.48. As such, there is little reason to explicitly detail the methodology for analyses whose results are not presented in this UFSAR.

Reference:

1. Updated Final Safety Analysis Report for the Standardized Advanced NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel, Docket Number 72-1029, Revision 11.

2. Revision 4 to Application for Approval of the Spent Fuel Cask Design for the NUHOMS® EOS System, Response to Request for Additional Information (Docket No. 72-1042, TAC No. L25028) (ADAMS ML15364A505).

Original Impact:

No change as a result of this RSI.

Supplemental Response to RSI 3-6:

Additional analysis has been performed to validate the stability of the EOS-HSM-SC under concurrent tornado wind and massive missile impact loading. As was performed for the EOS-HSM-RC, a dynamic and time-dependent analysis were performed, and are documented in calculation EOS01-0268 Rev. 1, included in Enclosure 9 of this submittal.

The loaded EOS-HSM-SC rotates a maximum of 0.5 and 2.91 degrees for the dynamic and time-dependent analyses respectively. This is less than the 21.8 degrees required to overturn the module. UFSAR Section 3.9.8.11.2 has been revised to include these results.

Supplemental Impact:

UFSAR Section 3.9.8.11.2 has been updated as described in the response.

Proprietary Information on Pages 10 through 16
Withheld Pursuant to 10 CFR 2.390

RSI 3-8:

Provide information to support the HSM-SC global structural response to missile effects in SAR section 3.9.8.10.6.2, as follows:

a) Provide additional structural component input information, i.e., thickness and length.

b) Provide the rationale behind modifying the idealization of the HSM-SC end walls from a simply-supported plate model in SAR section 3.9.4.10.6.2 to a simply-supported beam in section 3.9.8.10.6.2.

c) Provide a summary of resulting ductility ratios for each component evaluated.

d) Clearly document in the appropriate sections of the SAR whether credit is taken for the presence of shield walls acting as missile barriers when evaluating the contiguous HSM-SC overpack structure for compliance with codes and regulations for missile loading effects.

e) Provide SAR Reference 3.9.8-12: Bechtel Corporation "Design Guide Number C-2.45 for Design of Structures for Tornado Missile Impact," revision 0, April 1982.

The global structural analysis for tornado missile effects in SAR section 3.9.8.10.6.2 relies on single degree-of-freedom response charts and methodology from the cited reference to determine ductility ratios for various structural components of the HSM-SC. The SAR description in this section points to section 3.9.4.10.6.2 for a description of the methodology, which does not identify the input parameters such as thicknesses or lengths of the structural components being considered in the evaluation. Thus, it is unclear whether the HSM-SC evaluation is based on the end and rear shield walls, or those of the contiguous HSM-SC overpack. Section 2.4.2.1 of Ingecid Calculation 00624IT004, Rev. 0, (included in application Enclosure 12) states that all HSM-SC walls except the front wall are considered as "interior" (as defined by the Code) due to the presence of shield walls. This statement implies that the majority of the contiguous HSM-SC walls are not affected by missile impacts, an assumption that was not found to be clearly stated in the body of the SAR. In either case, no rationale is provided for the difference in the end wall support conditions between the HSM-RC and HSM-SC sections, or why the magnitude of the tabulated results is so disparate. The resulting ductility ratios for each HSM-SC component evaluated are not presented in SAR section 3.9.8.10.6.2, thus it is not possible to verify that they are within acceptable Code-prescribed limits. The staff notes that section 4.5.4.1 of NUREG-2215 discusses the information necessary for the review of hand calculations like those employed to determine component ductility ratios. This additional information, as well as a copy of the cited reference, are required to proceed with the review of the HSM-SC global structural response from missile effects.

This information is necessary to demonstrate compliance with 10 CFR 72.236(b), (d) and (l).

Original Response to RSI 3-8:

Item a:

As noted in UFSAR Section 3.9.8.1, the configuration of the HSM-SC, in terms of component dimensions and thicknesses, is essentially the same as that of the HSMS-FPS-RC, and component overall dimensions are identified on UFSAR Drawing EOS01-3300-SAR. The following thicknesses are applicable for the HSM-SC:

- 44-inch thick roof

- 42-inch thick front wall
- 36-inch thick end shield wall
- 36-inch thick rear shield wall
- 31.5-inch thick shielding door

Item b:

The HSM-SC end shield wall was evaluated considering both the simply supported plate, and simply supported beam idealization models. Modeling the shield wall as a beam produced more conservative results, so the more conservative idealization is reported in UFSAR Section 3.9.8.10.6.2.

Item c:

Item d:

The structural response of each of the five components listed above is evaluated individually and independently of other components. These are the only components that may interface with missile loading. The side and back walls of the contiguous HSM-SC are not evaluated for missile loading since they are always blocked by either another module or a shield wall. Similarly, no credit is taken for the contiguous HSM-SC walls behind the shield walls in the evaluations of the rear and end shield walls other than as simple supports.

Item e:

Reference 1 is attached to this RSI response as Enclosure 10.

Reference:

1. Bechtel Corporation, "Design Guide Number C-2.45 for Design of Structures for Tornado Missile Impact," Revision 0, April 1982.

Original Impact:

No change as a result of this RSI.

Proprietary Information on Pages 19 and 20
Withheld Pursuant to 10 CFR 2.390

Complete tornado missile evaluations for the EOS-HSM-SC front wall, roof, end shield wall, and rear shield wall can be found in calculation EOS01-0265 Rev. 1 included in Enclosure 9 of this submittal. The same evaluation for the door can be found in calculation EOS01-0320 Rev. 1 also included in Enclosure 9.

Supplemental Impact:

UFSAR Sections 3.9.8.10.6, 3.9.8.10.6, and 3.9.8.10.6.2 have been updated as described in the response.

Table RSI 3-8-1: Summary of Component-Missile Interactions

Missile	Ratio	Front Wall	Roof (221″ Span)	Roof (194″ Span)	End Shield Wall (Modeled as a Plate)	End Shield Wall (Modeled as a Beam)	Rear Shield Wall	Door
Wooden Utility Pole	C_R	8.86	4.60	5.24	13.1	4.54	13.1	3.63
	C_T	3.72	0.662	0.859	1.11	0.583	2.80	10.74
	μ	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Artillery Shell	C_R	6.09	3.16	3.60	8.98	3.12	8.98	2.49
	C_T	0.648	0.115	0.15	0.194	0.102	0.488	1.87
	μ	<1.0	<0.35	<0.45	<0.60	<0.35	<1.0	<1.0
Schedule 40 Pipe(1)	C_R	4.36	2.26	2.58	6.43	2.23	6.43	1.78
	C_T	2.09	0.373	0.484	0.627	0.328	1.58	6.05
	μ	<0.70	<0.60	<0.65	<0.80	<0.55	<0.75	0.65
Schedule 40 Pipe(2)	C_R	3.36	1.75	1.99	4.96	1.72	4.96	1.38
	C_T	1.61	0.288	0.373	0.483	0.253	1.22	4.66
	μ	<0.70	0.50	0.60	<0.65	0.45	<0.80	0.85
Automobile	C_R	6.5	3.38	3.85	9.59	3.33	9.59	2.66
	C_T	16.7	2.97	3.85	4.99	2.62	12.5	48.16
	μ	<0.50	<0.50	<0.55	<0.55	<0.50	<0.50	<0.50

Notes:

(1) Interface forcing function derived per Section 2.3.2 of Bechtel Design Guide C-2.45.

(2) Interface forcing function derived by unmodified impulse momentum theorem as in Section 2.3.1 of Bechtel Design Guide C-2.45.

(3) C_R and C_T values are calculated, while μ is approximated based on response charts in Bechtel Design Guide C-2.45. See supplementary response for discussion.

(4) Interactions with $C_R > 2.0$ are concluded to have ductility ratios less than those corresponding to the calculated C_T and $C_R = 2.0$. The values presented are likely very conservative overestimates of the true ductility ratios. See supplementary response for discussion.

Proprietary Information on Pages 23 and 24
Withheld Pursuant to 10 CFR 2.390

References

1. Ingecid Calculation 00624IT004 Revision 0, “Optimized Design of the EOS-HSM Steel Plate Composite Structure.”
2. Ingecid Calculation 00624IT003 Revision 0, “Effect of the Partial Composite Action on the Flexure Stiffness of the SC Sections.”
3. Ingecid Calculation 00624IT005 Revision 0, “Structural Assessment of the Laboratory Testing results.”

Original Impact:

UFSAR Sections 3.9.8.6.1 has been revised as described in the response.

UFSAR Table 3.9.8-3 has been revised as described in the response.

Table RSI 3-9-1
Dimensions and Parameters of EOS-HSM-SC Structure Components

Proprietary Information on Pages 26 through 34
Withheld Pursuant to 10 CFR 2.390

RSI 3-10:

Provide information for the determination of structural acceptability of the ITS connecting items of the HSM-SC, including vertical rods, roof connection angle and bolts, and connections bolts for door, shield walls, and OVC, as follows:

a) Identify materials, design codes, and design load combinations for each item.

b) Provide bounding structural design load demands resulting from design load combinations for each component being evaluated.

c) Provide the structural capacities per the applicable design code.

d) Provide demand-to-capacity ratios for all connection components.

The staff notes that the materials specifications of some of the listed items are included in SAR table 8-2. It is also noted that demand-to-capacity ratios for the heat shield connectors are reported in SAR section 3.9.8.10.4, however, no indication of the design code, material strength or load combinations considered is provided. The information in SAR section 3.9.8 is insufficient for the staff to begin its review of the HSM-SC.

This information is necessary to demonstrate compliance with 10 CFR 72.236(b), (d) and (l).

Original Response to RSI 3-10:

All HSM-SC connections and embedments and the methodology employed for their design are identical to those for the HSM-RC design as described below. Note that the roof connection angles, bolts, and embedments are not-important-to-safety, as noted in response to RSI 3-4, and, therefore, are omitted from this response. **[**

]

The material for the vertical threaded rods connecting the upper and lower segments of the HSM-SC is ASTM A722 Gr 150. The material for all other fasteners and embedments, including the door, shield wall, outlet vent cover, and heat shield threaded rods is ASTM A193 Gr B7. The embedments are designed to the requirements of Appendix D of ACI 349-06, as referenced in Section N9.4.3 of AISC N690-18. The bolts and external threaded rod connections are designed in accordance with the AISC Manual of Steel Construction. The load combinations considered are the same as for the HSM-RC design as shown in UFSAR Table 3.9.4-5.

UFSAR Section 3.9.8.10.7 and Tables 3.9.8-5 and 3.9.8-6 have been added to include the requested bounding demands, capacities, and demand-to-capacity ratios for the HSM-SC connection components. UFSAR Section 3.9.8.12 has been updated to add ACI 349-06, Appendix D as Reference 3.9.8-13.

Original Impact:

UFSAR Sections 3.9.8.10.7 and 3.9.8.12, and Tables 3.9.8-5 and 3.9.8-6 have been added as described in the response.

Supplemental Response to RSI 3-10:

As in the EOS-HSM-RC the steel components of the EOS-HSM-SC; including the FPS DSC support structure, heat shields, and axial retainer; are designed in accordance with the AISC Specification for Structural Steel Buildings using the Allowable Strength Design (ASD) methodology. As stated in the original response to this RSI, the concrete embedments are designed to the requirements of Appendix D of ACI 349-06, whereas bolts and external threaded rod connections are designed in accordance with the AISC Specification for Structural Steel Buildings using the ASD methodology. These embedments and connecting items are subject to the same load combinations as the rest of the EOS-HSM-SC structure; that is those load combinations prescribed by ANSI 57.9 as detailed in UFSAR Table 2-7 for concrete and steel components, respectively. UFSAR Sections 3.9.8.3 and 3.9.8.10.7 have been updated to clarify the design methodology and load combinations. Calculation EOS01-0330 Revision 0 documenting the evaluation of connection bolts and embedments for the EOS-HSM-SC is included in Enclosure 9 of this submittal.

Drawing EOS01-3300-SAR has been updated to include the supplementary reinforcement at the locations where it is considered for the structural safety evaluation of the embedments.

The reference in UFSAR Sections 3.9.8.3 and 3.9.8.10.7 has been changed from AISC Manual of Steel Construction to AISC Specification for Structural Buildings, and the reference has been revised in UFSAR Section 3.9.8.12.

Supplemental Impact:

UFSAR Sections 3.9.8.3, 3.9.8.10.7, and 3.9.8.12 have been updated as described in the response.

UFSAR Drawing EOS01-3300-SAR has been updated as described in the response.

RSI 3-11:

Provide information in the SAR for the HSM-SC heat shield structural adequacy check, including determination of associated in-structure response spectra (ISRS).

SAR section 3.9.8.10.4 addresses the heat shield design for the HSM-SC, referring to HSM-RC section 3.9.4.10.4, stating that the design is identical. However, SAR section 3.9.8.9 explains that a modal time history analysis of the HSM-SC is performed to obtain ISRS for the heat shield support points. This statement implies that different ISRS than those for the heat shields of the HSM-RC, as presented in figures 3.9.4-16 to -21, are employed to determine the response of the heat shield plates and support bolts. Based on the resulting heat shield plate and bolt results presented in SAR section 3.9.8.10.4, it appears that the resulting load demands are in fact different than those for the HSM-RC. Additionally, the design code, materials and load combinations employed for the structural adequacy check of the plates and bolts are not identified in the SAR. The information in SAR section 3.9.8.10.4 is insufficient for the staff to begin its review of the HSM-SC heat shields.

This information is necessary to demonstrate compliance with 10 CFR 72.236(b), (d) and (l).

Original Response to RSI 3-11:

The heat shields and support bolts for the HSM-SC are identical in terms of dimensions, materials, quantity, design code, and applicable load combinations to those used in the HSM-FPS-RC, as described in UFSAR Section 3.9.8.10.4. As such, the modal frequencies and mass participation factors are also identical to those presented in SAR Table 3.9.4-24 and Table 3.9.4-25a. However, the HSM-SC module itself is certain to produce slightly different spectral accelerations at the heat shield mounting points than the HSM-RC. Therefore, to validate the adequacy of the existing heat shield design for implementation in the HSM-SC, the same method of evaluation used for the HSM-RC and detailed in UFSAR Section 3.9.4.9.2, is repeated to determine the ISRS of the HSM-SC at the heat shield support locations and resulting equivalent static loads. This difference in equivalent static load, which is a result of different responses within the HSM module rather than differences in the heat shields or supports themselves, explains the discrepancy in load demands between the HSM-SC and HSM-RC.

UFSAR Figures 3.9.8-5 through 3.9.8-10 have been added to present the ISRS at the side and roof heat shield support points for the HSM-SC. UFSAR Section 3.9.8.9 has been revised to reference these figures and provide clarity that heat shield design is unchanged between the HSM-SC and HSM-FPS-RC, but the design loads differ due to HSM response.

Original Impact:

UFSAR Figure 3.9.8-5 through Figure 3.9.8-10 have been added as described in the response.

UFSAR Section 3.9.8.9 has been revised as described in the response.

Supplemental Response to RSI 3-11:

As in the EOS-HSM-RC the heat shield plates and bolts of the EOS HSM-SC are designed in accordance with the AISC Specification for Structural Steel Buildings using the Allowable Strength Design (ASD) methodology. The heat shield plates and bolts are subject to the same load combinations as the rest of the EOS-HSM-SC structure; that is those load combinations prescribed by ANSI 57.9 as detailed in UFSAR Table 2-7 for steel components. Given that the concrete shields the heat shields from wind, missile and flood loading, the accident-earthquake load combination governs. UFSAR Section 3.9.8.5 has been updated to clarify the heat shield design methodology and load combinations. Calculation EOS01-0320 Rev. 1 documenting the evaluation of the heat shields for the EOS-HSM-SC is included in Enclosure 9 of this submittal.

Supplemental Impact:

UFSAR Section 3.9.8.5 has been updated as described in the response.

List of New CoC 1042 Amendment 4, Revision 2 Technical Specifications Changes and Justifications

Changed Technical Specifications (TS) Area and Page Number	Justification
Table of Contents, List of Tables, and List of Figures	Updated
Section 4.4.4, Page 4-13	As described in the response to the supplemental response for RSI 3-7, a section N9.1.1(c) has been added.
Section 4.4.4, Page 4-14	As described in the response to the supplemental response for RSI 3-7, a section N9.1.4.b(a) has been added.
Section 4.4.4, Page 4-14	As described in the response to the supplemental response for RSI 3-7, a section N9.1.4.b(b) has been added.
Section 4.4.4, Page 4-15	As described in the response to the supplemental response for RSI 3-7, a section N9.1.7a(b) has been added.
Section 4.4.4, Page 4-15	As described in the response to the supplemental response for RSI 3-7, a section N9.3.6a has been added.

List of TS and UFSAR Pages
Involved in CoC 1042 Amendment 4, Revision 2

Technical Specifications Pages	
4-13	4-14
4-15	

UFSAR Pages and Drawing Sheets		
1-32	1-33	Drawing EOS01-3300-SAR (17 Sheets)
2-15	2-17	3-19
3-35	3.9.7-8	3.9.7-9
3.9.7-10	3.9.7-12	3.9.8-2
3.9.8-3	3.9.8-4	3.9.8-5
3.9.8-6	3.9.8-7	3.9.8-8
3.9.8-9	3.9.8-12	3.9.8-16
3.9.8-17	3.9.8-18	3.9.8-19
3.9.8-20	3.9.8-22	3.9.8-23
3.9.8-26	3.9.8-27	12-10

Enclosure 6 to E-62384

Proposed Technical Specifications, CoC 1042
Amendment 4, Revision 2

Revision 2 to Amendment 4 Proposed Technical Specifications

CoC 1042

APPENDIX A

NUHOMS® EOS SYSTEM GENERIC TECHNICAL SPECIFICATIONS

Amendment 4

List of Tables

List of Figures

1.0 USE AND APPLICATION

1.1 Definitions

-- NOTE --

The defined terms of this section appear in capitalized type and are applicable throughout these Technical Specifications and Bases.

Term	Definition
ACTIONS	ACTIONS shall be that part of a Specification that prescribes Required Actions to be taken under designated Conditions within specified Completion Times.
BLEU FUEL	Blended Low Enriched Uranium (BLEU) FUEL material is generated by down-blending high enriched uranium (HEU). Because the feedstock contains both unirradiated and irradiated HEU, fresh BLEU fuel has elevated concentrations of U-232, U-234, and U-236.
CONTROL COMPONENTS (CCs)	Authorized CCs include Burnable Poison Rod Assemblies (BPRAs), Thimble Plug Assemblies (TPAs), Control Rod Assemblies (CRAs), Control Element Assemblies (CEAs), Control Spiders, Rod Cluster Control Assemblies (RCCAs), Axial Power Shaping Rod Assemblies (APSRAs), Orifice Rod Assemblies (ORAs), Peripheral Power Suppression Assemblies (PPSAs), Vibration Suppression Inserts (VSIs), Flux Suppression Inserts (FSIs), Burnable Absorber Assemblies (BAAs), Neutron Source Assemblies (NSAs) and Neutron Sources. CCs not explicitly listed are also authorized as long as external materials are limited to zirconium alloys, nickel alloys, and stainless steels. Non-fuel hardware that are positioned within the fuel assembly after the fuel assembly is discharged from the core such as Guide Tubes or Instrument Tube Tie Rods or Anchors, Guide Tube Inserts, BPRA Spacer Plates or devices that are positioned and operated within the fuel assembly during reactor operation such as those listed above are also considered to be authorized CCs.

(continued)

1.1 Definitions (continued)

DAMAGED FUEL	DAMAGED FUEL assemblies are fuel assemblies containing fuel rods with known or suspected cladding defects greater than hairline cracks or pinhole leaks. The extent of damage in the fuel assembly, including non-cladding damage, is to be limited so that a fuel assembly maintains its configuration for normal and off-normal conditions. The extent of cladding damage is also limited so that no release of pellet material is observed during inspection and handling operations in the pool prior to loading operations. DAMAGED FUEL assemblies shall also contain top and bottom end fittings. DAMAGED FUEL assemblies may also contain missing or partial fuel rods.
DRY SHIELDED CANISTER (DSC)	An EOS-37PTH DSC, EOS-89BTH DSC, and 61BTH Type 2 DSC are sealed containers that provide confinement of fuel in an inert atmosphere.
FAILED FUEL	FAILED FUEL is defined as ruptured fuel rods, severed fuel rods, loose fuel pellets, fuel fragments, or fuel assemblies that may not maintain configuration for normal or off-normal conditions. FAILED FUEL may contain breached rods, grossly breached rods, or other defects such as missing or partial rods, missing grid spacers, or damaged spacers to the extent that the assembly may not maintain configuration for normal or off-normal conditions. FAILED FUEL shall be stored in a failed fuel canister (FFC).
FUEL BUILDING	The FUEL BUILDING is the site-specific area or facility where the LOADING OPERATIONS take place.
FUEL CLASS	A FUEL CLASS includes fuel assemblies of the same array size for a particular type of fuel design. For example, WEV 17x17, WEO 17x17, and ANP Advanced MK BW 17x17 fuel assemblies are part of a WE 17x17 FUEL CLASS.

(continued)

1.1 Definitions (continued)

HORIZONTAL STORAGE MODULE (HSM)	An HSM is a reinforced concrete structure for storage of a loaded DSC at a spent fuel storage installation. Where the term "HSM" is used without distinction, this term shall apply to both the EOS-HSM and HSM-MX. The term EOS-HSM refers to the base unit for storage of a single DSC as a single piece (EOS-HSM) or as a split base (EOS-HSMS). The term MATRIX (HSM-MX) refers to the two-tiered staggered structure for storage of the DSCs.
INDEPENDENT SPENT FUEL STORAGE INSTALLATION (ISFSI)	The facility within a perimeter fence licensed for storage of spent fuel within HSMs.
INTACT FUEL	Fuel assembly with no known or suspected cladding defects in excess of pinhole leaks or hairline cracks, and with no missing rods.
LOADING OPERATIONS	LOADING OPERATIONS include all licensed activities on a DSC in a TC while it is being loaded with fuel assemblies. LOADING OPERATIONS begin when the first fuel assembly is placed in the DSC and end when the TC is ready for TRANSFER OPERATIONS (i.e., when the cask is in a horizontal position on the transfer trailer.) LOADING OPERATIONS do not include DSC transfer between the TC and the HSM.
LOW-ENRICHED OUTLIER FUEL (LEOF)	LOW-ENRICHED OUTLIER FUEL is PWR and BWR fuel with enrichments below the minimum enrichment specified in Table 7A and Table 18, respectively.
RECONSTITUTED FUEL ASSEMBLY	A RECONSTITUTED FUEL ASSEMBLY is a fuel assembly where one or more fuel rods are replaced by low enriched uranium or natural uranium fuel rods or non-fuel rods.

(continued)

1.1 Definitions (continued)

STORAGE OPERATIONS	STORAGE OPERATIONS include all licensed activities that are performed at the ISFSI, while a DSC containing fuel assemblies is located in an HSM on the storage pad within the ISFSI perimeter. STORAGE OPERATIONS do not include DSC transfer between the TC and the HSM.
TRANSFER CASK (TC)	A TRANSFER CASK (TC) (EOS-TC108, EOS-TC125, EOS-TC135, and OS197/OS197H/OS197FC-B/OS197HFC-B) consists of a licensed NUHOMS® System TC. When used without distinction, the term EOS-TC includes the EOS-TC108, EOS-TC125, and EOS-TC135. The term OS197 includes the OS197/OS197H/OS197FC-B/OS197HFC-B. The TC is placed on a transfer trailer for movement of a DSC to the HSM.
TRANSFER OPERATIONS	TRANSFER OPERATIONS include all licensed activities involving the movement of a TC loaded with a DSC containing fuel assemblies. TRANSFER OPERATIONS begin after the TC has been placed horizontal on the transfer trailer ready for TRANSFER OPERATIONS and end when the DSC is at its destination and/or no longer horizontal on the transfer trailer. TRANSFER OPERATIONS include DSC transfer between the TC and the HSM.
UNLOADING OPERATIONS	UNLOADING OPERATIONS include all licensed activities on a DSC to unload fuel assemblies. UNLOADING OPERATIONS begin when the DSC is no longer horizontal on the transfer trailer and end when the last fuel assembly has been removed from the DSC. UNLOADING OPERATIONS do not include DSC transfer between the HSM and the TC.

1.0 USE AND APPLICATION

1.2 Logical Connectors

PURPOSE

The purpose of this section is to explain the meaning of logical connectors.

Logical connectors are used in Technical Specifications (TS) to discriminate between, and yet connect, discrete Conditions, Required Actions, Completion Times, Surveillances, and Frequencies. The only logical connectors that appear in TS are <u>AND</u> and <u>OR</u>. The physical arrangement of these connectors constitutes logical conventions with specific meanings.

BACKGROUND

Several levels of logic may be used to state Required Actions. These levels are identified by the placement (or nesting) of the logical connectors and by the number assigned to each Required Action. The first level of logic is identified by the first digit of the number assigned to a Required Action and the placement of the logical connector in the first level of nesting (i.e., left justified with the number of the Required Action). The successive levels of logic are identified by additional digits of the Required Action number and by successive indentions of the logical connectors.

When logical connectors are used to state a Condition, Completion Time, Surveillance, or Frequency, only the first level of logic is used, and the logical connector is left justified with the statement of the Condition, Completion Time, Surveillance, or Frequency.

EXAMPLES

The following examples illustrate the use of logical connectors:

<u>EXAMPLE 1.2-1</u>

ACTIONS:

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. LCO (Limiting Condition for Operation) not met.	A.1 Verify… <u>AND</u> A.2 Restore…	

In this example the logical connector <u>AND</u> is used to indicate that when in Condition A, both Required Actions A.1 and A.2 must be completed.

(continued)

1.2 Logical Connectors (continued)

EXAMPLES (continued)

EXAMPLE 1.2-2

ACTIONS:

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. LCO not met.	A.1 Stop… OR A.2 A.2.1 Verify… AND A.2.2 A.2.2.1 Reduce… OR A.2.2.2 Perform… OR A.3 Remove…	

This example represents a more complicated use of logical connectors. Required Actions A.1, A.2, and A.3 are alternative choices, only one of which must be performed as indicated by the use of the logical connector OR and the left justified placement. Any one of these three Actions may be chosen. If A.2 is chosen, then both A.2.1 and A.2.2 must be performed as indicated by the logical connector AND. Required Action A.2.2 is met by performing A.2.2.1 or A.2.2.2. The indented position of the logical connector OR indicates that A.2.2.1 and A.2.2.2 are alternative choices, only one of which must be performed.

1.0 USE AND APPLICATION

1.3 Completion Times

PURPOSE	The purpose of this section is to establish the Completion Time convention and to provide guidance for its use.
BACKGROUND	Limiting Conditions for Operation (LCOs) specify the lowest functional capability or performance levels of equipment required for safe operation of the facility. The ACTIONS associated with an LCO state Conditions that typically describe the ways in which the requirements of the LCO are not met. Specified with each stated Condition are Required Action(s) and Completion Times(s).
DESCRIPTION	The Completion Time is the amount of time allowed for completing a Required Action. It is referenced to the time of discovery of a situation (e.g., equipment or variable not within limits) that requires entering an ACTIONS Condition unless otherwise specified, providing the facility is in a specified condition stated in the Applicability of the LCO. Required Actions must be completed prior to the expiration of the specified Completion Time. An ACTIONS Condition remains in effect and the Required Actions apply until the Condition no longer exists or the facility is not within the LCO Applicability. Once a Condition has been entered, subsequent subsystems, components, or variables expressed in the Condition, discovered to be not within limits, will <u>not</u> result in separate entry into the Condition unless specifically stated. The Required Actions of the Condition continue to apply to each additional failure, with Completion Times based on initial entry into the Condition.
EXAMPLES	The following examples illustrate the use of Completion Times with different types of Conditions and Changing Conditions.

EXAMPLE 1.3-1

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
B. Required Action and associated Completion Time not met.	B.1 Perform Action B.1 AND B.2 Perform Action B.2	12 hours 36 hours

(continued)

1.3 Completion Times (continued)

EXAMPLES (continued)

Condition B has two Required Actions. Each Required Action has its own separate Completion Time. Each Completion Time is referenced to the time that Condition B is entered.

The Required Actions of Condition B are to complete action B.1 within 12 hours AND complete action B.2 within 36 hours. A total of 12 hours is allowed for completing action B.1 and a total of 36 hours (not 48 hours) is allowed for completing action B.2 from the time that Condition B was entered. If action B.1 is completed within 6 hours, the time allowed for completing action B.2 is the next 30 hours because the total time allowed for completing action B.2 is 36 hours.

EXAMPLES

EXAMPLE 1.3-2

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One system not within limit.	A.1 Restore system to within limit.	7 days
B. Required Action and associated Completion Time not met.	B.1 Perform Action B.1.	12 hours
	AND	
	B.2 Perform Action B.2.	36 hours

When a system is determined to not meet the LCO, Condition A is entered. If the system is not restored within 7 days, Condition B is also entered and the Completion Time clocks for Required Actions B.1 and B.2 start. If the system is restored after Condition B is entered, Condition A and B are exited, and therefore, the Required Actions of Condition B may be terminated.

(continued)

1.3 Completion Times (continued)

EXAMPLES
(continued)

EXAMPLE 1.3-3

ACTIONS

--NOTE--

Separate Condition entry is allowed for each component.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. LCO not met.	A.1 Restore compliance with LCO.	4 hours
B. Required Action and associated Completion Time not met.	B.1 Perform Action B.1.	6 hours
	AND	
	B.2 Perform Action B.2.	12 hours

The Note above the ACTIONS Table is a method of modifying how the Completion Time is tracked. If this method of modifying how the Completion Time is tracked was applicable only to a specific Condition, the Note would appear in that Condition rather than at the top of the ACTIONS Table.

The Note allows Condition A to be entered separately for each component, and Completion Times tracked on a per component basis. When a component is determined to not meet the LCO, Condition A is entered and its Completion Time starts. If subsequent components are determined to not meet the LCO, Condition A is entered for each component and separate Completion Times start and are tracked for each component.

IMMEDIATE COMPLETION TIME

When "Immediately" is used as a Completion Time, the Required Action should be pursued without delay and in a controlled manner.

1.0 USE AND APPLICATION

1.4 Frequency

PURPOSE

The purpose of this section is to define the proper use and application of Frequency requirements

---

DESCRIPTION

Each Surveillance Requirement (SR) has a specified Frequency in which the Surveillance must be met in order to meet the associated Limiting Condition for Operation (LCO). An understanding of the correct application of the specified Frequency is necessary for compliance with the SR.

The "specified Frequency" is referred to throughout this section and each of the Specifications of Section 3.0, Limiting Condition for Operation (LCO) and Surveillance Requirement (SR) Applicability. The "specified Frequency" consists of the requirements of the Frequency column of each SR, as well as certain Notes in the Surveillance column that modify performance requirements.

Situations where a Surveillance could be required (i.e., its Frequency could expire), but where it is not possible or not desired that it be performed until sometime after the associated LCO is within its Applicability, represent potential SR 3.0.4 conflicts. To avoid these conflicts, the SR (i.e., the Surveillance or the Frequency) is stated such that it is only "required" when it can be and should be performed. With a SR satisfied, SR 3.0.4 imposes no restriction.

(continued)

1.4 Frequency (continued)

EXAMPLES

The following examples illustrate the various ways that Frequencies are specified:

EXAMPLE 1.4-1

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
Verify pressure within limit.	12 hours

Example 1.4-1 contains the type of SR most often encountered in the Technical Specifications (TS). The Frequency specifies an interval (12 hours) during which the associated Surveillance must be performed at least one time. Performance of the Surveillance initiates the subsequent interval. Although the Frequency is stated as 12 hours, an extension of the time interval to 1.25 times the stated Frequency is allowed by SR 3.0.2 for operational flexibility. The measurement of this interval continues at all times, even when the SR is not required to be met per SR 3.0.1 (such as when the equipment is determined to not meet the LCO, a variable is outside specified limits, or the unit is outside the Applicability of the LCO). If the interval specified by SR 3.0.2 is exceeded while the facility is in a condition specified in the Applicability of the LCO, the LCO is not met in accordance with SR 3.0.1.

If the interval as specified by SR 3.0.2 is exceeded while the facility is not in a condition specified in the Applicability of the LCO for which performance of the SR is required, the Surveillance must be performed within the Frequency requirements of SR 3.0.2 prior to entry into the specified condition. Failure to do so would result in a violation of SR 3.0.4.

(continued)

1.4 Frequency (continued)

EXAMPLES (continued)

EXAMPLE 1.4-2

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
Verify flow is within limits.	Once within 12 hours prior to starting activity AND 24 hours thereafter

Example 1.4-2 has two Frequencies. The first is a one-time performance Frequency, and the second is of the type shown in Example 1.4-1. The logical connector "AND" indicates that both Frequency requirements must be met. Each time the example activity is to be performed, the Surveillance must be performed prior to starting the activity.

The use of "once" indicates a single performance will satisfy the specified Frequency (assuming no other Frequencies are connected by "AND"). This type of Frequency does not qualify for the 25% extension allowed by SR 3.0.2.

"Thereafter" indicates future performances must be established per SR 3.0.2, but only after a specified condition is first met (i.e., the "once" performance in this example). If the specified activity is canceled or not performed, the measurement of both intervals stops. New intervals start upon preparing to restart the specified activity.

(continued)

1.4 Frequency (continued)

EXAMPLES
(continued)

EXAMPLE 1.4-3

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
------------------- NOTE -------------------- Not required to be met until 96 hours after verifying the helium leak rate is within limit. ---	
Verify EOS DSC vacuum drying pressure is within limit.	Once after verifying the helium leak rate is within limit.

As the Note modifies the required performance of the Surveillance, it is construed to be part of the “specified Frequency.” Should the vacuum drying pressure not be met immediately following verification of the helium leak rate while in LOADING OPERATIONS, this Note allows 96 hours to perform the Surveillance. The Surveillance is still considered to be performed within the “specified Frequency.”

Once the helium leak rate has been verified to be acceptable, 96 hours, plus the extension allowed by SR 3.0.2, would be allowed for completing the Surveillance for the vacuum drying pressure. If the Surveillance was not performed within this 96 hour interval, there would then be a failure to perform the Surveillance within the specified Frequency, and the provisions of SR 3.0.3 would apply.

2.0 FUNCTIONAL AND OPERATING LIMITS

2.1 Fuel to be Stored in the EOS-37PTH DSC

PHYSICAL PARAMETERS:	
FUEL CLASS	Unconsolidated B&W 15x15, WE 14x14, WE 15x15, WE 17x17, CE 14x14, CE 15x15 and CE 16x16 FUEL CLASS PWR fuel assemblies (with or without CCs) that are enveloped by the fuel assembly design characteristics listed in Table 1.
Number of FUEL ASSEMBLIES with CCs	≤ 37
Maximum *Fuel* Assembly plus CC Weight	1900 lbs
DAMAGED FUEL ASSEMBLIES:	
Number and Location of DAMAGED FUEL Assemblies	Maximum of 8 DAMAGED FUEL Assemblies. Balance may be INTACT FUEL, empty *cells*, or dummy assemblies. Number and Location of DAMAGED FUEL assemblies are shown in Figures 1F, 1H, and 1K*, and 13*. The DSC basket cells which store DAMAGED FUEL assemblies are provided with top and bottom end caps.
FAILED FUEL:	
Number and Location of FAILED FUEL	Maximum of 4 FAILED FUEL locations. Balance may be INTACT FUEL assemblies, empty *cells*, or dummy assemblies. Number and Location of FAILED FUEL assemblies are shown in Figures 1F, 1H, and 1K*, and 13*. FAILED FUEL shall be stored in a failed fuel canister (FFC).
Maximum Uranium Loadings per FFC for FAILED FUEL	Per Table 2
RECONSTITUTED FUEL ASSEMBLIES:	
- *Limits for transfer in the EOS-TC125/135 AND storage in the EOS-HSM*	*Per Table 24*
- *Limits for transfer in the EOS-TC125/135 AND storage in the HSM-MX*	*≤ 37 RECONSTITUTED FUEL ASSEMBLIES per DSC with a minimum cooling time of 2 years*
- *Limits for transfer in the EOS-TC108*	*Per Table 25*

(continued)

2.1 Fuel to be Stored in the EOS-37PTH DSC (continued)

<u>BLENDED LOW ENRICHED URANIUM (BLEU) FUEL Assemblies:</u>	
• Number of BLEU FUEL Assemblies per DSC	≤ 37
<u>THERMAL PARAMETERS:</u>	
Maximum Heat Load Configuration (MHLC) and Decay Heat Calculations	*Per Figures 1B, 1C, 1D, 1E AND 1F for transfer in the EOS-TC108 and storage in EOS-HSM.* *Per Figures 1G, 1H AND 1I for transfer in the EOS-TC108 /TC125/TC135 and storage in HSM-MX.* *Per Figure 1K for transfer in the EOS-TC108 and storage in HSM-MX.* *Per Figure 12, which specifies maximum allowable heat loads in a six-zone configuration, for transfer in the EOS-TC125/TC135 and storage in the EOS-HSM.* *Heat load zoning configurations (HLZCs) enveloped by the MHLC in Figure 12 are allowed for transfer in the EOS-TC125/TC135 and storage in the EOS-HSM. Chapter 2, Section 2.4.3.2 of the UFSAR provides the specific HLZCs.* The maximum allowable heat loads may be reduced based on the thermal analysis methodology in the UFSAR *to accommodate site-specific conditions*. However, the maximum decay heat for each FA shall not exceed the values specified in the aforementioned figures. The licensee is responsible for ensuring that uncertainties in fuel enrichment and burnup are correctly accounted for in the decay heat calculations.

(continued)

2.1 Fuel to be Stored in the EOS-37PTH DSC (continued)

*THERMAL PARAMETERS* *(continued)*	For FAs with active fuel length shorter than 144 inches, reduce the maximum heat load per FA in each loading zone of the HLZCs using a scaling factor (SF) as shown below. $q_{Short\ FA} = q_{Bounding\ FA} \cdot SF,$ $SF = \frac{L_{a,Short\ FA}}{L_{a,Bounding\ FA}} \cdot \frac{k_{eff,Short\ FA}}{k_{eff,Bounding\ FA}}.$ Where, k_{eff}= Effective conductivity for FA, q = Decay heat load per assembly defined for each loading zone, L_a= Active fuel length, SF= Scaling factor (SF) for short FAs. The effective conductivity for the shorter FA should be determined using the same methodology documented in the UFSAR. For FAs with active fuel length greater than 144 inches, no scaling is required and the maximum heat loads listed for each HLZC are applicable.
Decay Heat per DSC	≤ 50.0 kW and as specified for the applicable heat load zone configuration

(continued)

2.1 Fuel to be Stored in the EOS-37PTH DSC (continued)

RADIOLOGICAL PARAMETERS:	
Maximum Assembly Average Burnup	62 GWd/MTU
Minimum Cooling Time	*For all fuel to be stored in the HSM-MX, minimum cooling time as a function of burnup and enrichment per Table 7B.* *For all fuel to be stored in the EOS-HSM, minimum cooling time as a function of burnup and enrichment per Table 7C.* *1 year for the EOS-TC125/135* *2 years for the EOS-TC108*
Minimum Assembly Average Initial Fuel Enrichment	As specified in Table 7A as a function of assembly average burnup.
Maximum Planar Average Initial Fuel Enrichment	As specified in Table 4 as a function of minimum soluble boron concentration
Minimum B-10 Concentration in Poison Plates	As specified in Table 5
Number and location of LOW-ENRICHED OUTLIER FUEL (LEOF)	≤ 4 LEOF in the peripheral locations. A minimum of three non-LEOFs shall circumferentially separate LEOFs within the peripheral locations. No limitation for LEOF in the inner locations. The peripheral and inner locations are defined in Figure 3.
CONTROL COMPONENTS (CCs)	
Maximum Co-60 equivalent activity for the CCs.	As specified in Table 3

2.0 FUNCTIONAL AND OPERATING LIMITS

2.2 Fuel to be Stored in the EOS-89BTH DSC

PHYSICAL PARAMETERS: FUEL CLASS	INTACT unconsolidated 7x7, 8x8, 9x9, 10x10, and 11x11 FUEL CLASS BWR assemblies (with or without channels) that are enveloped by the fuel assembly design characteristics listed in Table 6.
NUMBER OF INTACT FUEL ASSEMBLIES	≤ 89
Channel Hardware	Channeled fuel may be stored with or without associated channel hardware.
Maximum Uranium Loading	198 kg/assembly
Maximum *Fuel* Assembly Weight with a Channel	705 lb
RECONSTITUTED FUEL ASSEMBLIES:	
• Limits for transfer in the EOS-TC125	Per Table 22
• Limits for transfer in the EOS-TC108	Per Table 23
BLENDED LOW ENRICHED URANIUM (BLEU) FUEL ASSEMBLIES:	
• Number of BLEU FUEL Assemblies per DSC	≤ 89

(continued)

2.2 Fuel to be Stored in the EOS-89BTH DSC (continued)

THERMAL PARAMETERS:	
Maximum Heat Load Configuration (MHLC) and Decay Heat Calculations	Per Figure 2 for transfer in the EOS-TC108. Per Figure 11, which specifies maximum allowable heat loads in a six-zone configuration, for transfer in the EOS-TC125. Heat load zoning configurations (HLZCs) enveloped by the MHLC in Figure 11 are allowed for transfer in the EOS-TC125 and storage in the EOS-HSM or HSM-MX. Chapter 2, Section 2.4.3.2 of the UFSAR provides the specific HLZCs. The maximum allowable heat loads may be reduced based on the thermal analysis methodology in the UFSAR. However, the maximum decay heat for each FA shall not exceed the values specified in Figure 11. The licensee is responsible for ensuring that uncertainties in fuel enrichment and burnup are correctly accounted for in the decay heat calculations. For FAs with active fuel length shorter than 144 inches, reduce the maximum decay heat for each FA in each loading zone of the HLZCs using a scaling factor (SF) as shown below. $q_{Short\ FA} = q_{Bounding\ FA} \cdot SF,$ $SF = \frac{L_{a,Short\ FA}}{L_{a,Bounding\ FA}} \cdot \frac{k_{eff,Short\ FA}}{k_{eff,Bounding\ FA}}.$ Where, k_{eff} = Effective conductivity for FA, q = Decay heat load per assembly defined for each loading zone, L_a = Active fuel length, SF = Scaling factor for short FAs. The effective conductivity for the shorter FA should be determined using the same methodology documented in the UFSAR. For FAs with active fuel length greater than 144 inches, no scaling is required and the maximum heat loads listed for each HLZC are applicable.
Decay Heat per DSC	≤ 48.2 kW for EOS-TC125 ≤ 41.6 kW for EOS-TC108

(continued)

2.2 Fuel to be Stored in the EOS-89BTH DSC continued)

RADIOLOGICAL PARAMETERS:	
Maximum Assembly Average Burnup	62 GWd/MTU
Minimum Cooling Time	As specified as a function of burnup and enrichment per Table 21. 1.0 year for EOS-TC125 3.0 years for EOS-TC108; See Figure 2 for additional cooling times for HLZC 2 and 3 transferred in the EOS-TC108.
Maximum Lattice Average Initial Fuel Enrichment	Per Table 8
Minimum B-10 Concentration in Poison Plates	Per Table 8
Minimum Assembly Average Initial Fuel Enrichment	As specified in Table 18 as a function of assembly average burnup.
Number and location of LOW-ENRICHED OUTLIER FUEL (LEOF)	≤ 4 LEOF in the peripheral locations. A minimum of six non-LEOFs shall circumferentially separate LEOFs within the peripheral locations. No limitation for LEOF in the inner locations. The peripheral and inner locations are defined in Figure 8.

2.0 FUNCTIONAL AND OPERATING LIMITS

2.3 Fuel to be stored in the 61BTH Type 2 DSC

PHYSICAL PARAMETERS:	
FUEL CLASS	INTACT or DAMAGED or FAILED 7x7, 8x8, 9x9, 10x10 or 11x11 BWR assemblies (with or without channels) that are enveloped by the fuel assembly design characteristics listed in Table 13
Number of INTACT FUEL ASSEMBLIES	≤ 61
Channel Hardware	Chaneled fuel may be stored with or without associated channel hardware.
Maximum Uranium Loading	198 kg/ assembly
Maximum *Fuel* Assembly Weight with a Channel	705 lbs
DAMAGED FUEL ASSEMBLIES:	
Number and Location of DAMAGED FUEL Assemblies	Maximum of 61 DAMAGED FUEL assemblies as shown in Figure 5. Balance may be INTACT FUEL, empty *cells*, or dummy assemblies. The DSC basket cells which store DAMAGED FUEL assemblies are provided with top and bottom end caps.
FAILED FUEL:	
Number and Location of FAILED FUEL	Maximum of 4 FAILED FUEL locations as shown in Figure 5 Balance may be INTACT FUEL assemblies, empty *cells*, or dummy assemblies. FAILED FUEL shall be stored in a failed fuel canister (FFC)
Maximum Uranium Loadings per FFC for FAILED FUEL	Table 14
RECONSTITUTED FUEL ASSEMBLIES:	
• Number of RECONSTITUTED FUEL ASSEMBLIES per DSC	≤ 61
• Maximum number of irradiated stainless steel rods per DSC	120

(continued)

• Maximum number of irradiated stainless steel rods per RECONSTITUTED FUEL ASSEMBLY	10
• Loading restrictions for locations within the basket	Inner and peripheral loading locations are defined in Figure 6. Inner Loading Locations: • RECONSTITUTED FUEL ASSEMBLIES may be loaded in any compartment within the inner locations. Peripheral Loading Locations: • RECONSTITUTED FUEL ASSEMBLIES with ≤ 5 irradiated stainless steel rods per fuel assembly may be loaded into all peripheral locations (i.e., not restricted). • RECONSTITUTED FUEL ASSEMBLIES with > 5 and ≤ 10 irradiated stainless steel rods per fuel assembly shall have at least one fuel assembly that does not contain irradiated stainless steel rods on each peripherally adjacent location (see Figure 7).
<u>BLENDED LOW ENRICHED URANIUM (BLEU) FUEL Assemblies:</u>	
• Number of BLEU FUEL Assemblies per DSC	≤ 61
THERMAL/RADIOLOGICAL PARAMETERS:	
Heat Load Zone Configuration and Fuel Qualification	Limitations on decay heats are presented in the respective HLZC tables in Figures 4A through 4J.
Maximum Assembly Average Burnup	62 GWd/MTU
Minimum Cooling Time	For all fuel, minimum cooling time as a function of burnup and enrichment per Table 19. For the peripheral fuel of HLZC 2, 4, 5, 6, 7, and 8 only, minimum cooling time as a function of burnup and enrichment per Table 20. The peripheral and inner locations are defined in Figure 6.

(continued)

Minimum Assembly Average Initial Fuel Enrichment	As specified in Table 18 as a function of assembly average burnup.
Decay Heat per DSC	≤ 31.2 kW
Maximum Lattice Average Initial Enrichment	Per Table 9, Table 10, Table 11 or Table 12
Minimum B-10 Concentration in Poison Plates	Per Table 9, Table 10, Table 11 or Table 12
Number and location of LOW-ENRICHED OUTLIER FUEL (LEOF)	≤ 4 LEOF in the peripheral locations. A minimum of five non-LEOFs shall circumferentially separate LEOFs within the peripheral locations. No limitation for LEOF in the inner locations. The peripheral and inner locations are defined in Figure 6.

2.0 FUNCTIONAL OPERATING LIMITS

2.4 Functional and Operating Limits Violations

If any Functional and Operating Limit of 2.1 or 2.2 or 2.3 is violated, the following ACTIONS shall be completed:

2.4.1 The affected fuel assemblies shall be placed in a safe condition.

2.4.2 Within 24 hours, notify the NRC Operations Center.

2.4.3 Within 60 days, submit a special report which describes the cause of the violation and the ACTIONS taken to restore compliance and prevent recurrence.

3.0 LIMITING CONDITION FOR OPERATION (LCO) AND SURVEILLANCE REQUIREMENT (SR) APPLICABILITY

LIMITING CONDITION FOR OPERATION

LCO 3.0.1	LCOs shall be met during specified conditions in the Applicability, except as provided in LCO 3.0.2.
LCO 3.0.2	Upon discovery of a failure to meet an LCO, the Required Actions of the associated Conditions shall be met, except as provided in LCO 3.0.5. If the LCO is met or is no longer applicable prior to expiration of the specified Completion Time(s), completion of the Required Action(s) is not required, unless otherwise stated.
LCO 3.0.3	Not applicable to a spent fuel storage cask.
LCO 3.0.4	When an LCO is not met, entry into a specified condition in the Applicability shall not be made except when the associated ACTIONS to be entered permit continued operation in the specified condition in the Applicability for an unlimited period of time. This Specification shall not prevent changes in specified conditions in the Applicability that are required to comply with ACTIONS, or that are related to the unloading of a DSC. Exceptions to this Specification are stated in the individual Specifications. These exceptions allow entry into specified conditions in the Applicability when the associated ACTIONS to be entered allow operation in the specified condition in the Applicability only for a limited period of time.
LCO 3.0.5	Equipment removed from service or not in service in compliance with ACTIONS may be returned to service under administrative control solely to perform testing required to demonstrate it meets the LCO or that other equipment meets the LCO. This is an exception to LCO 3.0.2 for the system returned to service under administrative control to perform the testing required to demonstrate that the LCO is met.
LCO 3.0.6	Not applicable to a spent fuel storage cask.
LCO 3.0.7	Not applicable to a spent fuel storage cask.

(continued)

SURVEILLANCE REQUIREMENTS

SR 3.0.1	SRs shall be met during the specified conditions in the Applicability for individual LCOs, unless otherwise stated in the SR. Failure to meet a Surveillance, whether such failure is experienced during the performance of the Surveillance or between performances of the Surveillance, shall be failure to meet the LCO. Failure to perform a Surveillance within the specified Frequency shall be failure to meet the LCO except as provided in SR 3.0.3. Surveillances do not have to be performed on equipment or variables outside specified limits.
SR 3.0.2	The specified Frequency for each SR is met if the Surveillance is performed within 1.25 times the interval specified in the Frequency, as measured from the previous performance or as measured from the time a specified condition of the Frequency is met. For Frequencies specified as "once," the above interval extension does not apply. If a Completion Time requires periodic performance on a "once per . . ." basis, the above Frequency extension applies to each performance after the initial performance. Exceptions to this Specification are stated in the individual Specifications.
SR 3.0.3	If it is discovered that a Surveillance was not performed within its specified Frequency, then compliance with the requirement to declare the LCO not met may be delayed, from the time of discovery, up to 24 hours or up to the limit of the specified Frequency, whichever is less. This delay period is permitted to allow performance of the Surveillance. If the Surveillance is not performed within the delay period, the LCO must immediately be declared not met, and the applicable Condition(s) must be entered. When the Surveillance is performed within the delay period and the Surveillance is not met, the LCO must immediately be declared not met, and the applicable Condition(s) must be entered.
SR 3.0.4	Entry into a specified condition in the Applicability of an LCO shall not be made unless the LCO's Surveillances have been met within their specified Frequency. This provision shall not prevent entry into specified conditions in the Applicability that are required to comply with ACTIONS or that are related to the unloading of a DSC.

3.1 DSC Fuel Integrity

3.1.1 Fuel Integrity during Drying

LCO 3.1.1 Medium:

Helium shall be used for cover gas during drainage of bulk water (blowdown or draindown) from the DSC.

Pressure:

The DSC vacuum drying pressure shall be sustained at or below 3 Torr (3 mm Hg) absolute for a period of at least 30 minutes following evacuation.

APPLICABILITY: During LOADING OPERATIONS but before TRANSFER OPERATIONS.

ACTIONS:

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. If the required vacuum drying pressure cannot be obtained.	A.1	30 days
	A.1.1 Confirm that the vacuum drying system is properly installed. Check and repair the vacuum drying system as necessary. <u>OR</u>	
	A.1.2 Establish helium pressure of at least 0.5 atm and no greater than 15 psig in the DSC. <u>OR</u>	
	A.2 Flood the DSC with spent fuel pool water or water meeting the requirements of LCO 3.2.1, if applicable, submerging all fuel assemblies.	30 days

(continued)

3.1 DSC Fuel Integrity (continued)

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.1	Verify that the DSC vacuum drying pressure is less than or equal to 3 Torr (3 mm Hg) absolute for at least 30 minutes following evacuation.	Once per DSC, after an acceptable NDE of the inner top cover plate to DSC shell weld.

(continued)

3.1 DSC Fuel Integrity (continued)

3.1.2 DSC Helium Backfill Pressure

LCO 3.1.2 DSC helium backfill pressure shall be 2.5 ± 1 psig (stable for 30 minutes after filling) after completion of vacuum drying.

APPLICABILITY: During LOADING OPERATIONS but before TRANSFER OPERATIONS.

ACTIONS:

CONDITION	REQUIRED ACTION	COMPLETION TIME
---------------- NOTE ----------------- Not applicable until SR 3.1.2 is performed. --- A. The required backfill pressure cannot be obtained or stabilized.	A.1 A.1.1 Maintain helium atmosphere in the DSC cavity. AND A.1.2 Confirm, check and repair or replace as necessary the vacuum drying system, helium source and pressure gauge. AND A.1.3 Check and repair, as necessary, the seal weld between the inner top cover plate and the DSC shell.	30 days
	OR A.2 Establish the DSC helium backfill pressure to within the limit. If pressure exceeds the criterion, release a sufficient quantity of helium to lower the DSC cavity pressure within the limit. OR	30 days

(continued)

3.1 DSC Fuel Integrity (continued)

CONDITION	REQUIRED ACTION		COMPLETION TIME
	A.3	Flood the DSC with spent fuel pool water or water meeting the requirements of LCO 3.2.1, if applicable, submerging all fuel assemblies.	30 days

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.2	Verify that the DSC helium backfill pressure is 2.5 ± 1 psig stable for 30 minutes after filling.	Once per DSC, after the completion of SR 3.1.1 requirement.

(continued)

3.1 DSC Fuel Integrity (continued)

3.1.3 Time Limit for Completion of DSC Transfer

LCO 3.1.3 The time to transfer the DSC to the HSM shall be within the limits.

Additionally, if the DSC and HLZC combination result in a time limit for completion of transfer from the table below, the air circulation system shall be assembled and be verified to be operable within 7 days before commencing the TRANSFER OPERATIONS of the loaded DSC.

DSC MODEL	APPLICABLE HLZC	TIME LIMITS (HOURS)
EOS-37PTH	*HLZCs qualified per Figure 12*	8(1)
EOS-37PTH	HLZC 3	No Limit
EOS-37PTH	HLZC *1, 2, or* 4-11	8(1) *(2)*
EOS-89BTH	HLZCs qualified per Figure 11	8(1)
EOS-89BTH	HLZC 2	10(1)(3)
EOS-89BTH	HLZC 3	No Limit*(3)*
61BTH Type 2	HLZC 1, 2, 3, 4, or 9	No limit
61BTH Type 2	5, 6, or 8	23
61BTH Type 2	7 or 10	10

--NOTE--

1. The time limit for completion of a DSC transfer is defined as the time elapsed in hours after the initiation of draining of TC/DSC annulus water until the completion of insertion of the DSC into the HSM. For transfer of an EOS-DSC, the time limit for transfer operations is determined based on the EOS-37PTH DSC in EOS-TC125 with the maximum allowable heat load of 50 kW or EOS-89BTH DSC in EOS-TC125 with the maximum allowable heat load of 48.2 kW. If the maximum heat load of a DSC is less than 50 kW for EOS-37PTH DSC or 48.2 kW for the EOS-89BTH DSC, a new time limit can be determined to provide additional time for transfer operations. The calculated time limit shall not be less than the time limit specified in LCO 3.1.3. The calculation should be performed using the same methodology documented in the UFSAR.
2. *HLZC 2, 4-6 (shown in Figures 1B, 1D-1F) time limits apply for the EOS-37PTH DSC transferred in the EOS-TC108 only. HLZC 7-9 time limits apply for storage in the HSM-MX. If transferring the EOS-37PTH with HLZC 2, 4-6, or 11 in the EOS-TC125 and storing in the EOS-HSM, the limits for Figure 12 apply. Time limits also apply for HLZC 1, 2, and 4-11 when storing WE 14 x 14.*
3. HLZC 2 and 3 (shown in Figure 2) time limits apply for the EOS-89BTH transferred in the EOS-TC108 only. If transferring the EOS-89BTH with HLZC 2 or 3 in the EOS-TC125, the limits for Figure 11 apply.

(continued)

3.1 DSC Fuel Integrity (continued)

APPLICABILITY: During LOADING OPERATIONS AND TRANSFER OPERATIONS.

ACTIONS:

CONDITION	REQUIRED ACTION	COMPLETION TIME
---------------------NOTE ------------------- Not applicable until SR 3.1.3 is performed. --- A. The required time limit for completion of a DSC transfer not met.	A.1 If the TC is in the cask handling area in a vertical orientation, remove the TC top cover plate and fill the TC/DSC annulus with clean water. OR	2 hours
	A.2 If the TC is in a horizontal orientation on the transfer skid, initiate air circulation in the TC/DSC annulus by starting one of the redundant blowers. OR	1 hour (1) (2)
	A.3 Return the TC to the cask handling area and follow required action A.1 above.	5 hours (1) (2)

1. For EOS-37PTH and EOS-89BTH DSCs: If Required Action A.2 is initiated, run the blower for a minimum of 8 hours. After the blower is turned off, the time limit for completion of DSC transfer is 4 hours. If Required Action A.2 fails to complete within one hour, follow Required Action A.3 for the time remaining in the original Required Action A.3 completion time of 5 hours. The minimum duration of 8 hours to run the blower and the time limit of 4 hours after the blower is turned off for completion of the transfer operations are determined based on the EOS-37PTH DSC in EOS-TC125 with the maximum allowable heat load of 50 kW or EOS-89BTH DSC in EOS-TC125 with the maximum allowable heat load of 48.2 kW. If the maximum heat load of a DSC is less than 50 kW for EOS-37PTH DSC or 48.2 kW for the EOS-89BTH DSC, new time limits can be determined to provide additional time for these transfer operations. The calculated time limits shall not be less than 4 hours for completion of transfer operation after the blower is turned off. The calculation should be performed using the same methodology documented in the UFSAR.
2. For 61BTH Type 2 DSC: If Required Action A.2 is initiated, run the blower for a minimum of 8 hours. After the blower is turned off, the time limit for completion of DSC transfer is 4 hours. If Required Action A.2 fails to complete within one hour, follow Required Action A.3 for the time remaining in the original Required Action A.3 completion time of 5 hours. The minimum duration of 8 hours to run the blower and the time limit of 4 hours after the blower is turned off for completion of the transfer operations are determined based on the 61BTH Type 2 DSC in OS197FC-B TC with the maximum allowable heat load of 31.2 kW. If the maximum heat load of a DSC is less than 31.2 kW, new time limits can be determined to provide additional time for these transfer operations. The calculated time limits shall not be less than 4 hours for completion of transfer operation after the blower is turned off. The calculation should be performed using the same methodology documented in the UFSAR.

(continued)

3.1 DSC Fuel Integrity (continued)

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.3	Verify that the time limit for completion of DSC transfer is met.	Once per DSC, after the initiation of draining of TC/DSC annulus water.

3.2 Cask Criticality Control

3.2.1 Soluble Boron Concentration

LCO 3.2.1 The boron concentration of the spent fuel pool water and the water added to the cavity of a loaded EOS-37PTH DSC shall be at least the boron concentration shown in Table 4 for the basket type and fuel enrichment selected.

APPLICABILITY: During LOADING and UNLOADING OPERATIONS with fuel and liquid water in the EOS-37PTH DSC cavity.

ACTIONS:

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Soluble boron concentration limit not met.	A.1 Suspend loading of fuel assemblies into DSC. <u>AND</u>	Immediately
	A.2	
	A.2.1 Add boron and re-sample, and test the concentration until the boron concentration is shown to be at least that required. <u>OR</u>	Immediately
	A.2.2 Remove all fuel assemblies from DSC.	Immediately

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.2.1.1	Verify soluble boron concentration limit in spent fuel pool water and water to be added to the DSC cavity is met using two independent measurements (two samples analyzed by different individuals) for LOADING OPERATIONS.	Within 4 hours before insertion of the first fuel assembly into the DSC. <u>AND</u> Every 48 hours thereafter while the DSC is in the spent fuel pool or until the fuel has been removed from the DSC.
SR 3.2.1.2	Verify soluble boron concentration limit in spent fuel pool water and water to be added to the DSC cavity is met using two independent measurements (two samples analyzed by different individuals) for UNLOADING OPERATIONS.	Once within 4 hours prior to flooding DSC during UNLOADING OPERATIONS. <u>AND</u> Every 48 hours thereafter while the DSC is in the spent fuel pool or until the fuel has been removed from the DSC.

3.3 Radiation Protection

3.3.1 DSC and TRANSFER CASK (TC) Surface Contamination

LCO 3.3.1 Removable surface contamination on the outer top 1 foot surface of the DSC AND the exterior surfaces of the TC shall not exceed:

a. 2,200 dpm/100 cm^2 from beta and gamma sources; and

b. 220 dpm/100 cm^2 from alpha sources.

APPLICABILITY: During LOADING OPERATIONS

ACTIONS:

-- NOTE --

Separate condition entry is allowed for each DSC and TC.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Top 1 foot exterior surface of the DSC removable surface contamination limits not met.	A.1 Decontaminate the DSC to bring the removable contamination to within limits.	Prior to TRANSFER OPERATIONS
B. TC removable surface contamination limits not met.	B.1 Decontaminate the TC to bring the removable contamination to within limits	Prior to TRANSFER OPERATIONS

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.3.1.1	Verify that the removable contamination on the top 1 foot exterior surface of the DSC is within limits.	Once, prior to TRANSFER OPERATIONS.
SR 3.3.1.2	Verify by either direct or indirect methods that the removable contamination on the exterior surfaces of the TC is within limits.	Once, prior to TRANSFER OPERATIONS.

4.0 DESIGN FEATURES

The specifications in this section include the design characteristics of special importance to each of the physical barriers and to the maintenance of safety margins in the NUHOMS® EOS System design.

4.1 Site

4.1.1 Site Location

Because this UFSAR is prepared for a general license, a discussion of a site-specific ISFSI location is not applicable.

4.2 Storage System Features

4.2.1 Storage Capacity

The total storage capacity of the ISFSI is governed by the plant-specific license conditions.

4.2.2 Storage Pad

For sites for which soil-structure interaction is considered important, the licensee is to perform site-specific analysis considering the effects of soil-structure interaction. Amplified seismic spectra at the location of the HSM center of gravity (CG) is to be developed based on the soil-structure interaction (SSI) responses. EOS-HSM seismic analysis *for the reinforced concrete EOS-HSM (EOS-HSM-RC)* information is provided in UFSAR Appendix 3.9.4, Section 3.9.4.9.2. *The steel-plate composite EOS-HSM (EOS-HSM-SC) seismic analysis information is provided in UFSAR Appendix 3.9.8, Section 3.9.8.9.* HSM-MX seismic analysis information is provided in UFSAR Appendix A.3.9.4, Section A.3.9.4.9.2.

The storage pad location shall have no potential for liquefaction at the site-specific safe shutdown earthquake (SSE) level.

Additional requirements for the pad configuration are provided in Technical Specification 4.5.2.

4.3 Canister Criticality Control

The NUHOMS® EOS-37PTH DSC is designed for the storage of PWR fuel assemblies with a maximum planar average initial enrichment of less than or equal to 5.0 wt. % U-235 taking credit for soluble boron during LOADING OPERATIONS and the boron content in the poison plates of the DSC basket. The EOS-37PTH DSC uses a boron carbide/aluminum metal matrix composite (MMC) poison plate material. The EOS-37PTH DSC has two different neutron poison loading options, A and B, based on the boron content in the poison plates as listed in Table 5. Table 4 also defines the requirements for boron concentration in the DSC cavity water as a function of the DSC basket type for the various FUEL CLASSES authorized for storage in the EOS-37PTH DSC.

The NUHOMS® EOS-89BTH DSC is designed for the storage of BWR fuel assemblies with a maximum lattice average initial enrichment of less than or equal to 5.00 wt. % U-235 taking credit for the boron content in the poison plates of the DSC basket. There are three neutron poison loading options specified for the EOS-89BTH DSC depending on the type of poison material and the B-10 areal density in the plates, as specified in Table 8.

(continued)

4.0 Design Features (continued)

The 61BTH Type 2 DSC is designed for the storage of BWR fuel assemblies with a maximum lattice average initial enrichment of less than or equal to 5.0 wt. % U-235 taking credit for the boron content in the poison plates of the DSC basket. The 61BTH Type 2 DSC has multiple basket configurations based on the absorber material type (borated aluminum alloy, metal matrix composite (MMC), or Boral®) and boron content in the absorber plates as listed in Table 9 through Table 12.

4.3.1 Neutron Absorber Tests

The neutron absorber used for criticality control in the DSC baskets may be one of the following materials:

- Boron carbide/MMC
- BORAL® (EOS-89BTH or 61BTH Type 2 DSCs only)
- Borated aluminum (61BTH Type 2 DSC only)

Acceptance Testing (MMC, BORAL®, and borated aluminum)

B-10 areal density is verified by neutron attenuation testing or by chemical analysis of coupons taken adjacent to finished panels, and isotopic analysis of the boron carbide powder. The minimum B-10 areal density requirements are specified in Table 5 for EOS-37PTH, Table 8 for EOS-89BTH, and Table 9 through Table 12 for 61BTH Type 2 DSCs.

Finished panels are subject to visual and dimensional inspection.

Qualification Testing (MMC only)

MMCs are qualified for use in the NUHOMS® EOS System by verification of the following characteristics.

- The chemical composition is boron carbide particles in an aluminum alloy matrix.
- The form is with or without an aluminum skin.
- The median boron carbide particle size by volume is ≤ 80 microns with no more than 10% over 100 microns.
- The boron carbide content is ≤ 50% by volume.
- The porosity is ≤ 3%.

4.3.2 High Strength Low Alloy Steel for Basket Structure for EOS-37PTH and EOS-89BTH DSCs.

The basket structural material shall be a high strength low alloy (HSLA) steel meeting one of the following requirements A, B, or C:

A. ASTM A829 Gr 4130 or AMS 6345 SAE 4130, quenched and tempered at not less than 1050°F, 103.6 ksi minimum yield strength and 123.1 ksi minimum ultimate strength at room temperature.

B. ASME SA-517 Gr A, B, E, F, or P.

(continued)

4.0 Design Features (continued)

C. Other HSLA steel, with the specified heat treatment, meeting these qualification and acceptance criteria:

   i. If quenched and tempered, the tempering temperature shall be at no less than 1000 °F,

   ii. Qualified prior to first use by testing at least two lots and demonstrating that the fracture toughness value $K_{JIc} \geq 150$ ksi $\sqrt{in}$ at ≤ -40 °F with 95% confidence.

   iii. Qualified prior to first use by testing at least two lots and demonstrating that the 95% lower tolerance limit of yield strength and ultimate strength ≥ the values in UFSAR Table 8-10.

   iv. Meet production acceptance criteria based on the 95% lower tolerance limit of yield strength and ultimate strength at room temperature as determined by qualification testing described in Section 4.3.2.C.iii.

The basket structural material shall also meet one of the following production acceptance criteria for impact testing at ≤ -40 °F:

   a. Charpy testing per ASTM A370, minimum absorbed energy 25 ft-lb average, 20 ft-lb lowest of three (for sub-size specimens, reduce these criteria per ASTM A370-17 Table 9), or

   b. Dynamic tear testing per ASTM E604 with acceptance criterion minimum 80% shear fracture appearance.

4.4 Codes and Standards

4.4.1 HORIZONTAL STORAGE MODULE (HSM)

The reinforced concrete HSM is designed in accordance with the provisions of ACI 349-06. *The steel-plate composite HSM steel is designed in accordance with the provisions of ANSI/AISC N690-18. The steel-plate composite HSM concrete is designed and constructed in accordance with ACI 318-08.* Code alternatives are discussed in Technical Specification 4.4.4. Load combinations specified in ANSI 57.9-1984, Section 6.17.3.1 are used for combining normal operating, off-normal, and accident loads for the HSM.

(continued)

4.0 Design Features (continued)

4.4.2 DRY SHIELDED CANISTER (DSC) (EOS-37PTH, EOS-89BTH, and 61BTH Type 2)

The DSC confinement boundary is designed, fabricated and inspected to the maximum practical extent in accordance with ASME Boiler and Pressure Vessel Code Section III, Division 1, Subsection NB, NF, and NG, for Class 1 components. The ASME code edition years and any addenda for the various DSC types and relevant subsections are provided in the table below. Code alternatives are discussed in Technical Specification 4.4.4.

DSC Type	Applicable Code	Edition/Year
EOS-37PTH, EOS-89BTH	ASME B&PV Code, Section III, Division 1, Subsection NB	2010 Edition with Addenda through 2011
61BTH Type 2	ASME B&PV Code, Section III, Division 1, Subsections NB, NG and NF	1998 Edition with Addenda through 2000

4.4.3 TRANSFER CASK

The EOS-TC design stress analysis and OS197 design stress analysis and fabrication, exclusive of the trunnions and the neutron shield enclosures, is performed in accordance with applicable codes as provided in the table below. The stress allowables for the upper trunnions for the EOS-TCs and the upper and lower trunnions for the OS197 conform to ANSI N14.6-1993 for single-failure-proof lifting.

TC	Applicable Code	Edition/Year
EOS-TC	ASME B&PV Code, Section III, Division 1, Subsection NF for Class 1 supports	2010 Edition with Addenda through 2011
OS197	ASME B&PV Code, Section III, Division 1, Subsection NC for Class 2 vessels	1983 Edition with Winter 1985 Addenda

4.4.4 Alternatives to Codes and Standards

ASME Code alternatives for the EOS-37PTH, EOS-89BTH DSC, and 61BTH Type 2 DSC are listed below:

(continued)

4.0 Design Features (continued)

EOS-37PTH and EOS-89BTH DSC ASME Code Alternatives, Subsection NB

REFERENCE ASME CODE SECTION/ARTICLE	CODE REQUIREMENT	JUSTIFICATION AND COMPENSATORY MEASURES
NCA	All	Not compliant with NCA
NB-1100	Requirements for Code Stamping of Components	The canister shell, the inner top cover, the inner bottom cover or bottom forging assembly, the outer top cover, and the drain port cover and vent port plug are designed and fabricated in accordance with the ASME Code, Section III, Subsection NB to the maximum extent practical. However, Code Stamping is not required. As Code Stamping is not required, the fabricator is not required to hold an ASME “N” or “NPT” stamp, or to be ASME Certified.
NB-2121	Permitted Material Specifications	Type 2205 and UNS S31803 are duplex stainless steels that provide enhance resistance to chloride-induced stress corrosion cracking. They are not included in Section II, Part D, Subpart 1, Tables 2A and 2B. UNS S31803 has been accepted for Class 1 components by ASME Code Case N-635-1, endorsed by NRC Regulatory Guide 1.84. Type 2205 falls within the chemical and mechanical requirements of UNS S31803. Normal and off-normal temperatures remain below the 600 °F operating limit. Accident conditions may exceed this limit, but only for durations too short to cause embrittlement.
NB-2130 NB-4121	Material must be supplied by ASME approved material suppliers Material Certification by Certificate Holder	Material is certified to meet all ASME Code criteria but is not eligible for certification or Code Stamping if a non-ASME fabricator is used. As the fabricator is not required to be ASME certified, material certification to NB-2130 is not possible. Material traceability and certification are maintained in accordance with the NRC approved QA program associated with CoC 1042.
NB-2300	Fracture toughness requirements for material	Type 2205 and UNS S31803 duplex stainless steels are tested by Charpy V-notch only per NB-2300. Drop weight tests are not required. Impact testing is not required for the vent port plug.
NB-2531	Drain port cover; straight beam ultrasonic testing (UT) per SA-578 for all plates for vessel	SA-578 applies to 3/8" and thicker plate only; allow alternate UT techniques to achieve meaningful UT results.
NB- 2531 and NB-2541	Vent port plug UT and liquid penetrant testing (PT)	This plug may be made from plate or bar. Due to its small area, it has no structural function. It is leak tested along with the inner top cover plate after welding. Therefore, neither UT nor PT are required.

(continued)

4.0 Design Features (continued)

EOS-37PTH and EOS-89BTH DSC ASME Code Alternatives, Subsection NB

(continued)

REFERENCE ASME CODE SECTION/ARTICLE	CODE REQUIREMENT	JUSTIFICATION AND COMPENSATORY MEASURES
NB-4243 and NB-5230	Category C weld joints in vessels and similar weld joints in other components shall be full penetration joints. These welds shall be examined by UT or radiographic testing (RT) and either PT or magnetic particle testing (MT).	The shell to the outer top cover plate (OTCP) weld, the shell to the inner top cover weld, and the drain port cover and vent port plug welds are all partial penetration welds. The cover-to-shell welds are designed to meet the guidance provided in NUREG-1536, Revision 1 for the stress reduction factor. Nondestructive examination (NDE) is done by qualified personnel, in accordance with Section V and the acceptance standards of Section III, Subsection NB-5000, except as noted for OTCP weld option 2 ultrasonic examination. As an alternative to the NDE requirements of NB-5230 for Category C welds, all of these closure welds will be multi-layer welds and receive a root and final PT examination, except for the shell to the OTCP weld. <u>OTCP weld option 1</u> The shell to OTCP weld will be a multi-layer weld and receive multi-level PT examination in accordance with the guidance provided in NUREG 1536 Revision 1 for NDE. The multi-level PT examination provides reasonable assurance that flaws of interest will be identified. <u>OTCP weld option 2</u> The shell to the outer top cover plate weld will be examined by UT.
NB-5330	Ultrasonic Acceptance Standards	The UT acceptance criteria for OTCP weld option 2 are: 1. Rounded flaws are evaluated by the acceptance criteria of NB-5331(a). 2. Planar flaws are allowable up to the limit (W – Σhi) ≥ D at any location, where Σhi is the sum of the depth of aligned planar defects, W is the measured weld thickness, and D is the minimum weld depth required by NB-3000. 3. Planar flaws that penetrate the surface of the weld are not allowable.
NB-5520	NDE Personnel must be qualified to the 2006 edition of SNT-TC-1A	Permit use of the Recommended Practice SNT-TC-1A up to the edition as cited in Table NCA-7000-1 of the latest ASME Code edition listed in 10 CFR 50.55a at the time of construction.

(continued)

4.0 Design Features (continued)

EOS-37PTH and EOS-89BTH DSC ASME Code Alternatives, Subsection NB

(continued)

REFERENCE ASME CODE SECTION/ARTICLE	CODE REQUIREMENT	JUSTIFICATION AND COMPENSATORY MEASURES
NB-6000	All completed pressure retaining systems shall be pressure tested	The DSC is not a complete or “installed” pressure vessel until the top closure is welded following placement of fuel assemblies within the DSC. Due to the inaccessibility of the shell and lower end closure welds following fuel loading and top closure welding, as an alternative, the pressure testing of the DSC is performed in two parts. The DSC shell, shell bottom, including all longitudinal and circumferential welds, is pneumatically tested and examined at the fabrication facility when using the three plate bottom assembly. If using a single piece bottom forging, the fabrication pressure test may be waived although the helium leak test requirement remains in place. The low test pressure test does not stress a single piece bottom and bottom-to-shell weld sufficiently to cause pre-existing defects to propagate into leaks. For the purpose of finding leaks, the helium leak test is far more sensitive than the pressure test. The shell to the inner top cover closure weld is pressure tested and examined for leakage in accordance with NB-6300 in the field. The drain port cover and vent port plug welds will not be pressure tested; these welds and the shell to the inner top cover closure weld are helium leak tested after the pressure test. Per NB-6324 the examination for leakage shall be done at a pressure equal to the greater of the design pressure or three-fourths of the test pressure. As an alternative, if the examination for leakage of these field welds, following the pressure test, is performed using helium leak detection techniques, the examination pressure may be reduced to 1.5 psig. This is acceptable given the significantly greater sensitivity of the helium leak detection method.
NB-7000	Overpressure Protection	No overpressure protection is provided for the EOS-37PTH or EOS-89BTH DSC. The function of the DSC is to contain radioactive materials under normal, off-normal, and hypothetical accident conditions postulated to occur during transportation. The DSC is designed to withstand the maximum internal pressure considering 100% fuel rod failure at maximum accident temperature.

(continued)

EOS-37PTH and EOS-89BTH DSC ASME Code Alternatives, Subsection NB

(continued)

NB-8000	Requirements for nameplates, stamping and reports per NCA-8000	The EOS-37PTH and EOS-89BTH DSC are stamped or engraved with the information required by 10 CFR Part 72. Code stamping is not required for these DSCs. QA Data packages are prepared in accordance with requirements of the NRC approved QA program associated with CoC 1042.

(continued)

4.0 Design Features (continued)

61BTH Type 2 DSC ASME Code Alternatives for the Confinement Boundary

REFERENCE ASME CODE SECTION/ ARTICLE	CODE REQUIREMENT	ALTERNATIVES, JUSTIFICATION & COMPENSATORY MEASURES
NCA	All	Not compliant with NCA. Quality Assurance is provided according to 10 CFR Part 72 Subpart G in lieu of NCA-4000.
NCA-1140	Use of Code editions and addenda	Code edition and addenda other than those specified in Section 4.4.2 may be used for construction, but in no case earlier than 3 years before that specified in the Section 4.4.2 table. Materials produced and certified in accordance with ASME Section II material specification from Code Editions and Addenda other than those specified in Section 4.4.2 may be used, so long as the materials meet all the requirements of Article 2000 of the applicable Subsection of the Section III Edition and Addenda used for construction.
NB-1100	Requirements for Code Stamping of Components, Code reports and certificates, etc.	Code Stamping is not required. As Code Stamping is not required, the fabricator is not required to hold an ASME “N” or “NPT” stamp, or to be ASME Certified.
NB-1132	Attachments with a pressure retaining function, including stiffeners, shall be considered part of the component.	Bottom shield plug and outer bottom cover plate are outside code jurisdiction; these components together are much larger than required to provide stiffening for the inner bottom cover plate; the weld that retains the outer bottom cover plate and with it the bottom shield plug is subject to root and final PT examination.
NB-2130	Material must be supplied by ASME approved material suppliers.	Material is certified to meet all ASME Code criteria but is not eligible for certification or Code Stamping if a non-ASME fabricator is used. As the fabricator is not required to be ASME certified, material certification to NB-2130 is not possible. Material traceability and certification are maintained in accordance with TN’s NRC approved QA program.
NB-4121	Material Certification by Certificate Holder	
NB-4243 and NB-5230	Category C weld joints in vessels and similar weld joints in other components shall be full penetration joints. These welds shall be examined by UT or RT and either PT or MT.	The shell to the outer top cover weld, the shell to the inner top cover weld, the siphon and vent cover plate welds, and the vent and siphon block welds to the shell are all partial penetration welds. As an alternative to the NDE requirements of NB-5230 for Category C welds, all of these closure welds will be multi-layer welds and receive a root and final PT examination, except for the shell to the outer top cover weld. The shell to the outer top cover weld will be a multi-layer weld and receive multi-level PT examination in accordance with the guidance provided in NUREG-1536 Revision 1 for NDE. The multi-level PT Examination provides reasonable assurance that flaws of interest will be identified. The PT examination is done by qualified personnel, in accordance with Section V and the acceptance standards of Section III, Subsection NB-5000. All of these welds will be designed to meet the guidance provided in NUREG-1536 Revision 1 for stress reduction factor.

(continued)

4.0 Design Features (continued)

61BTH Type 2 DSC ASME Code Alternatives for the Confinement Boundary

REFERENCE ASME CODE SECTION/ ARTICLE	CODE REQUIREMENT	ALTERNATIVES, JUSTIFICATION & COMPENSATORY MEASURES
NB-6100 and 6200	All completed pressure retaining systems shall be pressure tested.	The 61BTH Type 2 DSC is not a complete or “installed” pressure vessel until the top closure is welded following placement of Fuel Assemblies with the DSC. Due to the inaccessibility of the shell and lower end closure welds following fuel loading and top closure welding, as an alternative, the pressure testing of the DSC is performed in two parts. The DSC shell and shell bottom (including all longitudinal and circumferential welds) is pressure tested and examined at the fabrication facility. The shell to the inner top cover closure weld are pressure tested and examined for leakage in accordance with NB-6300 in the field. The siphon/vent cover welds are not pressure tested; these welds and the shell to the inner top cover closure weld are helium leak tested after the pressure test. Per NB-6324, the examination for leakage shall be done at a pressure equal to the greater of the design pressure or three-fourths of the test pressure. As an alternative, if the examination for leakage of these field welds, following the pressure test, is performed using helium leak detection techniques, the examination pressure may be reduced to ≥ 1.5 psig. This is acceptable given the significantly greater sensitivity of the helium leak detection method.
NB-7000	Overpressure Protection	No overpressure protection is provided for the NUHOMS® DSCs. The function of the DSC is to contain radioactive materials under normal, off-normal and hypothetical accident conditions postulated to occur during transportation and storage. The DSC is designed to withstand the maximum possible internal pressure considering 100% fuel rod failure at maximum accident temperature.
NB-8000	Requirements for nameplates, stamping & reports per NCA-8000.	The NUHOMS® DSC nameplate provides the information required by 10 CFR Part 71, 49 CFR Part 173 and 10 CFR Part 72 as appropriate. Code stamping is not required for the DSC. QA data packages are prepared in accordance with the requirements of TN’s approved QA program.
NB-5520	NDE personnel must be qualified to a specific edition of SNT-TC-1A.	Permit use of the Recommended Practice SNT-TC-1A to include up to the most recent 2011 edition.

(continued)

61BTH Type 2 DSC ASME Code Alternatives for the Basket

REFERENCE ASME CODE SECTION/ ARTICLE	CODE REQUIREMENT	ALTERNATIVES, JUSTIFICATION & COMPENSATORY MEASURES
NCA	All	Not compliant with NCA. Quality Assurance is provided according to 10 CFR Part 72 Subpart G in lieu of NCA-4000.
NCA-1140	Use of Code editions and addenda	Code edition and addenda other than those specified in Section 4.4.2 may be used for construction, but in no case earlier than 3 years before that specified in the Section 4.4.2 table. Materials produced and certified in accordance with ASME Section II material specification from Code Editions and Addenda other than those specified in Section 4.4.2 may be used, so long as the materials meet all the requirements of Article 2000 of the applicable Subsection of the Section III Edition and Addenda used for construction.
NG/NF-1100	Requirements for Code Stamping of Components, Code reports and certificates, etc.	Code Stamping is not required. As Code Stamping is not required, the fabricator is not required to hold an ASME “N” or “NPT” stamp, or to be ASME Certified.
NG/NF-2000	Use of ASME Material	Some baskets include neutron absorber and aluminum plates that are not ASME Code Class 1 material. They are used for criticality safety and heat transfer, and are only credited in the structural analysis with supporting their own weight and transmitting bearing loads through their thickness. Material properties in the ASME Code for Type 6061 aluminum are limited to 400 °F to preclude the potential for annealing out the hardening properties. Annealed properties (as published by the Aluminum Association and the American Society of Metals) are conservatively assumed for the aluminum transition rails for use above the Code temperature limits.
NG/NF-2130	Material must be supplied by ASME approved material suppliers.	Material is certified to meet all ASME Code criteria but is not eligible for certification or Code Stamping if a non-ASME fabricator is used. As the fabricator is not required to be ASME certified, material certification to NG/NF-2130 is not possible. Material traceability and certification are maintained in accordance with TN’s NRC approved QA program.
NG/NF-4121	Material Certification by Certificate Holder	
NG-3352	Table NG-3352-1 lists the permissible welded joints and quality factors.	The fuel compartment tubes may be fabricated from sheet with full penetration seam weldments. Per Table NG-3352-1, a joint efficiency (quality) factor of 0.5 is to be used for full penetration weldments examined in accordance with ASME Section V visual examination (VT). A joint efficiency (quality) factor of 1.0 is utilized for the fuel compartment longitudinal seam welds (if present) with VT examination. This is justified because the compartment seam weld is thin and the weldment is made in one pass; and both surfaces of the weldment (inside and outside) receive 100% VT examination. The 0.5 quality factor, applicable to each surface of the weldment, results is a quality factor of 1.0 since both surfaces are 100% examined. In addition, the fuel compartments have no pressure retaining function and the stainless steel material that comprises the fuel compartment tubes is very ductile.
NG/NF-8000	Requirements for nameplates, stamping & reports per NCA-8000.	The NUHOMS® DSC nameplate provides the information required by 10 CFR Part 71, 49 CFR Part 173 and 10 CFR Part 72 as appropriate. Code stamping is not required for the DSC. QA data packages are prepared in accordance with the requirements of TN’s approved QA program.
NG/NF-5520	NDE personnel must be qualified to a specific edition of SNT-TC-1A.	Permit use of the Recommended Practice SNT-TC-1A to include up to the most recent 2011 edition.

(continued)

4.0 Design Features (continued)

Code alternatives for the HSM concrete specifications are listed below:

REFERENCE ACI349-06 SECTION/ARTICLE	CODE REQUIREMENT	ALTERNATIVES, JUSTIFICATION AND COMPENSATORY MEASURES
Appendix E, Section E.4-Concrete Temperatures, Paragraph E.4.3	Paragraph E.4.3 requires testing of concrete for temperatures higher than those given in Paragraph E.4.1.	The concrete temperature limit criteria in NUREG-1536, Section 8.4.14.2 is used for normal and off-normal conditions. Alternatively, per ACI 349-13, Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary, Section RE.4, the specified compressive strength, which may be tested up to 56 days, is increased to 7,000 psi for HSM fabrication so that any losses in properties (e.g., compressive strength) resulting from long-term thermal exposure will not affect the safety margins based on the specified 5,000 psi compressive strength used in the design calculations. Additionally, also as indicated in Section RE.4, short, randomly oriented steel fibers may be used to provide increased ductility, dynamic strength, toughness, tensile strength, and improved resistance to spalling. The safety margin on compressive strength is 40% for a concrete temperature limit of 300 °F normal and off-normal conditions.

(continued)

4.0 Design Features (continued)

Code alternatives for the steel-plate composite HSM specifications are listed below:

REFERENCE ANSI/AISC N690	*CODE REQUIREMENT*	*JUSTIFICATION AND COMPENSATORY MEASURES*
NB2	*Required load combinations for normal, severe environmental, and extreme environmental and abnormal conditions.*	*The load combinations contained in AISC N690-18 are intended to cover a wide range of structural applications where additional load combinations are used to cover various uncertainties. For the design of dry-storage structures, NUREG 1536, R1 (and the more current NUREG 2215) endorse the load combinations specified in Section 6.17.3.1 of ANSI 57.9-1984 as the most applicable load combinations. Therefore, the use of ANSI 57.9-1984 load combinations in lieu of those specified in AISC-N690-18 is acceptable for this application.*
N9.1.1.(a)	*For exterior SC walls, the minimum value of the section thickness, t_{sc}, shall be 18 inches (450 mm). For interior SC walls, the minimum t_{sc} shall be 12 inches (300 mm).*	*As presented in Commentary for Section N9.1.1(a) of N690, the minimum section thickness for exterior SC walls is based on Table 1 of NUREG-0800, Revision 3, Section 3.5.3, Revision 3. It requires minimum 16.9-inch thick (430mm) 4-ksi (28 MPa) reinforced concrete (RC) walls to resist a tornado missile. Conservatively, the SC wall is treated as a RC wall for missile loading. The thinner sections of the door are supported by the front wall of the EOS-HSM-SC during missile impact. Therefore, the door meets the specified minimum thickness value of 18 inches for exterior walls. The minimum thickness for interior walls is based on the maximum reinforcement ratio and minimum faceplate thickness. The specified minimum thickness value of 12 inches is conservatively rounded up from the actual minimum of 10 inches as presented in Commentary for Section N9.1.1(a) of N690. Therefore, the sections of the door and OVC that do not meet the specified thickness value of 12 inches, still meet the 10 inch minimum thickness requirement.*
N9.1.1(c)	*The reinforcement ratio of SC sections shall have a minimum value of 0.015 and a maximum value of 0.050.*	*According to AISC Steel Design Guide 32, high reinforcement ratios can potentially result in higher concrete stresses and change the governing in-plane shear limit state from steel faceplate yielding to concrete compression strut failure, which can potentially reduce the strength and ductility of SC walls. The reinforcement ratio for the thin walls of the EOS-HSM-SC minimally (less than 5%) exceeds the ratio of 0.050 and this exceedance facilitates compliance with the faceplate slenderness requirement in Section N9.1.3 of N690-18. The reinforcement ratio for the top segment of the front wall is marginally less than the minimum reinforcement ratio of 0.015 when the effective thickness of the front wall faceplate is considered. Per Commentary Section N9.1.1(c) of N690, use of a very low reinforcement ratio poses concerns regarding handling strength and stiffness in addition to residual stresses due to fabrication operations and concrete casting. These concerns are not applicable because the actual thickness is twice as large as the effective thickness.*

(continued)

4.0 Design Features (continued)

Code alternatives for the steel-plate composite HSM specifications are listed below (continued):

REFERENCE ANSI/AISC N690	*CODE REQUIREMENT*	*JUSTIFICATION AND COMPENSATORY MEASURES*
N9.1.1.(d)	*The specified minimum yield stress of faceplates, F_y, shall not be less than 50 ksi (350 MPa) nor more than 65 ksi (450 MPa).*	*The door and OVC steel plates are constructed from ASTM A36. As presented in the Commentary for Section N9.1.1(d) of N690, the minimum yield strength of faceplates is intended to prevent premature yielding due to residual stresses from concrete casting and thermally induced stresses. The door and OVC are free to grow when subjected to thermal loads and require a concrete volume of relatively low height resulting in insignificant pressure on the faceplates during casting as compared to a large EOS-HSM-SC wall. Therefore, stresses due to thermal growth and residual stress from concrete casting will not contribute to premature yielding of the faceplates in these components. Additionally, the margins for the door thickness to withstand local damage due to missile attack, ductile capacity for missile impact, and structural adequacy for punching shear are sufficiently large. The margins for the OVC are sufficiently large as well. Therefore, a material meeting the properties of ASTM A36 will have sufficient strength for this application.*
N9.1.4b(a)	*Steel anchors shall be spaced not to exceed the minimum spacing required to develop the yield strength of the faceplates over the development length.*	*This requirement ensures that sufficient composite action exists between the steel faceplate and concrete. However, the requirement does not consider the contribution of ties to available shear strength of the SC component, leading to inefficient designs for those components such as thin walls, for which the density of ties tends to be high. Studies based on finite element analysis demonstrate the contribution of ties to the composite action and show that composite action is adequate for the thin walls of the EOS-HSM-SC.*
N9.1.4b(b)	*Steel anchors shall be spaced not to exceed the minimum spacing required to prevent interfacial shear failure before out-of-plane shear failure of the SC section.*	*This requirement does not consider the required strength of the SC component but the available out-of-plane strength, leading to inefficient designs in those cases where the demand-to-capacity ratio for out-of-plane shear interaction is low. For the design of the EOS-HSM-SC, this criterion is modified such that the spacing of steel anchors required to prevent interfacial shear failure is deemed adequate if the demand-to-capacity ratio for out-of-plane shear interaction (presented in Section N9.3.6a of N690-18) is below 1.0 when required strength at least 1/3 greater than that determined by structural analysis is used. This approach is validated by laboratory test results.*

(continued)

4.0 Design Features (continued)

Code alternatives for the steel-plate composite HSM specifications are listed below (continued):

N9.1.7a(b)	*The flange fitted at the end of the sleeve for a fully developed edge at the opening perimeter shall extend a distance of at least the section thickness beyond the opening perimeter.*	*The front wall opening in the top segment of the EOS-HSM-SC only is considered as an opening because the majority of the front wall opening area is in the top segment and the bottom segment has only a slightly concave edge. The design of the front wall opening in the top segment of the EOS-HSM-SC follows the requirements on design and detailing around openings to the maximum practical extent possible to achieve a fully developed edge at the opening perimeter: a sufficiently fine finite element mesh is employed for the front wall and around its opening; a sleeve spanning across the opening from the front faceplate to the back faceplate is provided; and an equivalent flange is provided by thickening the front wall faceplate to provide additional strength in the stress concentration region. For the EOS-HSM-SC front wall, it is impractical to extend a distance of at least the section thickness beyond the opening perimeter because of the proximity of the front wall opening to the side walls.*
N9.3.6a	*The interaction of out-of-plane shear forces shall be limited by Equation A-N9-24 of N690-18.*	*The interaction of out-of-plane shear forces for thin walls of the EOS-HSM-SC is considered based on a modified approach described in the discussion on Section N9.1.4b(b) of N690-18.*

(continued)

4.0 Design Features (continued)

Proposed alternatives to the above-specified ASME and ACI codes, other than the aforementioned alternatives, may be used when authorized by the Director of the Office of Nuclear Material Safety and Safeguards, or designee. The applicant should demonstrate that:

1. The proposed alternatives would provide an acceptable level of quality and safety, or
2. Compliance with the specified requirements of above-specified ASME and ACI codes would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

The applicant should also submit information regarding the environmental impact of such a request to support the NRC’s NEPA regulations in 10 CFR Part 51. Any proposed alternatives must be submitted and approved prior to implementation.

Requests for exceptions in accordance with this section should be submitted in accordance with 10 CFR 72.4.

(continued)

4.5 Storage Location Design Features

The following storage location design features and parameters shall be verified by the system user to assure technical agreement with the UFSAR.

4.5.1 Storage Configuration

EOS-HSMs and HSM-MXs are placed together in single rows or back to back arrays. A rear shield wall is placed on the rear of any single row loaded EOS-HSM.

4.5.2 Concrete Storage Pad Properties to Limit DSC Gravitational Loadings Due to Postulated Drops

The EOS-37PTH DSC and EOS-89BTH DSC have been evaluated for drops of up to 65 inches onto a reinforced concrete storage pad. The 61BTH Type 2 DSC has been evaluated for drops of up to 80 inches onto a reinforced concrete storage pad.

4.5.3 Site Specific Parameters and Analyses

The following parameters and analyses are applicable to all HSMs unless specifically noted and shall be verified by the system user for applicability at their specific site. Other natural phenomena events, such as lightning, tsunamis, hurricanes, and seiches, are site specific and their effects are generally bounded by other events, but they should be evaluated by the user.

1. Flood levels up to 50 ft and water velocity of 15 fps.
2. One-hundred year roof snow load of 110 psf.
3. Normal ambient temperature is based on the heat load of the DSC as follows:

   For the EOS-HSM:

   a. For the EOS-37PTH DSCs with a heat load less than or equal to 41.8 kW or for the EOS-89BTH DSCs with a heat load less than or equal to 41.6 kW, the minimum temperature is -20 °F. The maximum calculated normal average ambient temperature corresponding to a 24-hour period is 90 °F.
   b. For the EOS-37PTH DSCs with a heat load greater than 41.8 kW or for the EOS-89BTH DSCs with a heat load greater than 41.6 kW, the minimum temperature is -20 °F. The maximum calculated average yearly temperature is 70 °F.

   For the HSM-MX:

   c. The minimum temperature is -20 °F. The maximum calculated normal average ambient temperature corresponding to a 24-hour period is 90 °F.
4. Off-normal ambient temperature range of -40 °F without solar insolation to 117 °F with full solar insolation. The 117 °F off-normal ambient temperature corresponds to a 24-hour calculated average temperature of 103 °F.

(continued)

5. The response spectra at the base of the HSMs shall be compared against the response spectra defined in UFSAR Section 2.3.4 for the EOS-HSM, and Section A.2.3.4 for the HSM-MX and shown to be enveloped by the UFSAR response spectra. If it is not enveloped, stability can be demonstrated by either static or dynamic analysis.
6. The potential for fires and explosions shall be addressed, based on site-specific considerations.
7. Supplemental Shielding: In cases where engineered features (i.e., berms, shield walls) are used to ensure that the requirements of 10 CFR 72.104(a) are met, such features are to be considered important to safety and must be evaluated to determine the applicable Quality Assurance Category.
8. If an INDEPENDENT SPENT FUEL STORAGE INSTALLATION (ISFSI) site is located in a coastal salt water marine atmosphere, then any load-bearing carbon steel DSC support structure rail components for the EOS-HSM, or front and rear DSC supports for the HSM-MX shall be procured with a minimum 0.20% copper content or stainless steel shall be used for corrosion resistance. For weld filler material used with carbon steel, 1% or more nickel bearing weld material would also be acceptable in lieu of 0.20% copper content.
9. If an ISFSI site is required to evaluate blockage of air vents for durations longer than evaluated in the UFSAR, a new duration can be determined based on site-specific parameters. The evaluation should be performed using the same methodology documented in the UFSAR.

5.0 ADMINISTRATIVE CONTROLS

5.1 Programs

Each user of the NUHOMS® EOS System will implement the following programs to ensure the safe operation and maintenance of the ISFSI:

- Radiological Environmental Monitoring Program (see 5.1.1 below)
- Radiation Protection Program (see 5.1.2 below)
- HSM Thermal Monitoring Program (see 5.1.3 below)

5.1.1 Radiological Environmental Monitoring Program

a. A radiological environmental monitoring program will be implemented to ensure that the annual dose equivalent to an individual located outside the ISFSI controlled area does not exceed the annual dose limits specified in 10 CFR 72.104(a).

b. Operation of the ISFSI will not create any radioactive materials or result in any credible liquid or gaseous effluent release.

5.1.2 Radiation Protection Program

The Radiation Protection Program will establish administrative controls to limit personnel exposure to As Low As Reasonably Achievable (ALARA) levels in accordance with 10 CFR Part 20 and Part 72.

a. As part of its evaluation pursuant to 10 CFR 72.212, the licensee shall perform an analysis to confirm that the limits of 10 CFR Part 20 and 10 CFR 72.104 will be satisfied under the actual site conditions and configurations considering the planned number of DSCs to be used and the planned fuel loading conditions. This analysis is also used to qualify fuel considered for loading, as outlined below:

   1. For the DSCs considered for loading, select HLZC(s) appropriate to store the spent fuel.
   2. Compute the decay heat of the fuel assemblies considered for loading. Methods include, but are not limited to, NRC Regulatory Guide 3.54, or the methodology described in the UFSAR (i.e., ORIGEN-ARP).
   3. Compute the source term for the fuel assemblies considered for loading. The design basis source terms provided in the UFSAR may be used for site-specific shielding analysis if they are shown to bound the site-specific source terms.
   4. Demonstrate computationally that the EOS-HSM or HSM-MX to be loaded meets the dose rate requirements of TS 5.1.2(c). This evaluation may be used as the basis for the dose rate limits established in TS 5.1.2(b).
   5. Demonstrate computationally that direct radiation from the ISFSI meets the requirements of 72.104.

(continued)

5.0 ADMINISTRATIVE CONTROLS (continued)

b. On the basis of the analysis in TS 5.1.2(a), the licensee shall establish a set of HSM dose rate limits which are to be applied to DSCs used at the site. Limits shall establish dose rates for:

  i. HSM front face,
  ii. HSM door centerline, and
  iii. End shield wall exterior for the EOS-HSM or exterior side wall of the HSM-MX monolith.

c. Notwithstanding the limits established in TS 5.1.2(b), the dose rate limits may not exceed the following values as calculated for a content of design basis fuel as follows:

For EOS-HSM:

  i. 65 mrem/hr average over the front face,
  ii. 15 mrem/hr at the door centerline, and
  iii. 5 mrem/hr average at the end shield wall exterior.

For HSM-MX:

  i. 165 mrem/hr average over the front face,
  ii. 15 mrem/hr at the door centerline, and
  iii. 5 mrem/hr average at the exterior side wall of the HSM-MX monolith.

If the measured dose rates do not meet the limits of TS 5.1.2(b) or TS 5.1.2(c), whichever are lower, the licensee shall take the following actions:

- Notify the U.S. Nuclear Regulatory Commission (Director of the Office of Nuclear Material Safety and Safeguards) within 30 days,
- Administratively verify that the correct fuel was loaded,
- Ensure proper installation of the HSM door,
- Ensure that the DSC is properly positioned on the DSC supports, and
- Perform an analysis to determine that placement of the as-loaded DSC at the ISFSI will not cause the ISFSI to exceed the radiation exposure limits of 10 CFR Part 20 and 10 CFR Part 72 and/or provide additional shielding to assure exposure limits are not exceeded.

d. A monitoring program to ensure the annual dose equivalent to any real individual located outside the ISFSI controlled area does not exceed regulatory limits is incorporated as part of the environmental monitoring program in the Radiological Environmental Monitoring Program of TS 5.1.1.

(continued)

5.0 ADMINISTRATIVE CONTROLS (continued)

e. When using the EOS-TC108 with a liquid neutron shield (NS), the NS shall be verified to be filled when DSC cavity draining or TC/DSC annulus draining operations are initiated and continually monitored during the first five minutes of the draining evolution to ensure the NS remains filled. The NS shall also be verified to be filled prior to the movement of the loaded TC from the decontamination area. Observation of water level in the expansion tank or some other means can be used to verify compliance with this requirement.

f. Following completion of the DSC shell assembly at the fabricator facility, the inner bottom cover plate, canister shell and all associated welds are leak-tested to demonstrate that these welds and components meet the “leak-tight” criterion ($\leq 1.0 \times 10^{-7}$ reference cm^3/sec) as defined in “American National Standard for Radioactive Materials – Leakage Tests on Packages for Shipment”, ANSI N14.5-1997. If the leakage rate exceeds 1.0×10^{-7} reference cm^3/sec, check and repair these welds or components.

Following completion of the welding of the DSC shell to the inner top cover and drain port cover and vent plug after fuel loading, these welds and components are leak-tested to demonstrate that they meet the “leak-tight” criterion ($\leq 1.0 \times 10^{-7}$ reference cm^3/sec) as defined in “American National Standard for Radioactive Materials - Leakage Tests on Packages for Shipment”, ANSI N14.5-1997. If the leakage rate exceeds 1.0×10^{-7} reference cm^3/sec, check and repair these welds or components.

5.1.3 HSM Thermal Monitoring Program

Two separate programs for the EOS-HSM and MATRIX HSM are described in Technical Specifications 5.1.3.1 and 5.1.3.2, respectively.

(continued)

5.0 ADMINISTRATIVE CONTROLS (continued)

5.1.3.1 EOS-HSM Thermal Monitoring Program

This program provides guidance for temperature measurements that are used to monitor the thermal performance of each EOS-HSM. The intent of the program is to prevent conditions that could lead to exceeding the concrete and fuel clad temperature criteria. Each user must implement either TS 5.1.3.1(a) OR 5.1.3.1(b).

a. Daily Visual Inspection of EOS-HSM Inlets and Outlets (Front Wall and Roof Birdscreens) and Wind Deflectors

  i. The user shall develop and implement procedures to perform visual inspection of EOS-HSM inlets and outlets on a daily basis.

  Perform a daily visual inspection of the air vents to ensure that EOS-HSM air vents are not blocked for more than 40 hours. If visual inspection indicates blockage, clear air vents and replace or repair birdscreens if damaged. If the air vents are blocked or could have been blocked for more than 40 hours, evaluate existing conditions in accordance with the site corrective action program to confirm that conditions adversely affecting the concrete or fuel cladding do not exist.

  ii. Daily Visual Inspection of Wind Deflectors

  If wind deflectors are required per TS 5.5, the user shall develop and implement procedures to perform visual inspection of the wind deflectors on a daily basis.

  There is a possibility that the wind deflectors could become damaged or lost by extreme winds, tornados, or other accidents. The condition caused by a damaged or lost wind deflector is bounded by the air vent blockage postulated and analyzed in the UFSAR accident analyses. The procedures shall ensure that the duration of a damaged or lost wind deflector will not exceed periods longer than 40 hours as assumed in the UFSAR analyses for vent blockage. If visual inspection indicates a damaged or lost wind deflector, replace or repair the wind deflector. If the wind deflectors are damaged or could have been damaged for more than 40 hours, evaluate existing conditions in accordance with the site corrective action program to confirm that conditions adversely affecting the concrete or fuel cladding do not exist.

b. Daily EOS-HSM Temperature Measurement Program

  i. The user shall develop a daily temperature measurement program to verify the thermal performance of each NUHOMS® EOS System. The user shall establish administrative temperature limits to (1) detect off-normal and accident blockage conditions before the EOS- HSM components and fuel cladding temperatures would exceed temperature design limits and (2) ensure the EOS-HSM air vents are not blocked for more than 40 hours. The daily temperature measurements shall include one of the following options:

    1. direct measurement of the EOS-HSM concrete temperature
    2. direct measurement of inlet and outlet air temperatures

(continued)

5.0 ADMINISTRATIVE CONTROLS (continued)

If the direct measurement of the inlet and outlet air temperatures (option 2) is performed, the measured temperature differences of the inlet and outlet vents of each individual EOS-HSM must be compared to the predicted temperature differences for each individual EOS-HSM during normal operations. The measured temperature difference between the inlet and outlet vents shall not exceed 138 °F.

ii. The user shall establish in the program, measurement locations in the EOS-HSM that are representative of the EOS-HSM thermal performance and directly correlated to the predicted fuel cladding temperatures, air mass flow rates, and NUHOMS® EOS System temperature distributions that would occur with the off-normal and accident blockage conditions, as analyzed in the UFSAR. The administrative temperature limits shall employ appropriate safety margins that ensure temperatures would not exceed design basis temperature limits in the UFSAR, and be based on the UFSAR methodologies used to predict thermal performance of the NUHOMS® EOS System. If the direct measurement of the inlet and outlet air temperatures (option 2) is performed, the user must develop procedures to measure air temperatures that are representative of inlet and outlet air temperatures, as analyzed in the UFSAR. The user must also consider site-specific environmental conditions, loaded decay heat patterns, and the proximity of adjacent EOS-HSM modules in the daily air temperature measurement program. The user must ensure that measured air temperatures reflect only the thermal performance of each individual module, and not the combined performance of adjacent modules.

iii. The user shall establish in the program the appropriate actions to be taken if administrative temperature criteria are exceeded. If an administrative temperature limit is exceeded during a daily measurement, the user shall inspect the vents, wind deflectors if installed, and implement TS 5.1.3.1(a) for the affected system, until the cause of the excursion is determined and necessary corrective actions are completed under the site corrective action program.

iv. If measurements or other evidence indicate that the EOS-HSM concrete temperatures have exceeded the concrete accident temperature limit of 500 °F for more than 40 hours, the user shall perform an analysis and/or tests of the concrete in accordance with TS 5.3. The user shall demonstrate that the structural strength of the EOS-HSM has an adequate margin of safety and take appropriate actions to return the EOS-HSM to normal operating conditions.

v. If measurements or other evidence indicate that off-normal or accident temperature limits for fuel cladding have been exceeded, verify that canister confinement is maintained and assess analytically the condition of the fuel. Additionally, within 30 days, take appropriate actions to restore the spent fuel to a safe configuration.

(continued)

5.0 ADMINISTRATIVE CONTROLS (continued)

5.1.3.2 HSM-MX Thermal Monitoring Program

This program provides guidance for temperature measurements that are used to monitor the thermal performance of each HSM-MX. There are no credible scenarios that could block both the inlet and outlet vents. Therefore, only blockage of inlet vent is considered in the UFSAR. The intent of the program is to prevent conditions that could lead to exceeding the concrete and fuel clad temperature criteria. Each user must implement either TS 5.1.3.2(a) OR 5.1.3.2(b).

a. Daily Visual Inspection of HSM-MX Inlets and Outlets (Front Wall and Roof Birdscreens)

The user shall develop and implement procedures to perform visual inspection of HSM-MX inlets and outlets on a daily basis.

Perform a daily visual inspection of the air vents to ensure that HSM-MX air vents are not blocked for more than 32 hours. If visual inspection indicates blockage, clear air vents and replace or repair birdscreens if damaged. If the air vents are blocked or could have been blocked for more than 32 hours, evaluate existing conditions in accordance with the site corrective action program to confirm that conditions adversely affecting the concrete or fuel cladding do not exist.

b. Daily HSM-MX Temperature Measurement Program

i. The user shall develop a daily temperature measurement program to verify the thermal performance of each HSM-MX System through direct measure of the HSM-MX concrete temperature. The user shall establish administrative temperature limits to (1) detect off-normal and accident blockage conditions before the HSM-*MX* components and fuel cladding temperatures would exceed temperature design limits and (2) ensure the HSM-MX air vents are not blocked for more than 32 hours.

ii. The user shall establish in the program measurement locations in the HSM-MX that are representative of the HSM-MX thermal performance and directly correlated to the predicted fuel cladding temperatures, air mass flow rates, and NUHOMS® MATRIX System temperature distributions that would occur with the off-normal and accident blockage conditions, as analyzed in the UFSAR. The administrative temperature limits shall employ appropriate safety margins that ensure temperatures would not exceed design basis temperature limits in the UFSAR, and be based on the UFSAR methodologies used to predict thermal performance of the NUHOMS® MATRIX System.

iii. The user shall establish in the program the appropriate actions to be taken if administrative temperature criteria are exceeded. If an administrative temperature limit is exceeded during a daily measurement, the user shall inspect the vents and implement TS 5.1.3.2(a) for the affected system, until the cause of the excursion is determined and necessary corrective actions are completed under the site corrective action program.

(continued)

5.0 ADMINISTRATIVE CONTROLS (continued)

iv. If measurements or other evidence indicate that the HSM-MX concrete temperatures have exceeded the concrete accident temperature limit of 500 °F for more than 32 hours, the user shall perform an analysis and/or tests of the concrete in accordance with TS 5.3. The user shall demonstrate that the structural strength of the HSM-MX has an adequate margin of safety and take appropriate actions to return the HSM-MX to normal operating conditions.

v. If measurements or other evidence indicate that off-normal or accident temperature limits for fuel cladding have been exceeded, verify that canister confinement is maintained and assess analytically the condition of the fuel. Additionally, within 30 days, take appropriate actions to restore the spent fuel to a safe configuration.

5.2 Lifting Controls

5.2.1 TC/DSC Lifting Height and Temperature Limits

The requirements of 10 CFR 72 apply to TC/DSC lifting/handling height limits outside the FUEL BUILDING. The requirements of 10 CFR Part 50 apply to TC/DSC lifting/handling height limits inside the FUEL BUILDING. Confirm the surface temperature of the TC before TRANSFER OPERATIONS of the loaded TC/DSC.

The lifting height of a loaded TC/ DSC is limited as a function of low temperature and the type of lifting/handling device, as follows:

- No lifts or handling of the TC/DSC at any height are permissible at TC surface temperatures below 0 °F
- The maximum lift height of the TC/DSC shall be 65 inches for the EOS-DSCs or 80 inches for the 61BTH Type 2 DSC if the surface temperature of the TC is above 0 °F and a non-single-failure-proof lifting/handling device is used.
- No lift height restriction is imposed on the TC/DSC if the TC surface temperature is higher than 0 °F, and a single-failure-proof lifting/handling system is used.

The requirements of 10 CFR Part 72 apply when the TC/DSC is in a horizontal orientation on the transfer trailer. The requirements of 10 CFR Part 50 apply when the TC/DSC is being lifted/handled using the cask handling crane/hoist. (This distinction is valid only with respect to lifting/handling height limits.)

5.2.2 Cask Drop

Inspection Requirement

The TC will be inspected for damage and the DSC will be evaluated after any TC with a loaded DSC side drop of 15 inches or greater.

(continued)

5.0 ADMINISTRATIVE CONTROLS (continued)

Background

TC/DSC handling and loading activities are controlled under the 10 CFR Part 50 license until a loaded TC/DSC is placed on the transporter, at which time fuel handling activities are controlled under the 10 CFR Part 72 license.

Safety Analysis

The analysis of bounding drop scenarios shows that the TC will maintain the structural integrity of the DSC confinement boundary from an analyzed side drop height of 65 inches for the EOS-DSCs and 80 inches for the 61BTH Type 2 DSC. This 65-inch/80-inch drop height envelopes the maximum height from the bottom of the TC when secured to the transfer trailer while en route to the ISFSI.

Although analyses performed for cask drop accidents at various orientations indicate much greater resistance to damage, requiring the inspection of the DSC after a side drop of 15 inches or greater ensures that:

1. The DSC will continue to provide confinement.
2. The TC can continue to perform its design function regarding DSC transfer and shielding.

5.3 Concrete Testing

HSM concrete shall be tested during the fabrication process for elevated temperatures to verify that there are no significant signs of spalling or cracking and that the concrete compressive strength is greater than that assumed in the structural analysis. Tests shall be performed at or above the calculated peak *accident* temperature and for a period no less than the permissible duration as specified in Technical Specification 5.1.3.

HSM concrete temperature testing shall be performed whenever:

- There is a change in the supplier of the cement, or
- There is a change in the source of the aggregate, or
- The water-cement ratio changes by more than 0.04.

(continued)

5.0 ADMINISTRATIVE CONTROLS (continued)

5.4 Hydrogen Gas Monitoring

For DSCs, while welding the inner top cover during LOADING OPERATIONS, and while cutting the inner top cover to DSC shell weld when the DSC cavity is wet during UNLOADING OPERATIONS, hydrogen monitoring of the space under the top shield plug in the DSC cavity is required, to ensure that the combustible mixture concentration remains below the flammability limit of 4%. If this limit is exceeded, all welding operations shall be stopped and the DSC cavity purged with helium to reduce hydrogen concentration safely below the limit before welding or cutting operations can be resumed.

5.5 EOS-HSM Wind Deflectors

If the heat load of an EOS-37PTH DSC during STORAGE OPERATIONS is greater than 41.8 kW, wind deflectors shall be installed on the EOS-HSM.

If the heat load of a fuel assembly loaded per HLZC 5 in the EOS-37PTH DSC during STORAGE OPERATIONS is greater than 1.625 kW, wind deflectors shall be installed on the EOS-HSM.

If the heat load of an EOS-89BTH DSC during STORAGE OPERATIONS is greater than 41.6 kW, wind deflectors shall be installed on the EOS-HSM.

Table 1
Fuel Assembly Design Characteristics for the EOS-37PTH DSC

PWR FUEL CLASS	B&W 15X15	WE 17X17	CE 15X15	WE 15X15	CE 14X14	WE 14X14	CE 16X16
Fissile Material	UO_2	UO_2	UO_2	UO_2	UO_2	UO_2	UO_2
Maximum Number of Fuel Rods	208	264	216	204	176	179	236
Maximum Number of Guide/ Instrument Tubes	17	25	9	21	5	17	5

Table 2
Maximum Uranium Loading per FFC for Failed PWR Fuel

Fuel Assembly Class	**Maximum Uranium Loading (MTU)**
WE 17x17	0.550
CE 16x16	0.456
BW 15x15	0.492
WE 15x15	0.480
CE 15x15	0.450
CE 14x14	0.400
WE 14x14	0.410

Table 3
Co-60 Equivalent Activity for CCs Stored in the EOS-37PTH DSC

Fuel Region	***Maximum Co-60 Equivalent Activity per DSC (Curies/DSC)***$^{(2)}$		
	Transfer in the EOS-TC108 AND (storage in the EOS-HSM OR HSM-MX)	***Transfer in the EOS-TC125/135 AND storage in the HSM-MX***	***Transfer in the EOS-TC125/135 AND storage in the EOS-HSM***
Active Fuel	32,656		*37,259*
Plenum/Top Region	6,671		*7,607*

Notes:

1. Not Used.
2. NSAs and Neutron Sources shall only be stored in the inner zone of the basket. Figure 3 defines the compartments categorized as the Inner and Peripheral Zones.

Table 4
Maximum Planar Average Initial Enrichment for EOS-37PTH

(2 Pages)

PWR Fuel Class	Minimum Soluble Boron (ppm)	Maximum Planar Average Initial Enrichment (wt. % U-235) as a Function of Soluble Boron Concentration and Basket Type (Fixed Poison Loading) With and Without CCs							
		Basket Type							
		A1/A2/A3/A4H/A4L/A5				B1/B2/B3/B4H/B4L/B5			
		w/o CCs		w/ CCs		w/o CCs		w/ CCs	
		INTACT FUEL	DAMAGED/ FAILED FUEL(2)	INTACT FUEL	DAMAGED/ FAILED FUEL(2)	INTACT FUEL	DAMAGED/ FAILED FUEL(3)	INTACT FUEL	DAMAGED/ FAILED FUEL(3)
WE 17x17 Class	2000	4.35	4.20	4.35	4.15	4.50	4.15	4.45	4.25
	2100	4.50	4.20	4.45	4.20	4.65	4.25	4.60	4.40
	2200	4.60	4.40	4.55	4.35	4.75	4.45	4.70	4.55
	2300	4.70	4.45	4.65	4.50	4.85	4.65	4.85	4.60
	2400	4.85	4.45	4.80	4.60	5.00	4.65	4.95	4.75
	2500	4.95	4.65	4.90	4.70	5.00	5.00	5.00	4.95
CE 16x16 Class	2000	5.00	4.75	5.00	4.70	5.00	5.00	5.00	5.00
	2100	5.00	5.00	5.00	5.00	-	-	-	-
	2200	-	-	-	-	-	-	-	-
	2300	-	-	-	-	-	-	-	-
	2400	-	-	-	-	-	-	-	-
	2500	-	-	-	-	-	-	-	-
BW 15x15 Class	2000	4.25	4.05	4.20	4.00	4.40	4.10	4.35	4.15
	2100	4.40	4.10	4.30	4.15	4.55	4.20	4.45	4.25
	2200	4.50	4.25	4.45	4.15	4.65	4.35	4.60	4.30
	2300	4.60	4.35	4.55	4.30	4.80	4.40	4.70	4.50
	2400	4.75	4.40	4.65	4.45	4.90	4.55	4.85	4.50
	2500	4.85	4.55	4.75	4.65	5.00	4.75	4.90	4.75
	2600	(1)	(1)	(1)	(1)	5.00	5.00	(1)	(1)
WE 15x15	2000	4.45	4.10	4.40	4.10	4.55	4.30	4.55	4.25
	2100	4.60	4.15	4.55	4.15	4.65	4.50	4.65	4.35
	2200	4.70	4.25	4.65	4.35	4.80	4.55	4.80	4.45
	2300	4.85	4.35	4.75	4.45	5.00	4.50	4.95	4.50
	2400	4.95	4.50	4.90	4.50	5.00	4.90	5.00	4.80
	2500	5.00	4.75	5.00	4.65	5.00	5.00	5.00	5.00
CE 15x15 Assembly Class	2000	4.60	4.25	4.55	4.20	4.75	4.35	4.70	4.30
	2100	4.70	4.45	4.65	4.40	4.85	4.50	4.85	4.35
	2200	4.85	4.50	4.80	4.45	5.00	4.60	4.95	4.60
	2300	5.00	4.55	4.90	4.65	5.00	5.00	5.00	4.80
	2400	5.00	5.00	5.00	4.85	5.00	5.00	5.00	5.00
	2500	-	-	5.00	5.00	-	-	-	-
CE 14x14 Assembly Class	2000	5.00	5.00	5.00	4.50	5.00	5.00	5.00	4.95
	2100	-	-	5.00	4.95	-	-	5.00	5.00
	2200	-	-	5.00	5.00	-	-	-	-
	2300	-	-	-	-	-	-	-	-
	2400	-	-	-	-	-	-	-	-
	2500	-	-	-	-	-	-	-	-

Table 4
Maximum Planar Average Initial Enrichment for EOS-37PTH

(2 Pages)

PWR Fuel Class	Maximum Planar Average Initial Enrichment (wt. % U-235) as a Function of Soluble Boron Concentration and Basket Type (Fixed Poison Loading) With and Without CCs								
	Minimum Soluble Boron (ppm)	Basket Type							
		A1/A2/A3/A4H/A4L/A5				B1/B2/B3/B4H/B4L/B5			
		w/o CCs		w/ CCs		w/o CCs		w/ CCs	
		INTACT FUEL	DAMAGED/ FAILED FUEL(2)	INTACT FUEL	DAMAGED/ FAILED FUEL(2)	INTACT FUEL	DAMAGED/ FAILED FUEL(3)	INTACT FUEL	DAMAGED/ FAILED FUEL(3)
WE 14x14 Class	2000	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	2100	-	-	-	-	-	-	-	-
	2200	-	-	-	-	-	-	-	-
	2300	-	-	-	-	-	-	-	-
	2400	-	-	-	-	-	-	-	-
	2500	-	-	-	-	-	-	-	-

Notes:

1. Not analyzed.
2. May only be stored in basket types A4H and A4L
3. May only be stored in basket types B4H and B4L

Table 5
Minimum B-10 Content in the Neutron Poison Plates of the EOS-37PTH DSC

Basket Type	Minimum B-10 Content (areal density) for MMC (mg/cm^2)
A1/A2/A3/A4H/A4L/A5	28.0
B1/B2/B3/B4H/B4L/B5	35.0

Table 6
Fuel Assembly Design Characteristics for the EOS-89BTH DSC

BWR FUEL CLASS	BWR Fuel ID	Example Fuel Designs [(1)(2)]
7 x 7	ENC-7-A	ENC-IIIA
7 x 7	ENC-7-B	ENC-III ENC-IIIE ENC-IIIF
7 x 7	GE-7-A	GE-1, GE-2, GE-3
8 x 8	ENC-8-A	ENC Va and Vb
8 x 8	ABB-8-A	SVEA-64
8 x 8	ABB-8-B	SVEA-64
8 x 8	FANP-8-A	FANP 8x8-2
8 x 8	GE-8-A	GE-4, XXX-RCN
8 x 8	GE-8-B	GE-5, GE-Pres GE-Barrier GE-8 Type 1
8 x 8	GE-8-C	GE-8 Type II
8 x 8	GE-8-D	GE-9, GE-10
9 x 9	FANP-9-A	FANP-9x9-79/2 FANP-9x9-72 FANP-9x9-80 FANP-9x9-81
9 x 9	FANP-9-B	Siemens QFA ATRIUM 9
9 x 9	GE-9-A	GE-11, GE-13
10 x 10	ABB-10-A	SVEA-92 SVEA-96Opt SVEA-100
10 x 10	ABB-10-B	SVEA-92 SVEA-96 SVEA-100
10 x 10	ABB-10-C	SVEA-96Opt2
10 x 10	FANP-10-A	ATRIUM 10 ATRIUM 10XM
10 x 10	GE-10-A	GE-12, GE-14
10 x 10	GE-10-B	GNF2
11 x 11	FANP-11-A	ATRIUM 11

Notes:

1. Any fuel channel average thickness up to 0.120 inch is acceptable on any of the fuel designs.
2. Example BWR fuel designs are listed herein and are not all-inclusive.

Table 7A
PWR Minimum Enrichments as a Function of Burnup

Burnup Range (GWd/MTU)	**Minimum Enrichment (wt. % U-235)**
1-6	0.7
7-16	1.3
17-30	1.8
31-62	Burnup/16(1)

Notes:

(1) Round enrichment down to the nearest 0.1%. Example: for 62 GWd/MTU, 62/16 = 3.875%, round down to 3.8%.

(2) Fuel below the minimum enrichment defined in this table is classified as LOW-ENRICHED OUTLIER FUEL. Number and location are specified in Section 2.1.

Table 7B

EOS-37PTH DSC Fuel Qualification Table *for Storage in the HSM-MX*, All Fuel

(Minimum required years of cooling time after reactor core discharge)

Burnup (GWd/FA)	Fuel Assembly Average Initial U-235 Enrichment (wt.%)												
	0.7	1.3	1.8	2.0	2.5	2.8	3.1	3.4	3.7	3.8	4.0	4.5	5.0
2.95	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
4.92		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
9.84			2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
14.76			2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
19.68					2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
22.14						2.16	2.12	2.09	2.05	2.04	2.02	2.00	2.00
24.60							2.35	2.31	2.28	2.26	2.24	2.18	2.14
27.06								2.55	2.51	2.49	2.47	2.41	2.35
29.52									2.76	2.75	2.71	2.64	2.58
30.50										2.85	2.82	2.74	2.67
34.10										3.22	3.20	3.11	3.03

Notes:

(1) The minimum cooling time is 2.0 years.

(2) The burnup in GWd/FA is the assembly average burnup in GWd/MTU multiplied by the MTU of the fuel assembly.

(3) Linear interpolation is allowed to obtain a cooling time within the specified range of burnup and enrichment values.

(4) Extrapolation is allowed to obtain a cooling time in the gray-shaded region.

Table 7C
EOS-37PTH DSC Fuel Qualification Table for Storage in the EOS-HSM, All Fuel

(Minimum required years of cooling time after reactor core discharge)

Burnup (GWd/FA)	*Fuel Assembly Average Initial U-235 Enrichment (wt.%)*												
	0.7	*1.3*	*1.8*	*2.0*	*2.5*	*2.8*	*3.1*	*3.4*	*3.7*	*3.8*	*4.0*	*4.5*	*5.0*
2.95	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*
3.44		*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*
7.87		*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*
8.36			*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*
9.84			*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*
14.76			*1.08*	*1.07*	*1.03*	*1.01*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*
19.68					*1.35*	*1.32*	*1.30*	*1.27*	*1.25*	*1.24*	*1.23*	*1.20*	*1.17*
22.14						*1.48*	*1.46*	*1.43*	*1.40*	*1.39*	*1.38*	*1.34*	*1.31*
24.60							*1.62*	*1.59*	*1.56*	*1.55*	*1.53*	*1.49*	*1.45*
27.06								*1.75*	*1.72*	*1.71*	*1.69*	*1.65*	*1.60*
29.52									*1.89*	*1.88*	*1.85*	*1.80*	*1.76*
30.50										*1.94*	*1.92*	*1.87*	*1.82*
34.10										*2.19*	*2.17*	*2.11*	*2.06*

Notes:

1. *The minimum cooling time is 1 year. For fuel transferred in the EOS-TC108, the minimum cooling time is 2.0 years.*
2. *The burnup in GWd/FA is the assembly average burnup in GWd/MTU multiplied by the MTU of the fuel assembly.*
3. *Linear interpolation is allowed to obtain a cooling time within the specified range of burnup and enrichment values.*
4. *Extrapolation is allowed to obtain a cooling time in the gray-shaded region.*

Table 8
Maximum Lattice Average Initial Enrichment and Minimum B-10 Areal Density for the EOS-89BTH DSC

Basket Type	Loading Configuration - Number of Fuel Assemblies (1)	Maximum Lattice Average Initial Enrichment (wt. % U-235)			Minimum B-10 Areal Density (mg/cm²)	
		All fuel Except ABB-10-C and ATRIUM 11	ABB-10-C Fuel	ATRIUM 11 Fuel	MMC	BORAL®
A1/A2/A3 (2)	89	4.20	4.05	4.05	32.7	39.2
	88	4.45	4.25	4.25		
	87	4.60	4.40	4.35		
	84	5.00	4.90	4.80		
B1/B2/B3 (2)	89	4.55	4.35	4.30	41.3	49.6
	88	4.80	4.60	4.50		
	87	4.95	4.70	4.65		
	84	5.00	5.00	5.00		
C1/C2/C3 (2)	89	4.85	4.60	(3)	Not Allowed	60.0

Note:

1. See Figure 10 for 88-FA, 87-FA and 84-FA loading configurations.
2. Mixing fuel types in the same DSC is permissible based on the calculated enrichments for each fuel type for a given basket type and loading configuration. For example, when mixing GNF2 and ATRIUM 11 fuels in basket type A1/A2/A3 and 88-fuel-assembly loading configuration, the maximum enrichment for GNF2 fuels is 4.45wt% and the maximum enrichment for ATRIUM 11 fuels is 4.25wt%.
3. ATRIUM 11 fuel is not an allowed content for basket type C1/C2/C3.

Table 9
Maximum Lattice Average Initial Enrichment and Minimum B-10 Areal Density for the 61BTH Type 2 DSC (Intact Fuel)

Basket Type	Maximum Lattice Average Initial Enrichment (wt. % U-235)(1)	Minimum B-10 Areal Density, (mg/cm^2)	
		Borated Aluminum/MMC	Boral®
A	3.7	22	27
B	4.1	32	38
C	4.4	42	50
D	4.6	48	58
E	4.8	55	66
F	5.0(1)	62	75

Note:

1) For ATRIUM 11 fuel assemblies, the U-235 wt. % enrichment is reduced by 0.55%. The ATRIUM 11 fuel assemblies are authorized for storage in the Type F basket only.

Table 10
Maximum Lattice Average Initial Enrichment and Minimum B-10 Areal Density for the 61BTH Type 2 DSC (Damaged Fuel)

Basket Type	Maximum Lattice Average Initial Enrichment (wt. % U-235)		Minimum B-10 Areal Density, (mg/cm^2)	
	Up to 4 Damaged Assemblies(1)	Five or More Damaged Assemblies(1) (16 Maximum)	Borated Aluminum/MMC	Boral®
A	3.7	2.80	22	27
B	4.1	3.10	32	38
C	4.4	3.20	42	50
D	4.6	3.40	48	58
E	4.8	3.50	55	66
F	5.0(2, 3)	3.60	62	75

Notes:

1) See Figure 5 for the location of damaged fuel assemblies within the 61BTH Type 2 DSC.
2) ATRIUM 11 fuel assemblies are authorized for storage only in the Type F basket only with a maximum of 4 damaged fuel assemblies.
3) For ATRIUM 11 fuel assemblies, the U-235 wt. % enrichment is reduced by 0.55%.

Table 11

Maximum Lattice Average Initial Enrichment and Minimum B-10 Areal Density for the 61BTH Type 2 DSC (Failed and Damaged Fuel)

Basket Type	**Maximum Lattice Average Initial Enrichment (wt. % U-235)**		**Minimum B-10 Areal Density (mg/cm^2)**	
	Up to 4 Failed Assemblies (Corner Locations)(1, 2)	**Up to 4 Failed Assemblies (Corner Locations) and up to 12 Damaged Assemblies (Interior Locations)(1, 2)**	**Borated Aluminum/MMC**	**Boral®**
A	3.7	2.8	22	27
B	4.0	3.1	32	38
C	4.4	3.2	42	50
D	4.6	3.4	48	58
E	4.8	3.4	55	66
F	5.0	3.5	62	75

Notes:

1) See Figure 5 for the locations of the failed and damaged assemblies within the 61BTH Type 2 DSC.
2) Failed ATRIUM 11 fuel assemblies are not authorized for storage in the 61BTH Type 2 DSC.

Table 12
Maximum Lattice Average Initial Enrichments and Minimum B-10 Areal Density for the 61BTH Type 2 DSC for > 16 Damaged Fuel Assemblies

Basket Type	Up to 57 Damaged Fuel at 3.30 wt. % U-235		Minimum B-10 Areal Density (mg/cm^2)	
	Remaining Four Intact Assemblies (1)	Remaining Four Damaged Assemblies (1)	Borated Aluminum/MMC	Boral®
A	-	-	-	-
B	-	-	-	-
C	-	-	-	-
D	5.00	4.20	48	58
E	5.00	4.20	55	66
F	5.00	4.20	62	75

Note:
1) See Figure 5 for the locations of the damaged assemblies within the 61BTH Type 2 DSC

Table 13
BWR Fuel Assembly Design Characteristics for the 61BTH Type 2 DSC

BWR FUEL CLASS	Initial Design or Reload Fuel Designation(1) (3)
7x7-49/0	GE1 GE2 GE3
8x8-63/1	GE4
8x8-62/2	GE-5 GE-Pres GE-Barrier GE8 Type I
8x8-60/4	GE8 Type II
8x8-60/1	GE9 GE10
9x9-74/2	GE11 GE13
10x10-92/2	GE12 GE14 GNF2
7x7-49/0	ENC-IIIA
7x7-48/1Z	ENC-III(2)
8x8-60/4Z	ENC Va ENC Vb
8x8-62/2	FANP 8x8-2
9x9-79/2	FANP9 9x9-2
Siemens QFA	9x9
10x10-91/1	ATRIUM-10 ATRIUM-10XM
11x11	ATRIUM-11

Notes:

(1) Any fuel channel average thickness up to 0.120 inch is acceptable on any of the fuel designs.

(2) Includes ENC-IIIE and ENC-IIIF.

(3) Initial designs or reload fuel designations belonging to a listed fuel class, but not listed herein may be qualified for storage using the same methodology as documented in the UFSAR.

Table 14
Maximum Uranium Loading per FFC for Failed 61BTH Type 2 Fuel

Fuel Assembly Class	Maximum MTU/Assembly
7x7	0.198
8x8	0.188
9x9	0.180
10x10	0.187

Table 15
Deleted

Table 16
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Table 17
System Configurations for 61BTH Type 2 HLZCs

HLZC	Storage Module	Transfer Cask
1	HSM-MX	OS197/OS197H/ OS197FC-B/OS197HFC-B
2	HSM-MX	OS197/OS197H/ OS197FC-B/OS197HFC-B
3	HSM-MX	OS197/OS197H/ OS197FC-B/OS197HFC-B
4	HSM-MX	OS197/OS197H/ OS197FC-B/OS197HFC-B
5	HSM-MX	OS197FC-B/OS197HFC-B
6	HSM-MX	OS197FC-B/OS197HFC-B
7	HSM-MX	OS197FC-B/OS197HFC-B
8	HSM-MX	OS197FC-B/OS197HFC-B
9	HSM-MX	OS197/OS197H/ OS197FC-B/OS197HFC-B
10	HSM-MX	OS197FC-B/OS197HFC-B

Table 18
BWR Minimum Enrichments as a Function of Burnup (EOS-89BTH DSC and 61BTH Type 2 DSC)

Burnup Range (GWd/MTU)	Minimum Enrichment (wt. %)
1-6	0.7
7-19	0.9
20-35	Burnup/20(1)
36-62	Burnup/16(1)

Notes:

1) Round down to the nearest 0.1%. Example: for 62 GWd/MTU, 62/16 = 3.875%, round down to 3.8%.
2) Fuel below the minimum enrichment defined in this table is classified as LOW-ENRICHED OUTLIER FUEL. Number and location are specified in Section 2.2 for the EOS-89BTH DSC and in Section 2.3 for the 61BTH Type 2 DSC.

Table 19
61BTH Type 2 DSC Fuel Qualification Table, All Fuel

(Minimum required years of cooling time after reactor core discharge)

Burnup (GWd/FA)	Fuel Assembly Average Initial U-235 Enrichment (wt.%)														
	0.7	0.9	1.0	1.5	1.7	2.2	2.5	2.8	3.1	3.4	3.7	3.8	4.0	4.5	5.0
1.19	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1.39		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
2.97		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
3.76		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
3.96			2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
5.94				2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
6.93					2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
7.13						2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
7.92							2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
8.91								2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
9.90									2.11	2.06	2.01	2.00	2.00	2.00	2.00
10.89										2.29	2.24	2.22	2.19	2.11	2.05
11.88											2.48	2.46	2.43	2.34	2.27
12.28												2.57	2.53	2.44	2.36

Notes:

1) The minimum cooling time is 2.0 years.
2) The burnup in GWd/FA is the assembly average burnup in GWd/MTU multiplied by the MTU of the fuel assembly.
3) Linear interpolation is allowed to obtain a cooling time within the specified range of burnup and enrichment values.
4) Extrapolation is allowed to obtain a cooling time in the gray-shaded region.

Table 20
61BTH Type 2 DSC Fuel Qualification Table, HLZC 2, 4, 5, 6, 7, and 8, Peripheral Locations

(Minimum required years of cooling time after reactor core discharge)

Burnup (GWd/FA)	Fuel Assembly Average Initial U-235 Enrichment (wt.%)														
	0.7	0.9	1.0	1.5	1.7	2.2	2.5	2.8	3.1	3.4	3.7	3.8	4.0	4.5	5.0
1.19	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1.39		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
2.97		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
3.76		2.35	2.33	2.23	2.20	2.12	2.09	2.06	2.03	2.01	2.00	2.00	2.00	2.00	2.00
3.96			2.41	2.31	2.28	2.20	2.16	2.13	2.10	2.08	2.06	2.05	2.04	2.02	2.00
5.94				3.13	3.09	2.98	2.93	2.88	2.83	2.79	2.75	2.74	2.72	2.67	2.63
6.93					3.55	3.43	3.36	3.29	3.24	3.18	3.14	3.12	3.10	3.03	2.98
7.13						3.52	3.45	3.39	3.33	3.27	3.22	3.21	3.18	3.11	3.06
7.92							3.87	3.79	3.71	3.64	3.58	3.57	3.53	3.45	3.38
8.91								4.39	4.29	4.20	4.12	4.10	4.05	3.94	3.85
9.90									5.03	4.91	4.80	4.77	4.70	4.56	4.43
10.89										5.86	5.70	5.65	5.56	5.35	5.18
11.88											6.97	6.89	6.75	6.45	6.19
12.28												7.53	7.36	7.00	6.70

Notes:

1) The minimum cooling time is 2.0 years.
2) The burnup in GWd/FA is the assembly average burnup in GWd/MTU multiplied by the MTU of the fuel assembly.
3) Linear interpolation is allowed to obtain a cooling time within the specified range of burnup and enrichment values.
4) Extrapolation is allowed to obtain a cooling time in the gray-shaded region.
5) The peripheral locations are defined in Figure 6.

Table 21
EOS-89BTH DSC Fuel Qualification Table, All Fuel

(Minimum required years of cooling time after reactor core discharge)

Burnup (GWd/FA)	Fuel Assembly Average Initial U-235 Enrichment (wt.%)														
	0.7	0.9	1.0	1.5	1.7	2.2	2.5	2.8	3.1	3.4	3.7	3.8	4.0	4.5	5.0
1.19	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.39		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2.97		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3.76		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3.96			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5.94				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6.93					1.11	1.06	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7.13						1.09	1.06	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7.92							1.17	1.14	1.11	1.08	1.06	1.05	1.04	1.00	1.00
8.91								1.28	1.25	1.22	1.19	1.18	1.16	1.12	1.09
9.90									1.40	1.36	1.33	1.32	1.30	1.25	1.21
10.89										1.51	1.48	1.46	1.44	1.39	1.34
11.88											1.63	1.62	1.59	1.53	1.48
12.28												1.68	1.66	1.60	1.54

Notes:

1) The minimum cooling time is 1.0 year.
2) The burnup in GWd/FA is the assembly average burnup in GWd/MTU multiplied by the MTU of the fuel assembly.
3) Linear interpolation is allowed to obtain a cooling time within the specified range of burnup and enrichment values.
4) Extrapolation is allowed to obtain a cooling time in the gray-shaded region.
5) For fuel transferred in the EOS-TC108, additional cooling time restrictions are specified in Figure 2.

Table 22
EOS-89BTH DSC Reconstituted Fuel Limits for Transfer in the EOS-TC125

Parameter	Limit
Number of RECONSTITUTED FUEL ASSEMBLIES per DSC	≤ 89
Maximum number of irradiated stainless steel rods per RECONSTITUTED FUEL ASSEMBLY	Per table below
Minimum cooling time	Per table below

Number of Irradiated Stainless Steel Rods per Fuel Assembly										Minimum Cooling Time (years)
7x7 Class		8x8 Class		9x9 Class		10x10 Class		11x11 Class		
Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
0	5	0	6	0	7	0	9	0	11	Per Table 21
6	15	7	18	8	22	10	26	12	34	2.00
16	20	19	24	23	29	27	34	35	46	2.25
21	25	25	30	30	37	35	43	47	57	2.50
26	30	31	36	38	44	44	51	58	69	2.75
31	35	37	42	45	51	52	60	70	80	3.00
36	49	43	64	52	81	61	100	81	112	3.25

Table 23
EOS-89BTH DSC Reconstituted Fuel Limits for Transfer in the EOS-TC108

Parameter	Limit
Number of RECONSTITUTED FUEL ASSEMBLIES per DSC	• ≤ 89 (all types) • ≤ 49 containing irradiated stainless steel rods
Maximum number of irradiated stainless steel rods per DSC	• 100 for 7x7 Class • 120 for 8x8 Class • 140 for 9x9 Class • 180 for 10x10 Class • 220 for 11x11 Class
Maximum number of irradiated stainless steel rods per RECONSTITUTED FUEL ASSEMBLY	• 5 for 7x7 Class • 6 for 8x8 Class • 7 for 9x9 Class • 9 for 10x10 Class • 11 for 11x11 Class
Loading restrictions for locations within the basket	Per Figure 9
Minimum cooling time	Per Table 21

Table 24
EOS-37PTH DSC Reconstituted Fuel Limits for Transfer in the EOS-TC125/135 AND Storage in the EOS-HSM

Parameter	*Limit*
Number of RECONSTITUTED FUEL ASSEMBLIES per DSC	*≤ 37*
Maximum number of irradiated stainless steel rods per RECONSTITUTED FUEL ASSEMBLY	*Per table below*
Minimum cooling time	*Per table below*

Number of Irradiated Stainless Steel Rods per Fuel Assembly								*Minimum Cooling Time (years)*
14x14 Class		*15x15 Class*		*16x16 Class*		*17x17 Class*		
Min.	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	
0	*8*	*0*	*10*	*0*	*11*	*0*	*13*	*Per Table 7C*
9	*17*	*11*	*20*	*12*	*23*	*14*	*25*	*3.00*
18	*34*	*21*	*40*	*24*	*45*	*26*	*51*	*4.00*
35	*51*	*41*	*60*	*46*	*68*	*52*	*76*	*4.50*
52	*68*	*61*	*80*	*69*	*91*	*77*	*102*	*5.00*
69	*85*	*81*	*100*	*92*	*113*	*103*	*127*	*5.25*
86	*102*	*101*	*120*	*114*	*136*	*128*	*152*	*5.50*
103	*118*	*121*	*140*	*137*	*159*	*153*	*178*	*5.75*
119	*135*	*141*	*160*	*160*	*182*	*179*	*203*	*6.00*
136	*179*	*161*	*216*	*183*	*236*	*204*	*264*	*6.25*

Table 25
EOS-37PTH DSC Reconstituted Fuel Limits for Transfer in the EOS-TC108

Number of RECONSTITUTED FUEL ASSEMBLIES per DSC	• *≤ 37 (all types)* • *≤ 21 containing irradiated stainless steel rods*
Maximum number of irradiated stainless steel rods per DSC	• *32 for 14x14 Class* • *40 for 15x15 Class* • *48 for 16x16 and 17x17 Classes*
Maximum number of irradiated stainless steel rods per RECONSTITUTED FUEL ASSEMBLY	• *4 for 14x14 Class* • *5 for 15x15 Class* • *6 for 16x16 and 17x17 Classes*
Loading restrictions for locations within the basket	*Per Figure 14*
Minimum cooling time	*2 years*

Figure 1A

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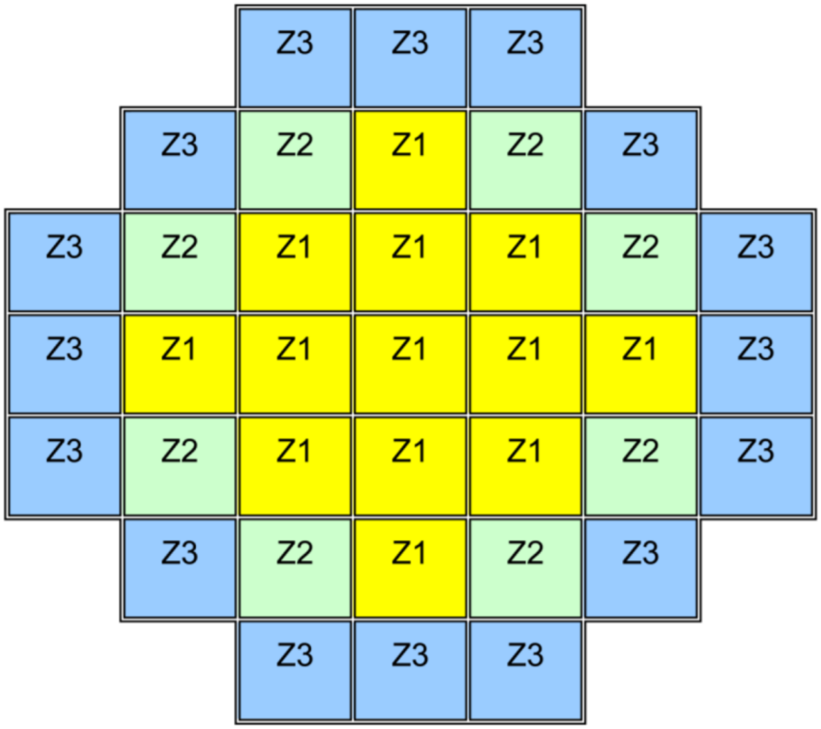
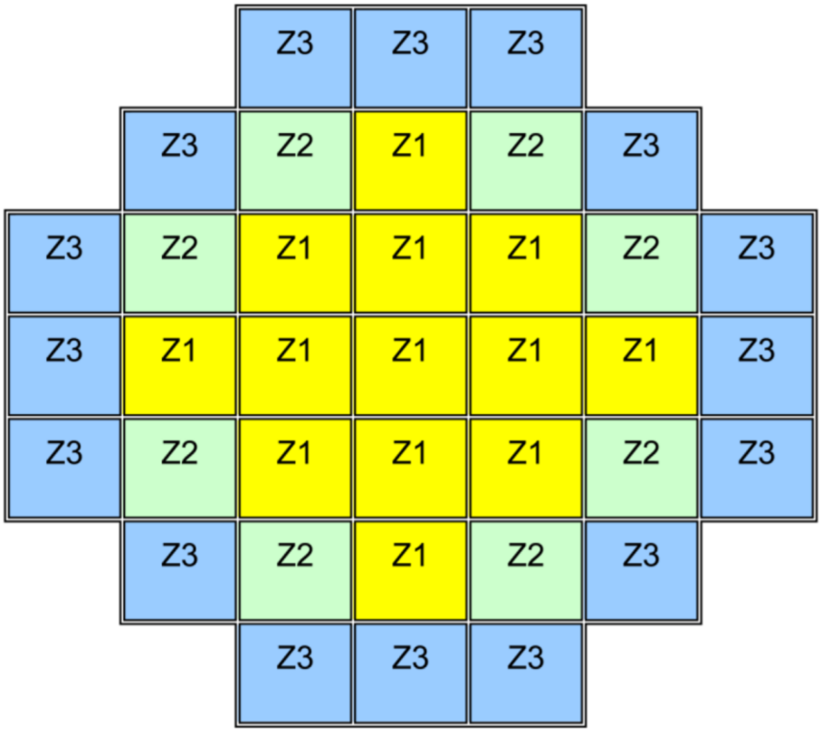


Zone Number	1	2	3
Maximum Decay Heat, (H), (kW/FA plus CCs, if included)	1.0	1.5	1.05
Maximum Number of Fuel Assemblies	13	8	16
Maximum Decay Heat per DSC (kW)	41.8		

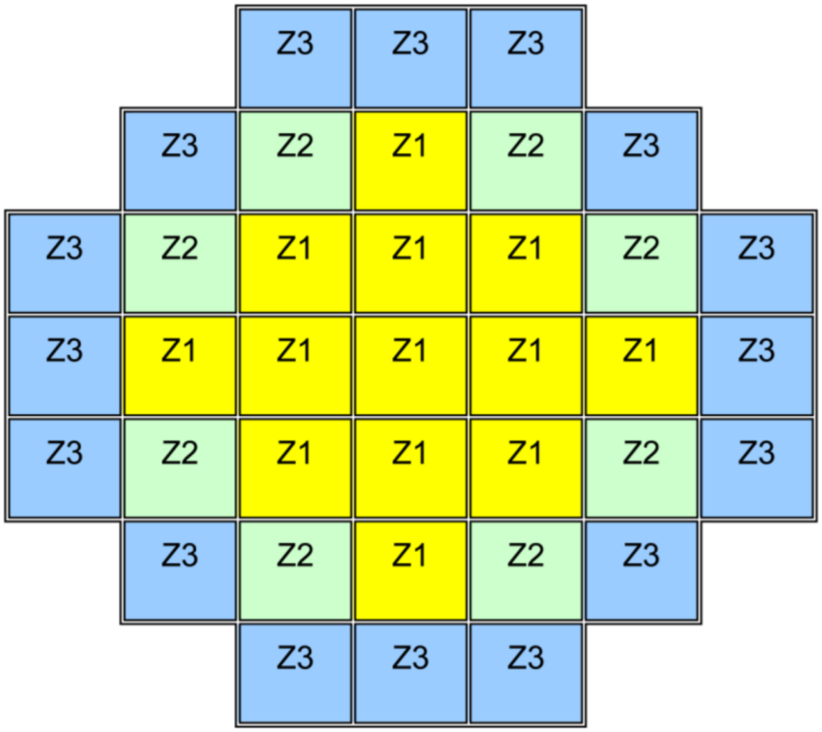
Figure 1B
Heat Load Zone Configuration 2 for the EOS-37PTH DSC



		Z3	Z3	Z3		
	Z3	Z2	Z1	Z2	Z3	
Z3	Z2	Z1	Z1	Z1	Z2	Z3
Z3	Z1	Z1	Z1	Z1	Z1	Z3
Z3	Z2	Z1	Z1	Z1	Z2	Z3
	Z3	Z2	Z1	Z2	Z3	
		Z3	Z3	Z3		

Zone Number	1	2	3
Maximum Decay Heat (kW/FA plus CCs, if included)	0.95	1.0	1.0
Maximum Number of Fuel Assemblies	13	8	16
Maximum Decay Heat per DSC (kW)	36.35		

Figure 1C
Heat Load Zone Configuration 3 for the EOS-37PTH DSC

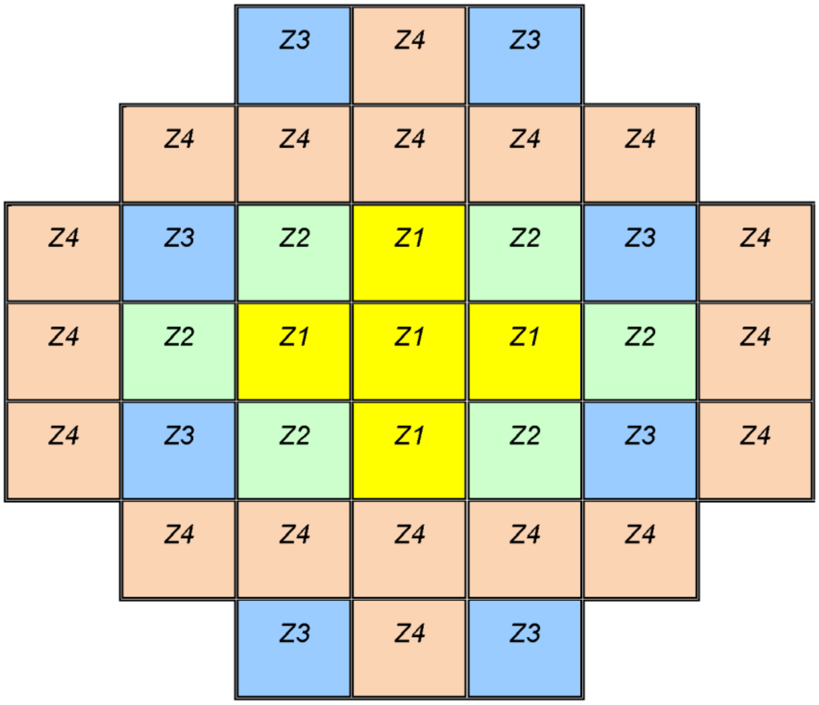


Zone Number	1	2	3
Maximum Decay Heat (kW/FA plus CCs, if included)	1.0	1.625	1.6
Maximum Number of Fuel Assemblies	13	8	16
Maximum Decay Heat per DSC (kW)	50.0(1)		

Notes:

1. Adjust payload to maintain total canister heat load within the specified limit.

Figure 1D
Heat Load Zone Configuration 4 for the EOS-37PTH DSC



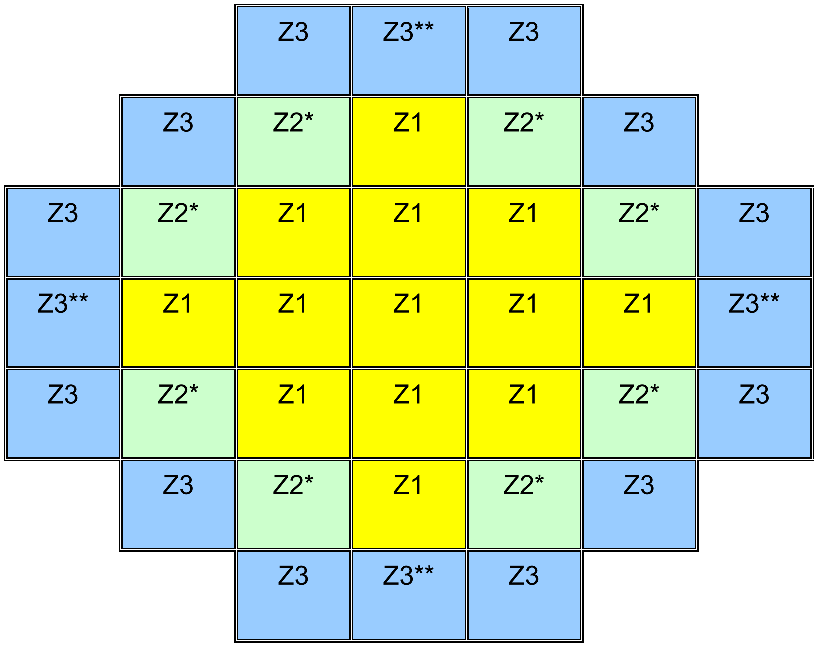
		Z3	Z4	Z3		
	Z4	Z4	Z4	Z4	Z4	
Z4	Z3	Z2	Z1	Z2	Z3	Z4
Z4	Z2	Z1	Z1	Z1	Z2	Z4
Z4	Z3	Z2	Z1	Z2	Z3	Z4
	Z4	Z4	Z4	Z4	Z4	
		Z3	Z4	Z3		

Zone Number	1	2	3	4
Maximum Decay Heat (kW/FA plus CCs, if included)	0.7	0.5	2.4	0.85
Maximum Number of Fuel Assemblies	5	6	8	18
Maximum Decay Heat per DSC (kW)	41.0			

Notes:

1. Adjust payload to maintain total canister heat load within the specified limit.

Figure 1E
Heat Load Zone Configuration 5 for the EOS-37PTH DSC



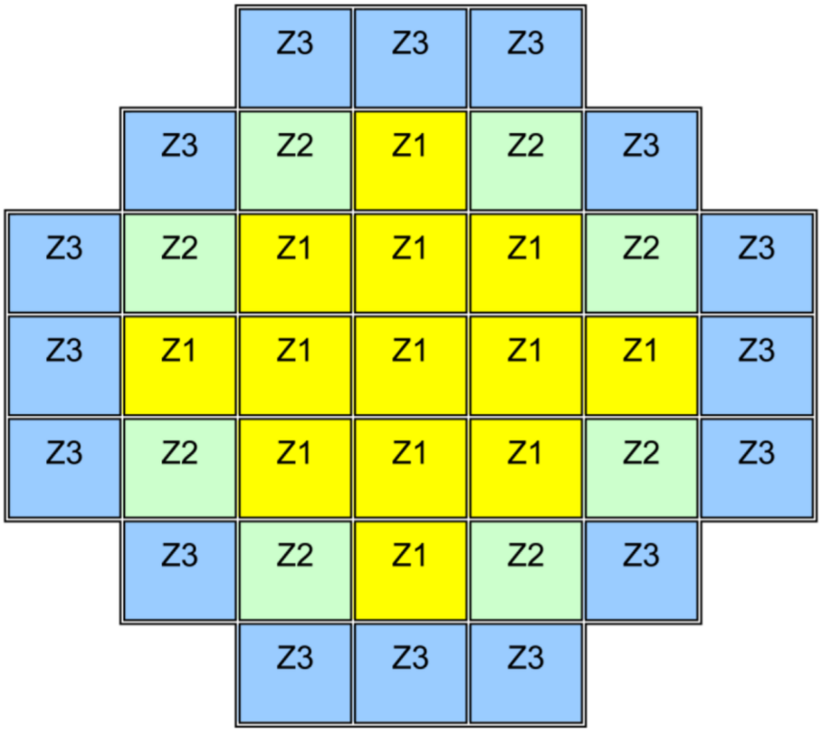
		Z3	Z3**	Z3		
	Z3	Z2*	Z1	Z2*	Z3	
Z3	Z2*	Z1	Z1	Z1	Z2*	Z3
Z3**	Z1	Z1	Z1	Z1	Z1	Z3**
Z3	Z2*	Z1	Z1	Z1	Z2*	Z3
	Z3	Z2*	Z1	Z2*	Z3	
		Z3	Z3**	Z3		

(*) denotes location where INTACT or DAMAGED FUEL can be stored.
(**) denotes location where INTACT or FAILED FUEL can be stored.

Zone Number	1	2(1)	3(1)
Maximum Decay Heat (kW/FA plus CCs, if included)	1.0	1.5	1.3125(2)
Maximum Number of Fuel Assemblies	13	8	16
Maximum Decay Heat per DSC (kW)	46.00		

1. DAMAGED FUEL and FAILED FUEL shall not be loaded in the same DSC.
2. The maximum allowable heat load per FAILED FUEL compartment is 0.8 kW.

Figure 1F
Heat Load Zone Configuration 6 for the EOS-37PTH DSC



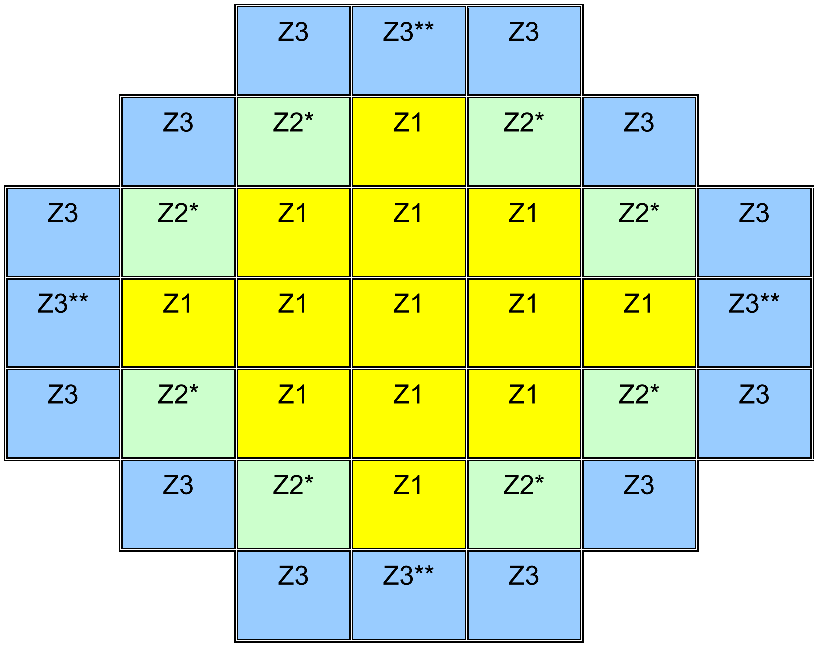
		Z3	Z3	Z3		
	Z3	Z2	Z1	Z2	Z3	
Z3	Z2	Z1	Z1	Z1	Z2	Z3
Z3	Z1	Z1	Z1	Z1	Z1	Z3
Z3	Z2	Z1	Z1	Z1	Z2	Z3
	Z3	Z2	Z1	Z2	Z3	
		Z3	Z3	Z3		

Zone Number	1	2	3
Maximum Number of Fuel Assemblies	13	8	16
Upper Compartment			
Maximum Decay Heat (kW/FA plus CCs, if included)	1.0	1.60	1.3125
Maximum Decay Heat per DSC (kW)	41.8(1)		
Lower Compartment			
Maximum Decay Heat (kW/FA plus CCs, if included)	0.9	1.60	1.60
Maximum Decay Heat per DSC (kW)	50.0(1)		

Notes:

1. Adjust payload to maintain total canister heat load within the specified limit.

Figure 1G
Heat Load Zone Configuration 7 for the EOS-37PTH DSC



		Z3	Z3**	Z3		
	Z3	Z2*	Z1	Z2*	Z3	
Z3	Z2*	Z1	Z1	Z1	Z2*	Z3
Z3**	Z1	Z1	Z1	Z1	Z1	Z3**
Z3	Z2*	Z1	Z1	Z1	Z2*	Z3
	Z3	Z2*	Z1	Z2*	Z3	
		Z3	Z3**	Z3		

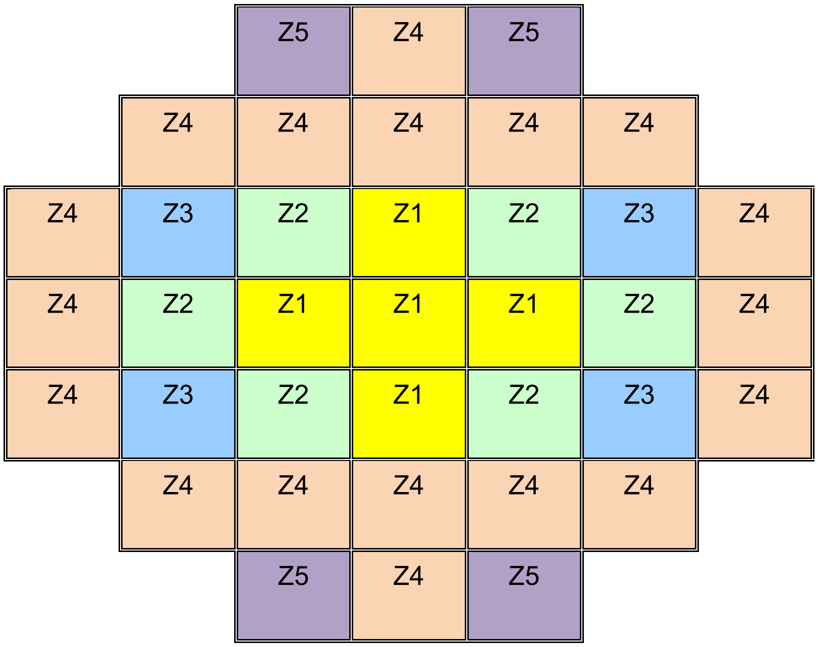
(*) denotes location where INTACT or DAMAGED FUEL can be stored.
(**) denotes location where INTACT or FAILED FUEL can be stored.

Zone Number	1	$2^{(2)}$	$3^{(2)(3)}$
Maximum Number of Fuel Assemblies	13	8	16
Upper Compartment			
Maximum Decay Heat (kW/FA plus CCs, if included)	0.8	1.50	1.50
Maximum Decay Heat per DSC (kW)	$41.8^{(1)(4)}$		
Lower Compartment			
Maximum Decay Heat (kW/FA plus CCs, if included)	0.8	1.50	1.50
Maximum Decay Heat per DSC (kW)	$46.4^{(1)}$		

Notes:

1. The maximum decay heat per DSC is limited to 41.8 kW when DAMAGED or FAILED FUEL is loaded.
2. DAMAGED FUEL and FAILED FUEL shall not be loaded in the same DSC.
3. The maximum allowable heat load per FAILED FUEL is 0.8 kW.
4. Adjust payload to maintain total canister heat load within the specified limit.

Figure 1H
Heat Load Zone Configuration 8 for the EOS-37PTH DSC

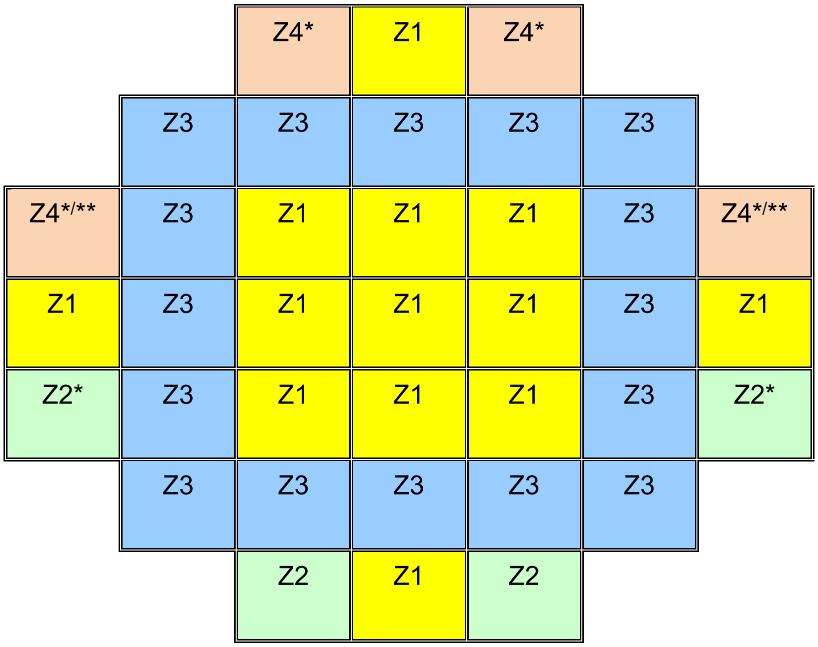


		Z5	Z4	Z5		
	Z4	Z4	Z4	Z4	Z4	
Z4	Z3	Z2	Z1	Z2	Z3	Z4
Z4	Z2	Z1	Z1	Z1	Z2	Z4
Z4	Z3	Z2	Z1	Z2	Z3	Z4
	Z4	Z4	Z4	Z4	Z4	
		Z5	Z4	Z5		

Zone Number	1	2	3	4	5
Maximum Decay Heat (kW/FA plus CCs, if included)	0.50	0.70	2.0	0.75	2.4
Maximum Number of Fuel Assemblies	5	6	4	18	4
Maximum Decay Heat per DSC (kW)	37.80				

Figure 1I
Heat Load Zone Configuration 9 for the EOS-37PTH DSC

Figure 1J
Deleted



		Z4*	Z1	Z4*		
	Z3	Z3	Z3	Z3	Z3	
Z4*/**	Z3	Z1	Z1	Z1	Z3	Z4*/**
Z1	Z3	Z1	Z1	Z1	Z3	Z1
Z2*	Z3	Z1	Z1	Z1	Z3	Z2*
	Z3	Z3	Z3	Z3	Z3	
		Z2	Z1	Z2		

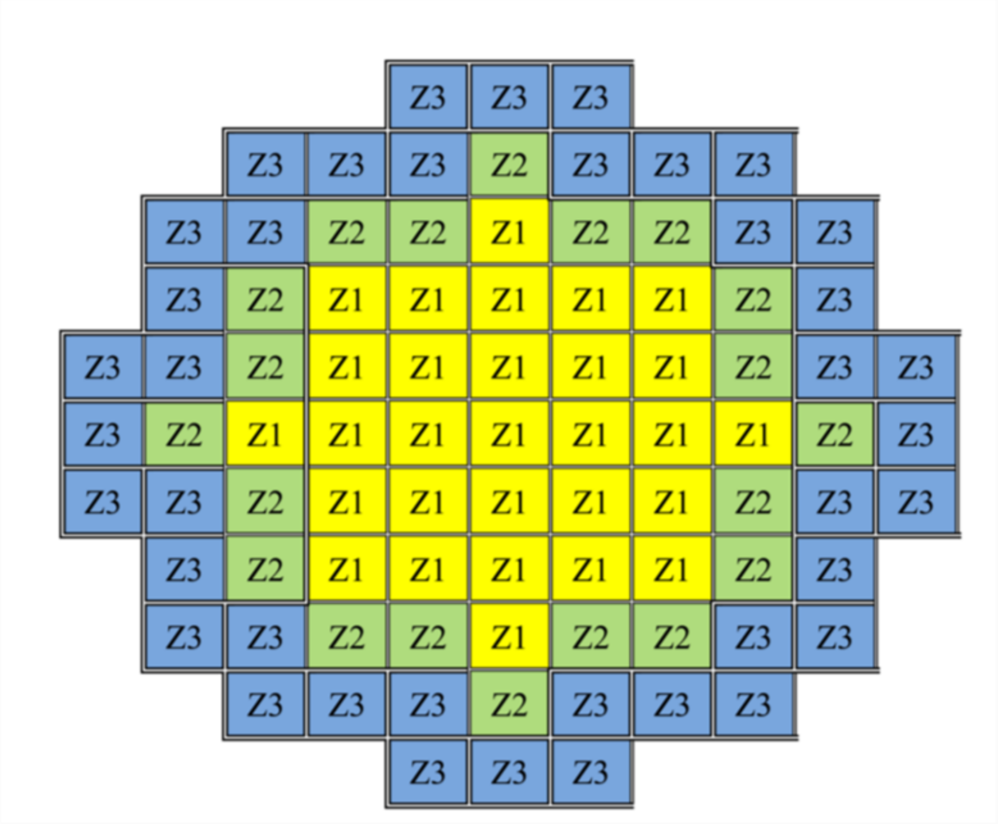
(*) denotes location where INTACT or DAMAGED FUEL ASSEMBLY can be stored.
(**) denotes location where INTACT or FAILED FUEL can be stored.

Zone Number	1	2(1)	3	4(1)
Maximum Number of Fuel Assemblies	13	4	16	4
Upper Compartment				
Maximum Decay Heat (kW/FA plus CCs, if included)	0.5	3.0	0.7	3.0(2)
Maximum Decay Heat per DSC (kW)	41.8			
Lower Compartment				
Maximum Decay Heat (kW/FA plus CCs, if included)	0.5	3.5	0.7	3.2(2)
Maximum Decay Heat per DSC (kW)	44.5			

Notes:

1. DAMAGED FUEL and FAILED FUEL shall not be loaded in the same DSC.
2. The maximum allowable heat load per FAILED FUEL is 0.8 kW.

Figure 1K
Heat Load Zone Configuration 11 for the EOS-37PTH DSC



				Z3	Z3	Z3				
		Z3	Z3	Z3	Z2	Z3	Z3	Z3		
	Z3	Z3	Z2	Z2	Z1	Z2	Z2	Z3	Z3	
	Z3	Z2	Z1	Z1	Z1	Z1	Z1	Z2	Z3	
Z3	Z3	Z2	Z1	Z1	Z1	Z1	Z1	Z2	Z3	Z3
Z3	Z2	Z1	Z1	Z1	Z1	Z1	Z1	Z1	Z2	Z3
Z3	Z3	Z2	Z1	Z1	Z1	Z1	Z1	Z2	Z3	Z3
	Z3	Z2	Z1	Z1	Z1	Z1	Z1	Z2	Z3	
	Z3	Z3	Z2	Z2	Z1	Z2	Z2	Z3	Z3	
		Z3	Z3	Z3	Z2	Z3	Z3	Z3		
				Z3	Z3	Z3				

Heat Load Zone Configuration 2

Zone Number	1	2	3(1)
Maximum Decay Heat (kW/FA plus channel, if included)	0.4	0.5	0.5
Maximum Number of Fuel Assemblies	29	20	40
Maximum Decay Heat per DSC (kW)	41.6		

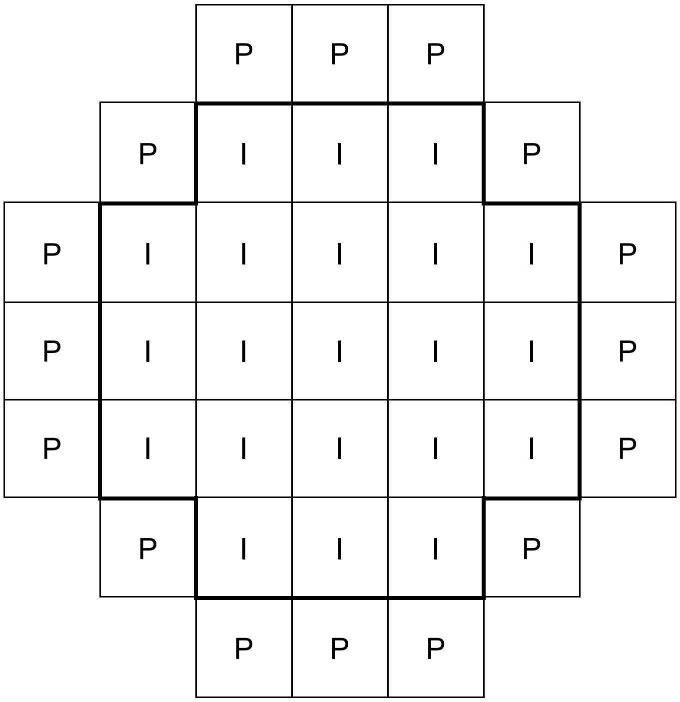
Heat Load Zone Configuration 3

Zone Number	1	2	3(2)
Maximum Decay Heat (kW/FA plus channel, if included)	0.36	0.4	0.4
Maximum Number of Fuel Assemblies	29	20	40
Maximum Decay Heat per DSC (kW)	34.44		

Notes:

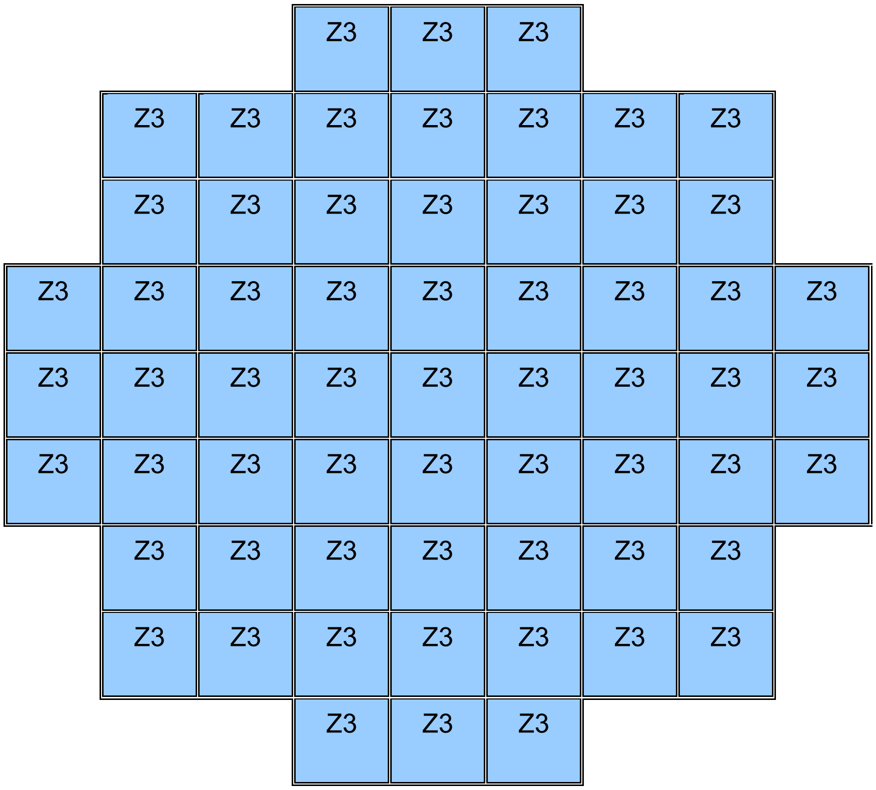
1. The minimum cooling time for HLZC 2 Zone 3 in the EOS-TC108 is 9.7 years.
2. The minimum cooling time for HLZC 3 Zone 3 in the EOS-TC108 is 9.0 years.

Figure 2
EOS-89BTH DSC Heat Load Zone Configurations for transfer in the EOS-TC108



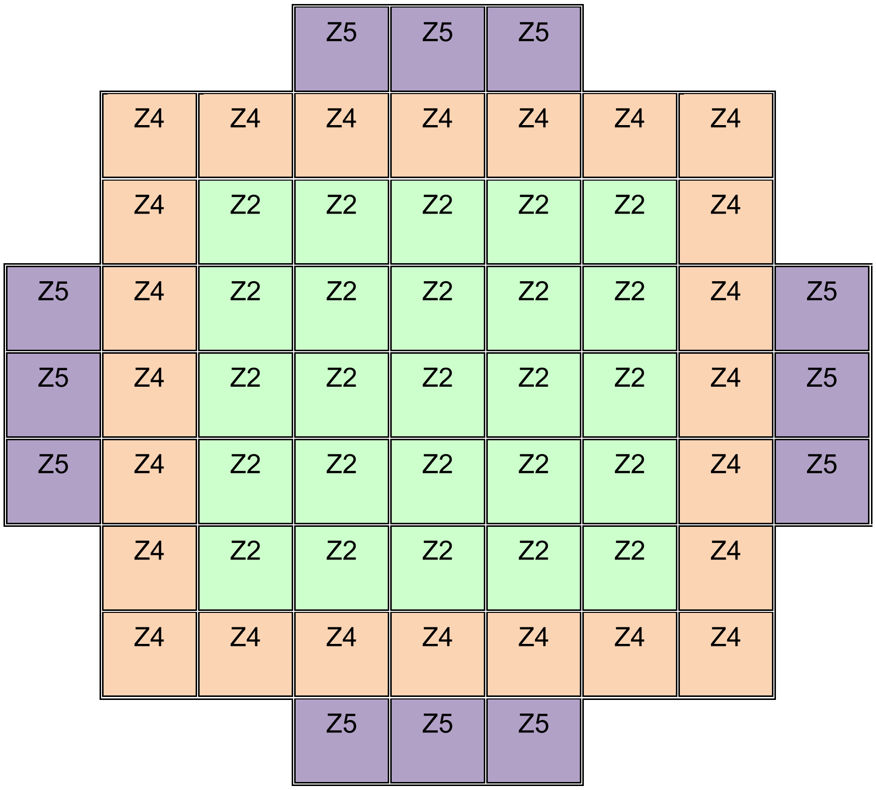
		P	P	P		
	P	I	I	I	P	
P	I	I	I	I	I	P
P	I	I	I	I	I	P
P	I	I	I	I	I	P
	P	I	I	I	P	
		P	P	P		

Figure 3
Peripheral (P) and Inner (I) Fuel Locations for the EOS-37PTH DSC



	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Maximum Decay Heat (kW/FA)	NA	NA	0.393	NA	NA	NA
Maximum Decay Heat per Zone (kW)	NA	NA	22.0	NA	NA	NA
Maximum Decay Heat per DSC (kW)	22.0					

Figure 4A
Heat Load Zone Configuration 1 for the 61BTH Type 2 DSC

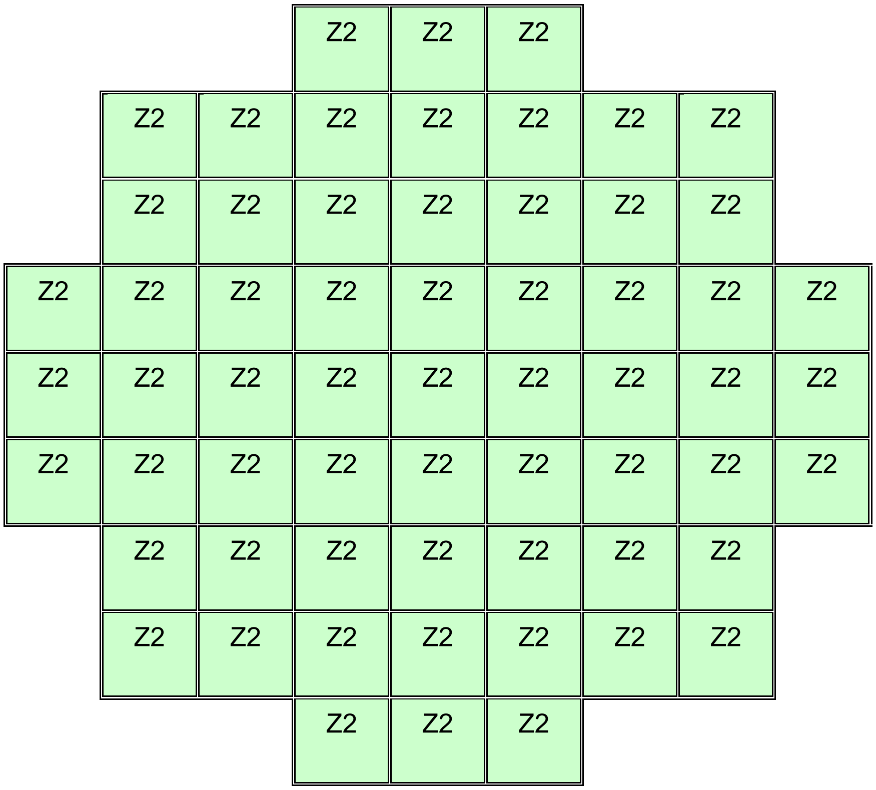


			Z5	Z5	Z5			
	Z4	Z4	Z4	Z4	Z4	Z4	Z4	
	Z4	Z2	Z2	Z2	Z2	Z2	Z4	
Z5	Z4	Z2	Z2	Z2	Z2	Z2	Z4	Z5
Z5	Z4	Z2	Z2	Z2	Z2	Z2	Z4	Z5
Z5	Z4	Z2	Z2	Z2	Z2	Z2	Z4	Z5
	Z4	Z2	Z2	Z2	Z2	Z2	Z4	
	Z4	Z4	Z4	Z4	Z4	Z4	Z4	
			Z5	Z5	Z5			

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Maximum Decay Heat (kW/FA)	NA	0.35	NA	0.48	0.54	NA
Maximum Decay Heat per Zone (kW)	NA	8.75	NA	11.52	6.48	NA
Maximum Decay Heat per DSC (kW)	22.0(1)					

(1) Adjust payload to maintain total DSC heat load within the specified limit

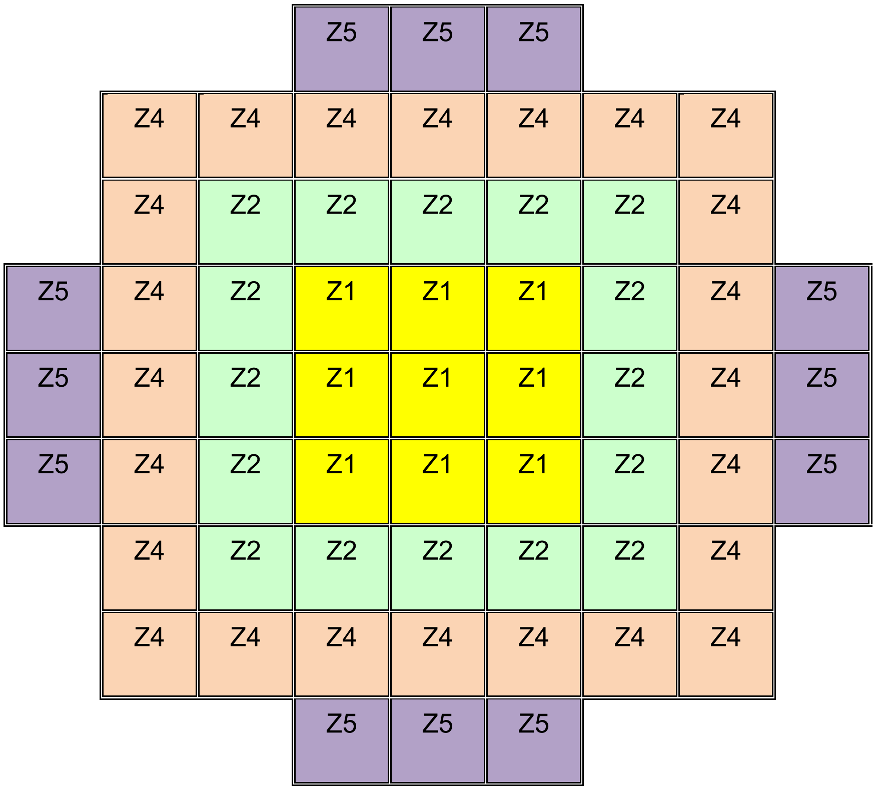
Figure 4B
Heat Load Zone Configuration 2 for the 61BTH Type 2 DSC



			Z2	Z2	Z2			
	Z2	Z2	Z2	Z2	Z2	Z2	Z2	
	Z2	Z2	Z2	Z2	Z2	Z2	Z2	
Z2	Z2	Z2	Z2	Z2	Z2	Z2	Z2	Z2
Z2	Z2	Z2	Z2	Z2	Z2	Z2	Z2	Z2
Z2	Z2	Z2	Z2	Z2	Z2	Z2	Z2	Z2
	Z2	Z2	Z2	Z2	Z2	Z2	Z2	
	Z2	Z2	Z2	Z2	Z2	Z2	Z2	
			Z2	Z2	Z2			

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Maximum Decay Heat (kW/FA)	NA	0.35	NA	NA	NA	NA
Maximum Decay Heat per Zone (kW)	NA	19.4	NA	NA	NA	NA
Maximum Decay Heat per DSC (kW)	19.4					

Figure 4C
Heat Load Zone Configuration 3 for the 61BTH Type 2 DSC

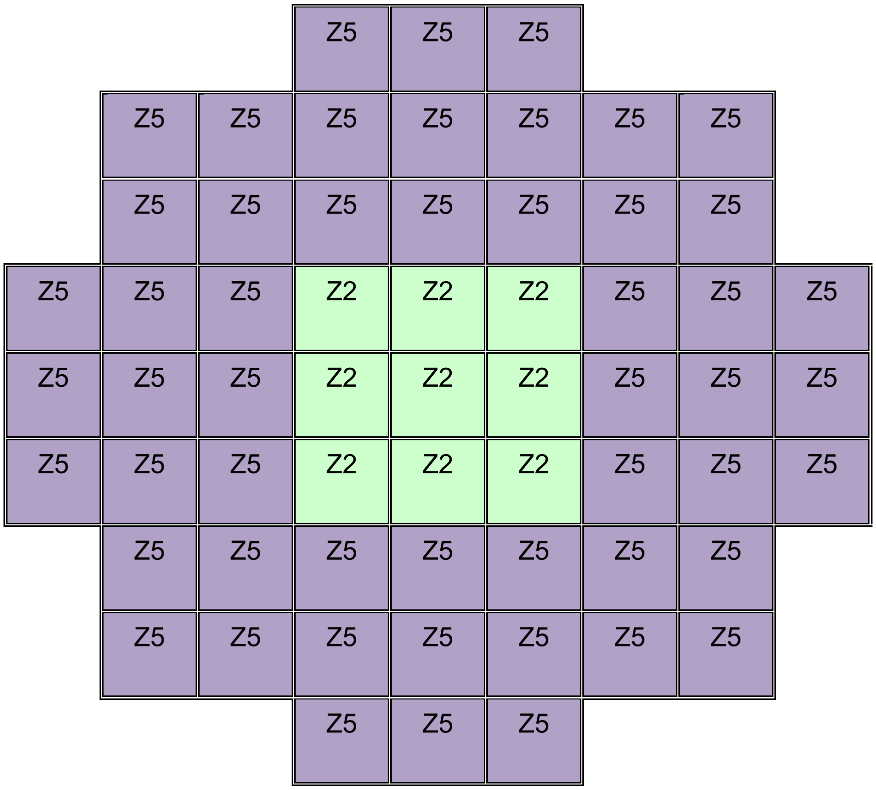


			Z5	Z5	Z5			
	Z4	Z4	Z4	Z4	Z4	Z4	Z4	
	Z4	Z2	Z2	Z2	Z2	Z2	Z4	
Z5	Z4	Z2	Z1	Z1	Z1	Z2	Z4	Z5
Z5	Z4	Z2	Z1	Z1	Z1	Z2	Z4	Z5
Z5	Z4	Z2	Z1	Z1	Z1	Z2	Z4	Z5
	Z4	Z2	Z2	Z2	Z2	Z2	Z4	
	Z4	Z4	Z4	Z4	Z4	Z4	Z4	
			Z5	Z5	Z5			

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Maximum Decay Heat (kW/FA)	0.22	0.35	NA	0.48	0.54	NA
Maximum Decay Heat per Zone (kW)	1.98	5.60	NA	11.52	6.48	NA
Maximum Decay Heat per DSC (kW)	19.4(1)					

(1) Adjust payload to maintain total DSC heat load within the specified limit.

Figure 4D
Heat Load Zone Configuration 4 for the 61BTH Type 2 DSC

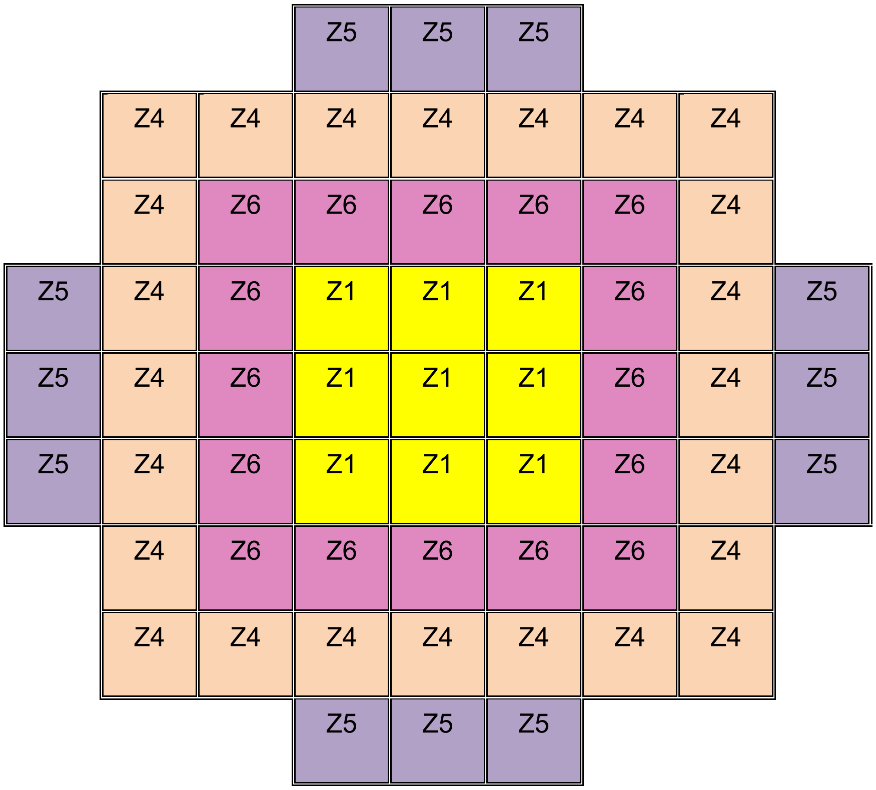


			Z5	Z5	Z5			
	Z5	Z5	Z5	Z5	Z5	Z5	Z5	
	Z5	Z5	Z5	Z5	Z5	Z5	Z5	
Z5	Z5	Z5	Z2	Z2	Z2	Z5	Z5	Z5
Z5	Z5	Z5	Z2	Z2	Z2	Z5	Z5	Z5
Z5	Z5	Z5	Z2	Z2	Z2	Z5	Z5	Z5
	Z5	Z5	Z5	Z5	Z5	Z5	Z5	
	Z5	Z5	Z5	Z5	Z5	Z5	Z5	
			Z5	Z5	Z5			

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Maximum Decay Heat (kW/FA)	NA	0.35	NA	NA	0.54	NA
Maximum Decay Heat per Zone (kW)	NA	3.15	NA	NA	28.08	NA
Maximum Decay Heat per DSC (kW)	31.2(1)					

(1) Adjust payload to maintain total DSC heat load within the specified limit.

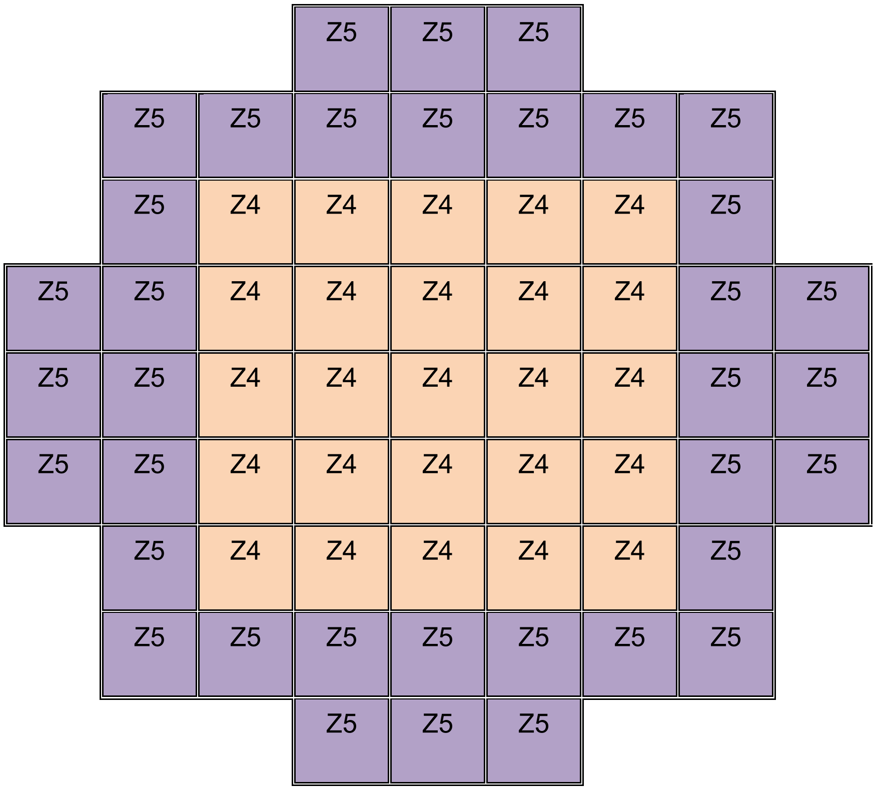
Figure 4E
Heat Load Zone Configuration 5 for the 61BTH Type 2 DSC



			Z5	Z5	Z5			
	Z4	Z4	Z4	Z4	Z4	Z4	Z4	
	Z4	Z6	Z6	Z6	Z6	Z6	Z4	
Z5	Z4	Z6	Z1	Z1	Z1	Z6	Z4	Z5
Z5	Z4	Z6	Z1	Z1	Z1	Z6	Z4	Z5
Z5	Z4	Z6	Z1	Z1	Z1	Z6	Z4	Z5
	Z4	Z6	Z6	Z6	Z6	Z6	Z4	
	Z4	Z4	Z4	Z4	Z4	Z4	Z4	
			Z5	Z5	Z5			

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Maximum Decay Heat (kW/FA)	0.22	NA	NA	0.48	0.54	0.70
Maximum Decay Heat per Zone (kW)	1.98	NA	NA	11.52	6.48	11.20
Maximum Decay Heat per DSC (kW)	31.2					

Figure 4F
Heat Load Zone Configuration 6 for the 61BTH Type 2 DSC

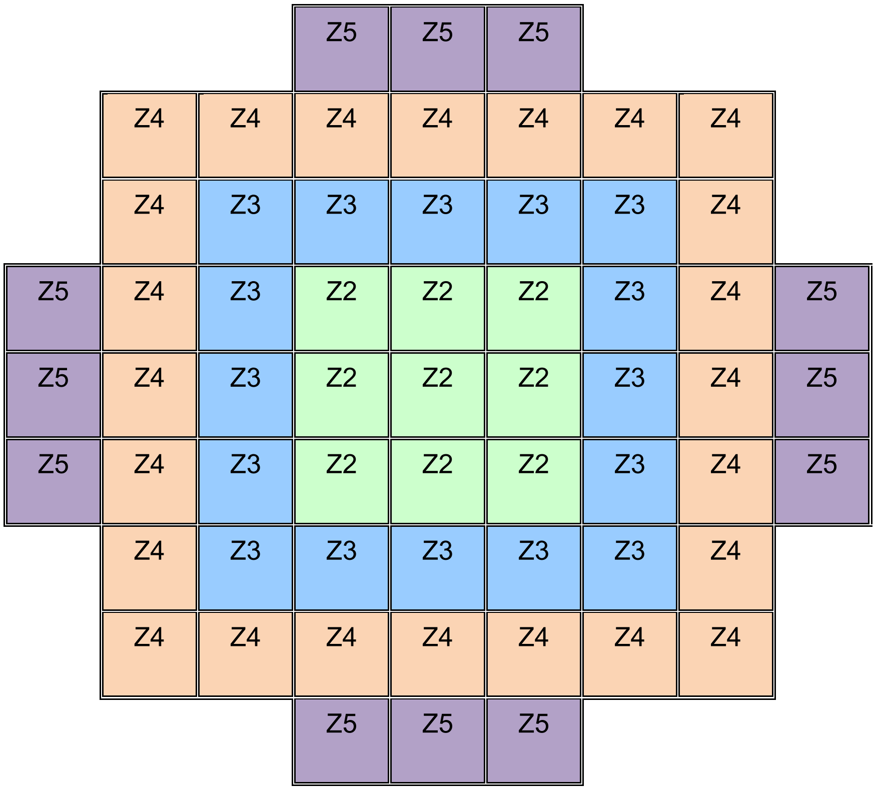


			Z5	Z5	Z5			
	Z5	Z5	Z5	Z5	Z5	Z5	Z5	
	Z5	Z4	Z4	Z4	Z4	Z4	Z5	
Z5	Z5	Z4	Z4	Z4	Z4	Z4	Z5	Z5
Z5	Z5	Z4	Z4	Z4	Z4	Z4	Z5	Z5
Z5	Z5	Z4	Z4	Z4	Z4	Z4	Z5	Z5
	Z5	Z4	Z4	Z4	Z4	Z4	Z5	
	Z5	Z5	Z5	Z5	Z5	Z5	Z5	
			Z5	Z5	Z5			

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Maximum Decay Heat (kW/FA)	NA	NA	NA	0.48	0.54	NA
Maximum Decay Heat per Zone (kW)	NA	NA	NA	12.00	19.44	NA
Maximum Decay Heat per DSC (kW)	31.2(1)					

(1) Adjust payload to maintain total DSC heat load within the specified limit.

Figure 4G
Heat Load Zone Configuration 7 for the 61BTH Type 2 DSC

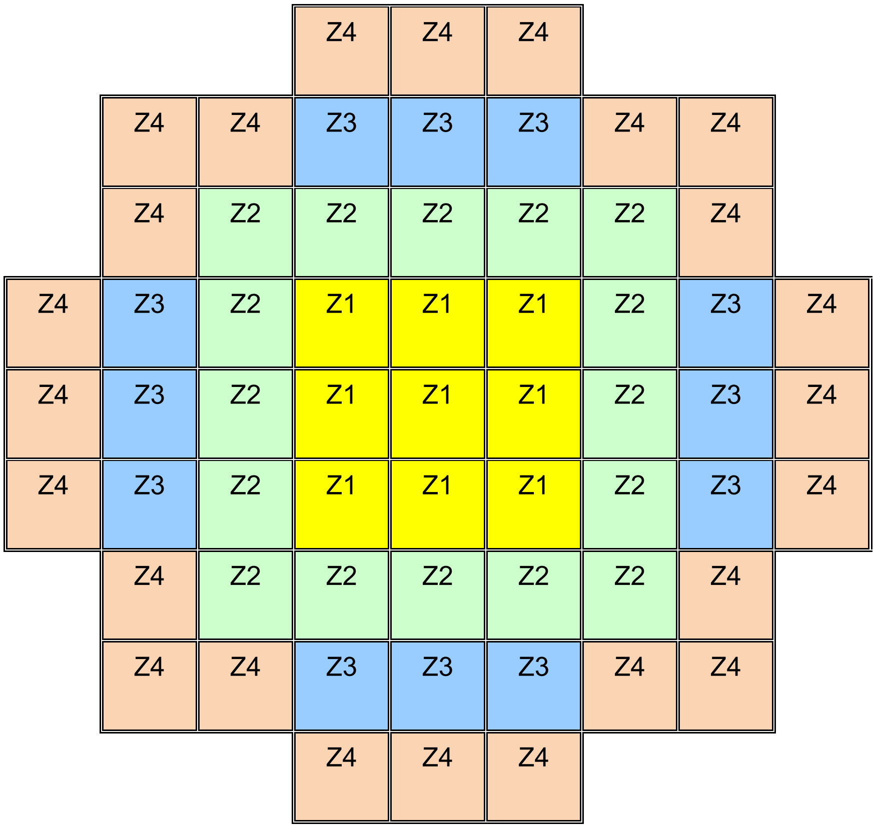


			Z5	Z5	Z5			
	Z4	Z4	Z4	Z4	Z4	Z4	Z4	
	Z4	Z3	Z3	Z3	Z3	Z3	Z4	
Z5	Z4	Z3	Z2	Z2	Z2	Z3	Z4	Z5
Z5	Z4	Z3	Z2	Z2	Z2	Z3	Z4	Z5
Z5	Z4	Z3	Z2	Z2	Z2	Z3	Z4	Z5
	Z4	Z3	Z3	Z3	Z3	Z3	Z4	
	Z4	Z4	Z4	Z4	Z4	Z4	Z4	
			Z5	Z5	Z5			

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Maximum Decay Heat (kW/FA)	NA	0.35	0.393	0.48	0.54	NA
Maximum Decay Heat per Zone (kW)	NA	3.15	6.288	11.52	6.48	NA
Maximum Decay Heat per DSC (kW)	27.4 (1)					

(1) Adjust payload to maintain total DSC heat load within the specified limit.

Figure 4H
Heat Load Zone Configuration 8 for the 61BTH Type 2 DSC

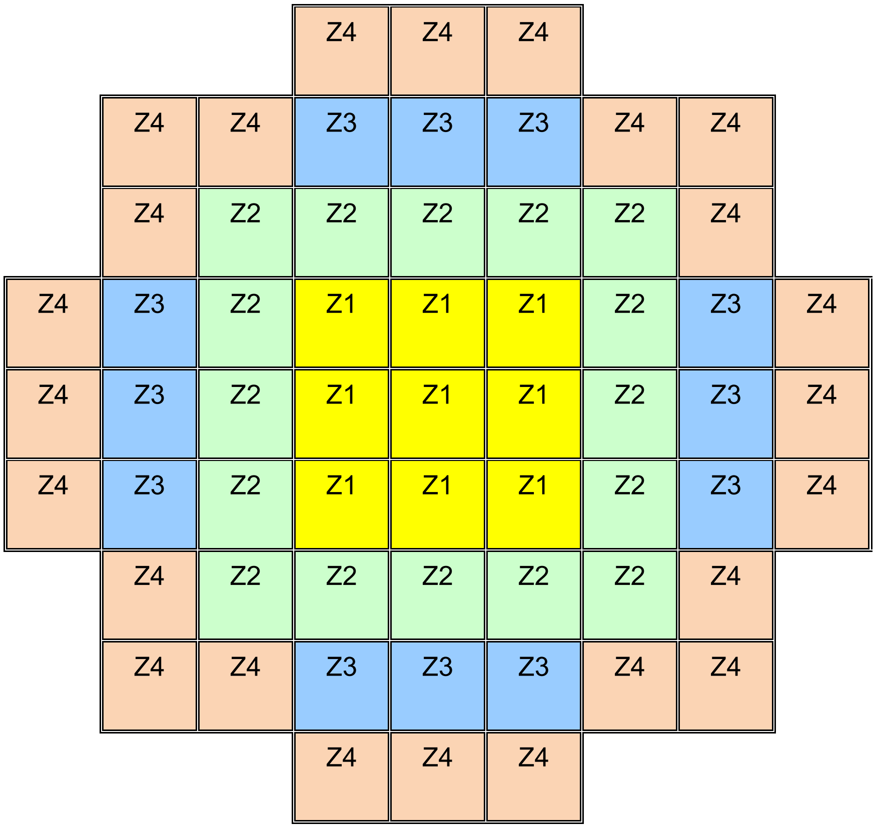


			Z4	Z4	Z4			
	Z4	Z4	Z3	Z3	Z3	Z4	Z4	
	Z4	Z2	Z2	Z2	Z2	Z2	Z4	
Z4	Z3	Z2	Z1	Z1	Z1	Z2	Z3	Z4
Z4	Z3	Z2	Z1	Z1	Z1	Z2	Z3	Z4
Z4	Z3	Z2	Z1	Z1	Z1	Z2	Z3	Z4
	Z4	Z2	Z2	Z2	Z2	Z2	Z4	
	Z4	Z4	Z3	Z3	Z3	Z4	Z4	
			Z4	Z4	Z4			

	Zone 1	Zone 2	Zone 3	Zone 4
Maximum Decay Heat (kW/FA)	0.393	0.48	0.35	0.35
Maximum Decay Heat per Zone (kW)	3.54	7.68	4.2	8.4
Maximum Decay Heat per DSC (kW)	22.0(1)			

Note 1: Adjust payload to maintain total canister heat load within the specified limit.

Figure 4I
Heat Load Zone Configuration 9 for the 61BTH Type 2 DSC



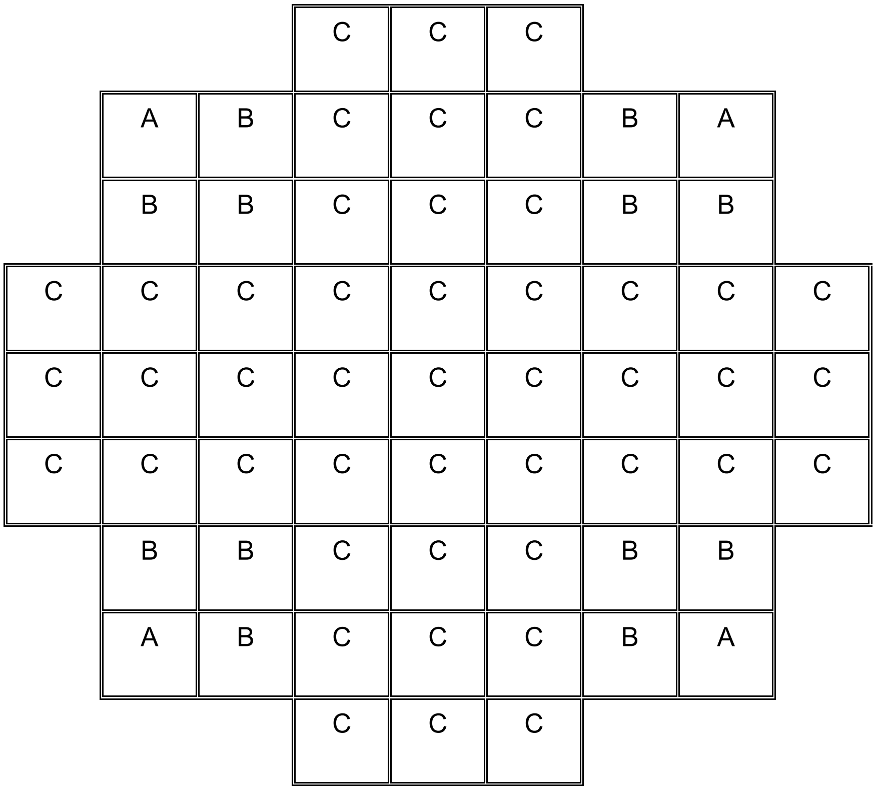
			Z4	Z4	Z4			
	Z4	Z4	Z3	Z3	Z3	Z4	Z4	
	Z4	Z2	Z2	Z2	Z2	Z2	Z4	
Z4	Z3	Z2	Z1	Z1	Z1	Z2	Z3	Z4
Z4	Z3	Z2	Z1	Z1	Z1	Z2	Z3	Z4
Z4	Z3	Z2	Z1	Z1	Z1	Z2	Z3	Z4
	Z4	Z2	Z2	Z2	Z2	Z2	Z4	
	Z4	Z4	Z3	Z3	Z3	Z4	Z4	
			Z4	Z4	Z4			

	Zone 1	Zone 2	Zone 3	Zone 4
Maximum Decay Heat (kW/FA)	0.393	0.48(2)	1.20(2)	0.48(2)
Maximum Decay Heat per Zone (kW)	3.54	7.68	14.4	11.52
Maximum Decay Heat per DSC (kW)	31.2(1)			

Note 1: Adjust payload to maintain total canister heat load within the specified limit.

Note 2: If the maximum decay heat per FA in Zone 3 is greater than 0.9 kW, the maximum decay heat per FA in Zone 2 and Zone 4 shall be less than or equal to 0.393 kW.

Figure 4J
Heat Load Zone Configuration 10 for the 61BTH Type 2 DSC



			C	C	C			
	A	B	C	C	C	B	A	
	B	B	C	C	C	B	B	
C	C	C	C	C	C	C	C	C
C	C	C	C	C	C	C	C	C
C	C	C	C	C	C	C	C	C
	B	B	C	C	C	B	B	
	A	B	C	C	C	B	A	
			C	C	C			

A	Corner Locations See Note 1	B	Interior Locations See Note 2
C	Interior/Edge Locations See Note 3		

Note 1: When loading up to 4 damaged or 4 failed assemblies, these must be placed in corner “A” locations, and the remaining locations “B” and “C” shall be loaded with intact fuel. If fewer than 4 damaged or 4 failed assemblies are to be stored, the remaining “A” locations may be loaded with intact fuel provided they meet the respective damaged or failed enrichment limits of Table 10 or Table 11. Damaged and failed fuel shall not be mixed, i.e., up to four damaged assemblies may be stored, or up to four failed assemblies may be stored in “A” locations.

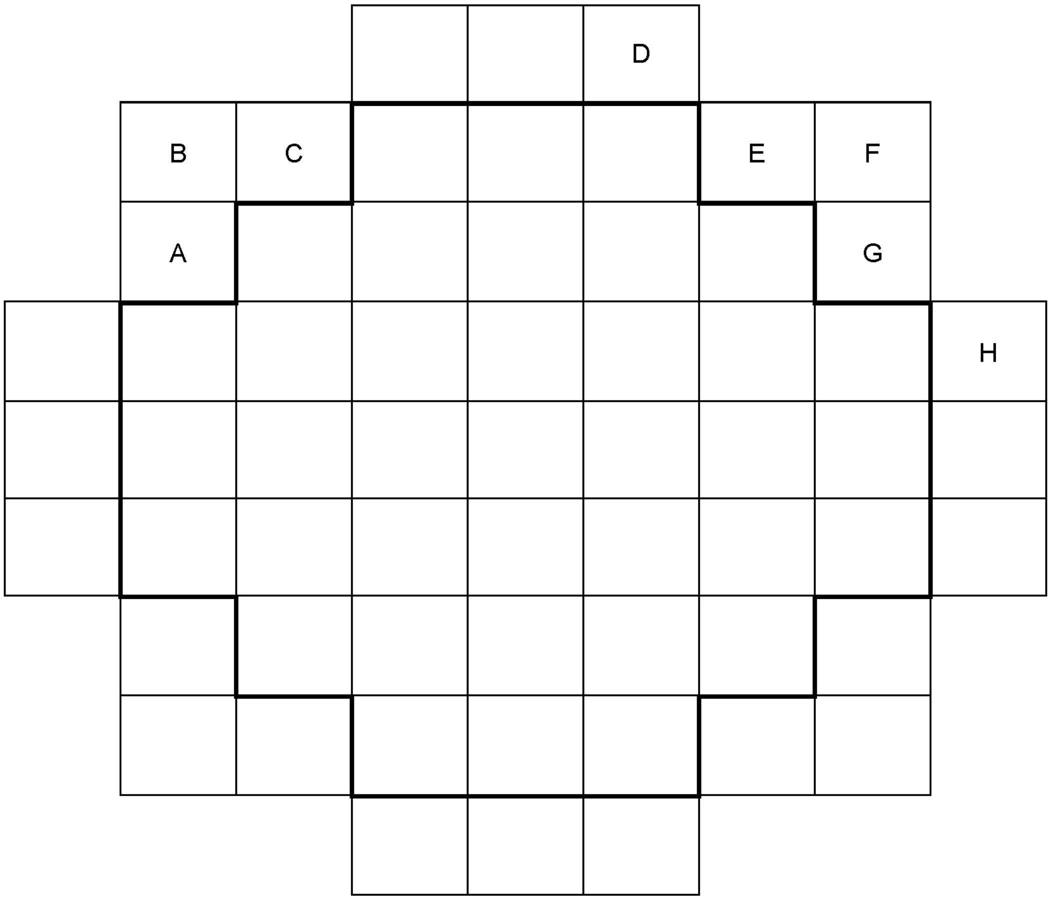
Note 2: If loading more than four damaged assemblies, place first four damaged assemblies in the corner “A” locations per Note 1, and up to 12 additional damaged assemblies in these interior “B” locations, with the remaining intact in a 61BTH Type 2 Basket. The maximum lattice average initial enrichment of assemblies (damaged or intact stored in the 2x2 cells) is limited to the “Five or More Damaged Assemblies” column of Table 10. For the 61BTH Type 2 DSC containing both damaged and failed fuel assemblies, this enrichment is limited to the “and up to 12 Damaged Assemblies” column of Table 11.

Note 3: If loading more than 16 damaged assemblies, place the first 57 damaged assemblies in the interior/edge "C" and the interior “B” locations. Place the remaining four intact or damaged assemblies in the corner "A" locations. The maximum lattice average initial enrichments of assemblies is limited to the “Remaining Four Intact Assemblies” or “Remaining Four Damaged Assemblies” column of Table 12.

Figure 5
Location of Damaged and Failed Fuel Assemblies inside the 61BTH Type 2 DSC

			P	P	P			
	P	P	I	I	I	P	P	
	P	I	I	I	I	I	P	
P	I	I	I	I	I	I	I	P
P	I	I	I	I	I	I	I	P
P	I	I	I	I	I	I	I	P
	P	I	I	I	I	I	P	
	P	P	I	I	I	P	P	
			P	P	P			

Figure 6
Peripheral (P) and Inner (I) Fuel Locations for the 61BTH Type 2 DSC

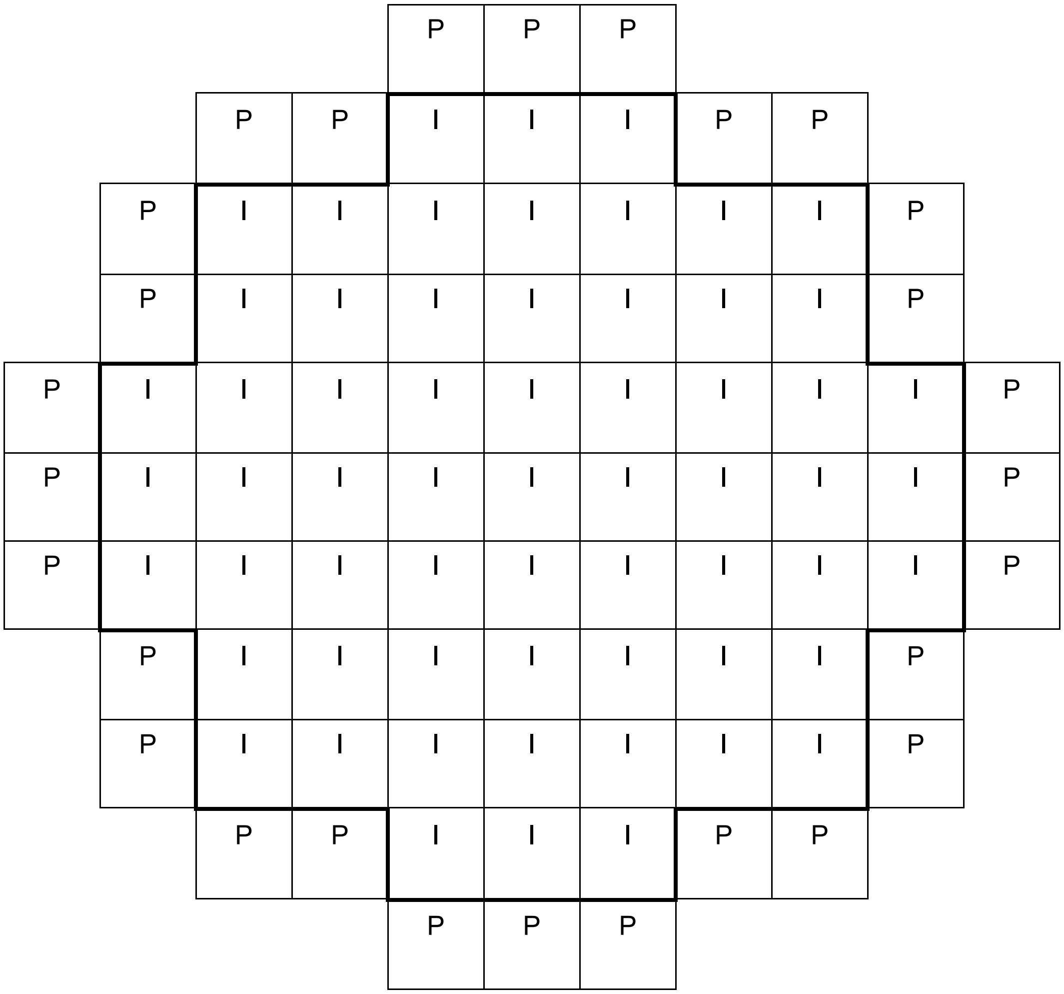


RECONSTITUTED FUEL ASSEMBLIES with ≤ 5 irradiated stainless steel rods may be loaded into all peripheral locations (i.e., not restricted). See Figure 6 for peripheral locations.

A RECONSTITUTED FUEL ASSEMBLY with > 5 and ≤ 10 irradiated stainless steel rods may be loaded in any peripheral location, with additional restrictions in accordance with Section 2.3. Examples:

- If Location B contains a RECONSTITUTED FUEL ASSEMBLY with > 5 irradiated stainless steel rods, peripherally adjacent Locations A and C shall contain fuel assemblies that do not contain irradiated stainless steel rods.
- If Locations E and G contain RECONSTITUTED FUEL ASSEMBLIES with > 5 irradiated stainless steel rods, peripherally adjacent Locations D, F, and H shall contain fuel assemblies that do not contain irradiated stainless steel rods.

Figure 7
Peripheral Location Restrictions for Reconstituted Fuel with Irradiated Stainless Steel Rods for the 61BTH Type 2 DSC



				P	P	P				
		P	P	I	I	I	P	P		
	P	I	I	I	I	I	I	I	P	
	P	I	I	I	I	I	I	I	P	
P	I	I	I	I	I	I	I	I	I	P
P	I	I	I	I	I	I	I	I	I	P
P	I	I	I	I	I	I	I	I	I	P
	P	I	I	I	I	I	I	I	P	
	P	I	I	I	I	I	I	I	P	
		P	P	I	I	I	P	P		
				P	P	P				

Figure 8
Peripheral (P) and Inner (I) Fuel Locations for the EOS-89BTH DSC

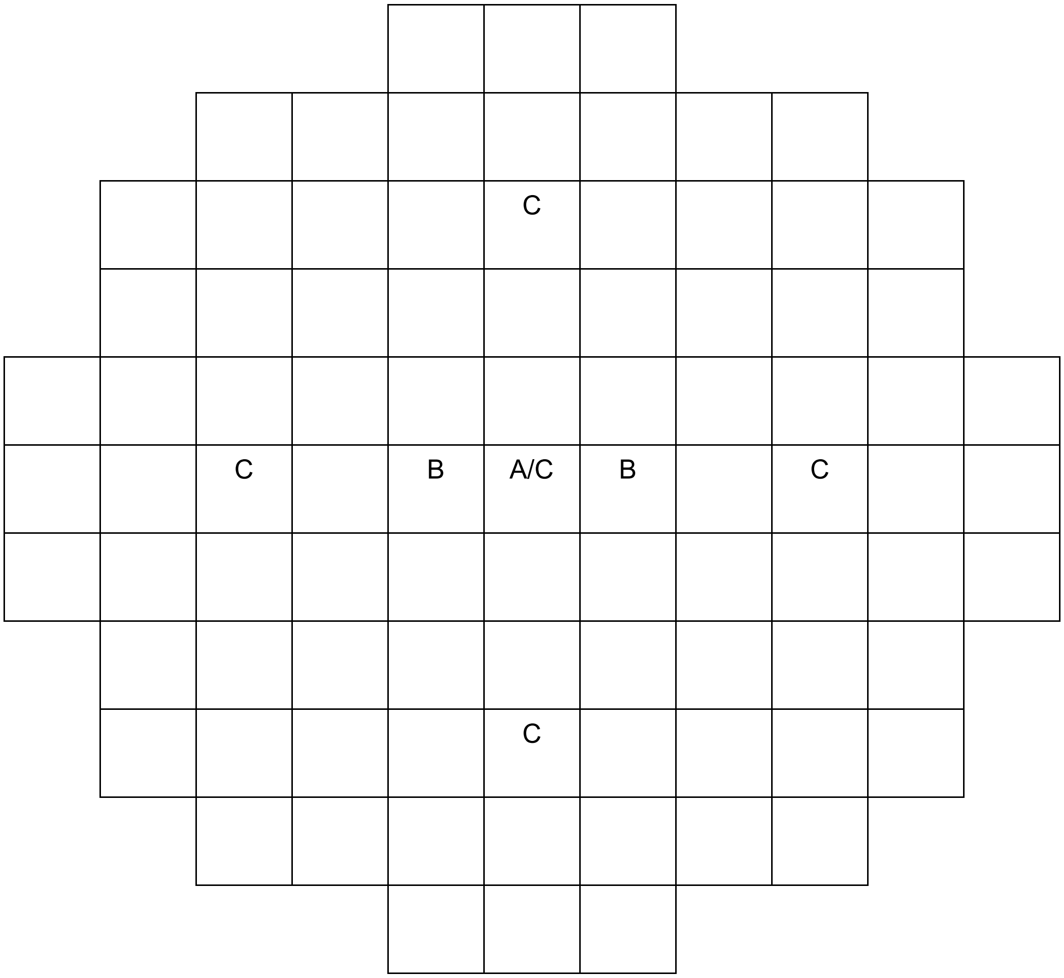
				X	X	X				
		X	X	X	R	X	X	X		
	X	X	R	R	R	R	R	X	X	
	X	R	R	R	R	R	R	R	X	
X	X	R	R	R	R	R	R	R	X	X
X	R	R	R	R	R	R	R	R	R	X
X	X	R	R	R	R	R	R	R	X	X
	X	R	R	R	R	R	R	R	X	
	X	X	R	R	R	R	R	X	X	
		X	X	X	R	X	X	X		
				X	X	X				

R = RECONSTITUTED FUEL ASSEMBLIES with irradiated stainless steel rods allowed at these locations.

X = RECONSTITUTED FUEL ASSEMBLIES with irradiated stainless steel rods not allowed at these locations.

Note: No restrictions on location for RECONSTITUTED FUEL ASSEMBLIES that do not contain irradiated stainless steel rods.

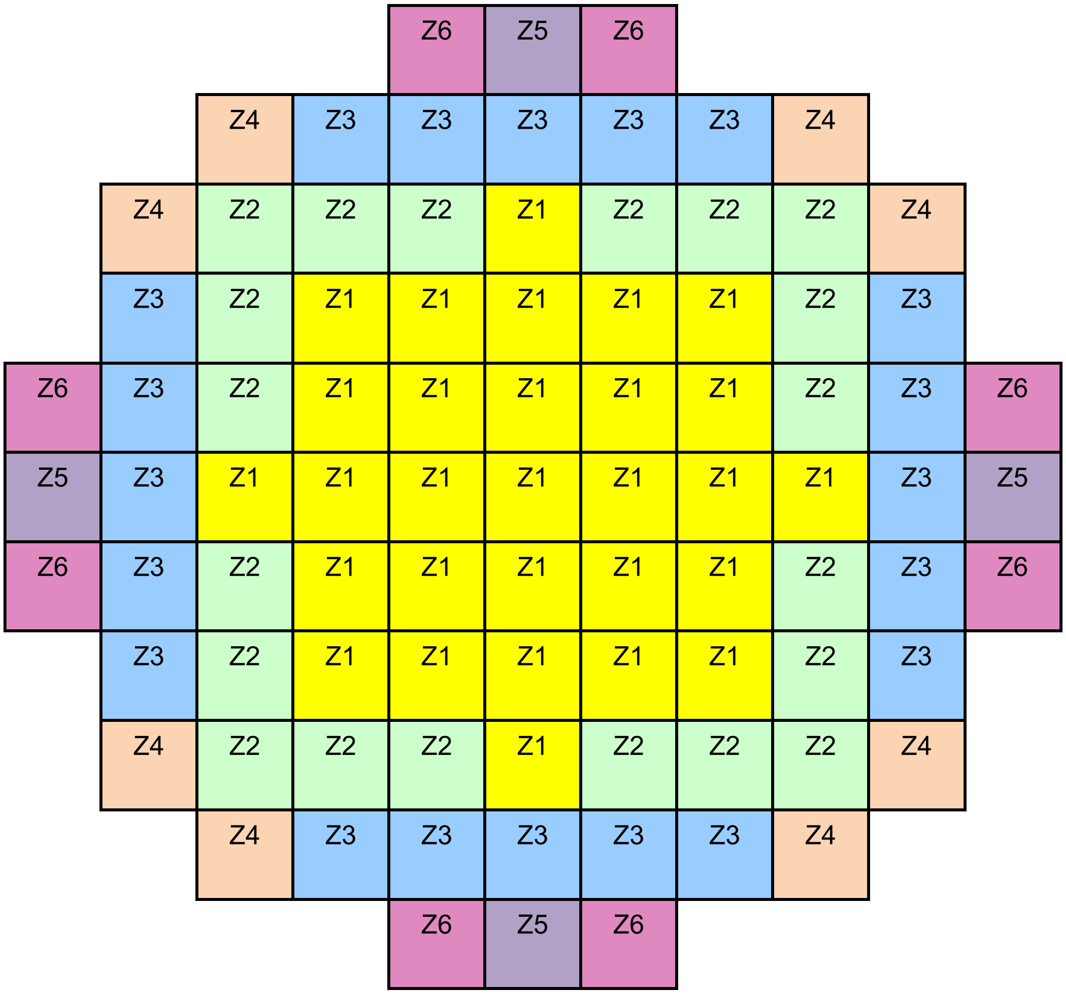
Figure 9
EOS-89BTH DSC Allowed Reconstituted Fuel Locations for Transfer in the EOS-TC108



Note:

1. Location identified as “A” is for empty placement in 88-FA Loading
2. Locations identified as “B” are for empty placements in 87-FA Loading
3. Locations identified as “C” are for empty placements in 84-FA Loading

Figure 10
Empty Locations in Short-Loading Configurations for the EOS-89BTH DSC



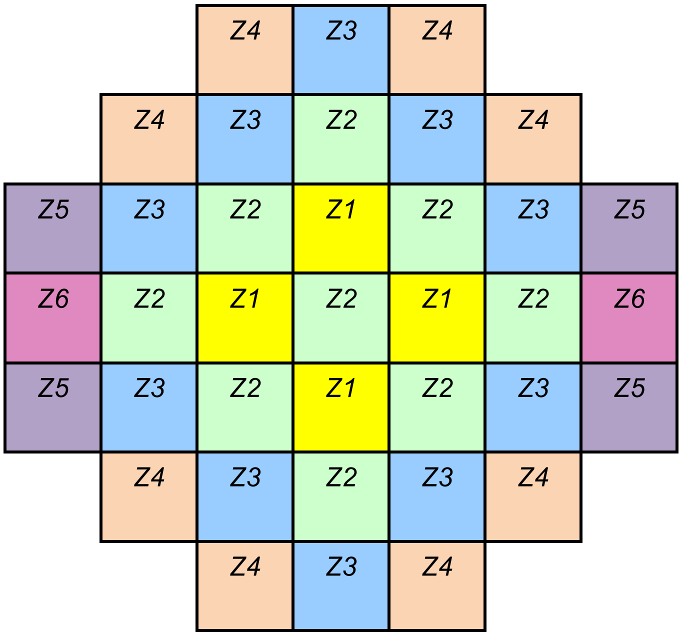
				Z6	Z5	Z6				
		Z4	Z3	Z3	Z3	Z3	Z3	Z4		
	Z4	Z2	Z2	Z2	Z1	Z2	Z2	Z2	Z4	
	Z3	Z2	Z1	Z1	Z1	Z1	Z1	Z2	Z3	
Z6	Z3	Z2	Z1	Z1	Z1	Z1	Z1	Z2	Z3	Z6
Z5	Z3	Z1	Z1	Z1	Z1	Z1	Z1	Z1	Z3	Z5
Z6	Z3	Z2	Z1	Z1	Z1	Z1	Z1	Z2	Z3	Z6
	Z3	Z2	Z1	Z1	Z1	Z1	Z1	Z2	Z3	
	Z4	Z2	Z2	Z2	Z1	Z2	Z2	Z2	Z4	
		Z4	Z3	Z3	Z3	Z3	Z3	Z4		
				Z6	Z5	Z6				

Zone No.	Z1	Z2	Z3	Z4	Z5	Z6
Max. Decay Heat per SFA (kW)	0.40	0.60	1.30	1.70	1.30	1.70
No. of Fuel Assemblies	29	20	20	8	4	8
Heat Load Per Zone	11.6	12.0	26.0	13.6	5.2	13.6
Max. Decay Heat per DSC (kW)	See Note 1 for EOS-HSM and Note 2 for HSM-MX					

Notes:

1. Maximum heat load for EOS-89BTH DSC during Storage is 48.2 kW in EOS-HSM.
2. Maximum heat load for EOS-89BTH DSC during Storage is 48.2 kW in lower compartment of HSM-MX and 41.8 kW in upper compartment of HSM-MX.

Figure 11
Maximum Heat Load Configuration 1 for EOS-89BTH DSC (MHLC-89-1) Transferred in the EOS-TC125



		Z4	Z3	Z4		
	Z4	Z3	Z2	Z3	Z4	
Z5	Z3	Z2	Z1	Z2	Z3	Z5
Z6	Z2	Z1	Z2	Z1	Z2	Z6
Z5	Z3	Z2	Z1	Z2	Z3	Z5
	Z4	Z3	Z2	Z3	Z4	
		Z4	Z3	Z4		

Zone No.	*Z1*	*Z2*	*Z3*	*Z4*	*Z5*	*Z6*
Max. Decay Heat per SFA (kW)	*1.5*	*1.0*	*2.4*	*3.5*	*4.3*	*1.6*
No. of Fuel Assemblies	*4*	*9*	*10*	*8*	*4*	*2*
Heat Load Per Zone	*6.0*	*9.0*	*24.0*	*28.0*	*17.2*	*3.2*
Max. Decay Heat per DSC (kW)	*See Note 1*					

Notes:

1. *Maximum heat load for EOS-37PTH DSC during Storage is 50.0 kW in the EOS-HSM.*
2. *See Figure 13 for Damaged/failed fuel locations.*
3. *MHLC-37-1 is only applicable for transfer operations in an EOS-TC125 or EOS-TC135 transfer cask and storage in an EOS-HSM storage module. It is not applicable to the following configurations:*
   A. transfer in an EOS-TC108 transfer cask and storage in either an EOS-HSM or HSM-MX storage module or
   B. transfer in an EOS-TC125 or EOS-TC135 transfer cask and storage in an HSM-MX storage module.

Figure 12
Maximum Heat Load Configuration 1 for EOS-37PTH DSC (MHLC-37-1) Transferred in the EOS-TC125/135 AND Stored in the EOS-HSM

		D2	F1	D2		
		D1		D1		
D2/F2	D1				D1	D2/F2
F1						F1
D2	D1				D1	D2
		D1		D1		
			F1			

Notes:

1. *The damaged fuel locations are marked with a "D1" for configuration 1, and "D2" for configuration 2. Only one configuration may be loaded in each DSC.*
2. *The Failed fuel locations are marked with an "F1" for configuration 1, and "F2" for configuration 2. Only one configuration may be loaded in each DSC. Failed fuel in all configurations is limited to 0.8 kW.*
3. *Damaged and failed fuel shall not be loaded in the same DSC.*

Figure 13
Damaged and Failed Fuel Configurations for the EOS-37PTH DSC

		X	*X*	*X*		
	X	*R*	*R*	*R*	*X*	
X	*R*	*R*	*R*	*R*	*R*	*X*
X	*R*	*R*	*R*	*R*	*R*	*X*
X	*R*	*R*	*R*	*R*	*R*	*X*
	X	*R*	*R*	*R*	*X*	
		X	*X*	*X*		

R = RECONSTITUTED FUEL ASSEMBLIES with irradiated stainless steel rods allowed at these locations.

X = RECONSTITUTED FUEL ASSEMBLIES with irradiated stainless steel rods not allowed at these locations.

Note: No restrictions on location for RECONSTITUTED FUEL ASSEMBLIES that do not contain irradiated stainless steel rods.

Figure 14
EOS-37PTH DSC Allowed Reconstituted Fuel Locations for Transfer in the EOS-TC108

Enclosure 7 to E-62384

CoC 1042 Amendment 4, Revision 2 UFSAR Changed Pages

(Proprietary)

Withheld Pursuant to 10 CFR 2.390

Enclosure 8 to E-62384

CoC 1042 Amendment 4, Revision 2 UFSAR Changed Pages

(Public)

Table 1-1
Key Design Parameters of the NUHOMS® EOS System Components
(2 Pages)

EOS-37PTH DSC	
Overall Length (in.)	219.12 (max for TC135)
	197.65 (max for TC125 and TC108)
Outside Diameter (in.)	75.50
Cavity Length (in.)	To fit fuel to be stored accounting for irradiation growth and differential thermal growth.
Shell Thickness (in.)	0.5
Design Weight of Loaded EOS-37PTH DSC (lbs.)*(2)*	135,000 (max for TC135)
	124,000 (max for TC125 and TC108)
Materials of Construction	Stainless steel or duplex shell assembly and carbon steel internals, carbon steel shield plugs, aluminum
Neutron Absorbing Material	MMC as specified in Chapter 10
Internal Atmosphere	Helium
EOS-89BTH DSC	
Overall Length (in.)	197.65 (max. for TC125 and TC108)
Outside Diameter (in.)	75.50
Cavity Length (in.)	To fit fuel to be stored accounting for irradiation growth and differential thermal growth.
Shell Thickness (in.)	0.5
Design Weight of Loaded EOS-89BTH DSC (lbs.)*(2)*	124,000 (max for TC125 and TC108)
Materials of Construction	Stainless steel or duplex shell assembly and carbon steel internals, carbon steel shield plugs, aluminum
Neutron Absorbing Material	BORAL™, MMC, as specified in Chapter 10
Internal Atmosphere	Helium
Horizontal Storage Module (*EOS-HSM-RC/ EOS-HSM-SC*):	
Overall length (without back shield wall)	19’ EOS-Short
	20’ 8” EOS-Medium
	22’ 4” EOS-Long
Overall width (without end shield walls)	9’-8”
Overall height (without vent covers)	18’ 6”

Table 1-1
Key Design Parameters of the NUHOMS® EOS System Components
(2 Pages)

EOS-HSM-RC Total Weight not including DSC (lbs.)	311,000 EOS-Short
	334,000 EOS-Medium(1)
	351,000 EOS-Long
EOS-HSM-SC Total Weight not including DSC (lbs.)	*361,000*
Materials of Construction *(EOS-HSM-RC)*	Reinforced concrete and structural steel
Materials of Construction (EOS-HSM-SC)	*Concrete, structural steel for faceplates, and carbon/alloy/bolt steels for studs and tie bars*
Heat Removal	Conduction, convection, and radiation
OnSite Transfer Cask (EOS-TC)	
Overall Length (in)	206.76 EOS-TC108
	208.21 EOS-TC125
	228.71 EOS-TC135
Outside Diameter (in)	90.61 EOS-TC108 w/ NS tank
	88.50 EOS-TC108 w/o NS tank
	95.38 *maximum* EOS-TC125
	95.38 EOS-*TC135*
Cavity Length (in)	199.17 EOS-TC108
	199.25 EOS-TC125
	219.75 EOS-TC135
Lead Thickness (in)	2.50 EOS-TC108
	3.12-3.56 EOS-TC125
	3.56 EOS-TC135
Gross Weight (with neutron shield and steel lid and no payload) (tons)	46.5 EOS-TC108
	62.1 *maximum* EOS-TC125
	67.9 EOS-TC135
Materials of Construction	Carbon steel shell assemblies and closures with lead shielding, aluminum and carbon steel lids and aluminum neutron shield tank for the TC108
Internal Atmosphere	Air

Note

1: Without the optional outlet vent dose reduction hardware presented in Item 2, Section 1.2.1.3.

2: DSC weights listed are conservative overestimates used for transfer cask and critical lift evaluations. Design weights for EOS-HSM structural and stability evaluations are identified in Chapter 3.

All Indicated Changes are in response to Revised RSI 3-1

Proprietary and Security Related Information
for Drawing EOS01-3300-SAR, Rev. 0C
Withheld Pursuant to 10 CFR 2.390

The determination of the DBT velocity pressure is in accordance with the requirements of American Society of Civil Engineers (ASCE) 7-10 [2-12]. The resistance to sliding of the HSM under these design pressures is determined considering the bounding condition of a single EOS-HSM with end shield walls or a single HSM-MX monolith. *The resistance to overturning of the HSM under these design pressures is determined considering a single EOS-HSM with one end shield wall or a single HSM-MX monolith.*

2.3.1.3 Tornado Missiles

The design basis tornado missiles specified in NRC Regulatory Guide 1.76, Revision 1 [2-8] are used to evaluated the HSM. As specified in NUREG-0800, Revision 3, Section 3.5.1.4 [2-10], the postulated missiles include at least:

- A massive high-kinetic-energy missile that deforms on impact.
- A rigid missile to test penetration resistance.
- A small rigid missile of a size sufficient to just pass through any openings in protective barriers.

The DBT missiles for the HSM are listed below:

Missile Type	Schedule 40 Pipe	Automobile	Solid Steel Sphere
Dimensions	6.625 in. dia x 15 ft long	16.4 ft x 6.6 ft x 4.3 ft	1 in. dia
Mass	287 lb	4000 lb	0.147 lb
C_DA/m	0.0212 ft^2/lb	0.0343 ft^2/lb	0.0166 ft^2/lb
V_{Mh}^{max}	135 ft/s	135 ft/s	26 ft/s

Evaluation for the effects of small diameter solid spherical missiles is not required because there are no openings in the HSM leading directly to the DSC through which such missiles could pass. Barrier design should be evaluated assuming a normal impact to the surface for the Schedule 40 pipe and automobile missiles. The automobile missile is considered to impact at all altitudes less than 30 feet above grade level. While the design basis missiles are described above, the structural evaluations may be performed using more bounding missiles and additional missiles.

In determining the overall effects of a DBT missile impact, overturning, and sliding of the HSM, the force due to the missile impact is applied to the structure at the most adverse location. For hand calculations, conservation of momentum is used to demonstrate that sliding and/or tipping of a single module does not result in an unstable condition for the module. The coefficient of restitution is conservatively assumed as zero so that 100% of the missile energy is transferred to the HSM. The missile energy transferred to the HSM dissipates by sliding friction and/or an increase in potential energy by raising the HSM center of gravity. The calculations assume the missile impact force as evenly distributed over the impact area, and use a 0.6 coefficient of friction for concrete on concrete surfaces.

All Indicated Changes are in response to Revised RSI 3-2

2.3.3 Water Level (Flood) Design

EOS-HSM inlet vents are blocked when the depth of flooding is greater than 0.76 m (2 ft-6 in.) above the level of the ISFSI basemat. The DSC is wetted when flooding exceeds a depth of 1.7 m (5 ft-8 in.) above ISFSI basemat. Greater flood heights result in submersion of the DSC and blockage of the EOS-HSM outlet vents.

The DSC and EOS-HSM are conservatively designed for an enveloping design basis flood. The flood is postulated to result from natural phenomena such as tsunamis and seiches as specified by 10 CFR 72.122(b) [2-6]. A bounding assumption of a 15-meter (50-foot) flood height and water velocity of 4.6 m/sec (15 fps) is used for the flood evaluation. The EOS-HSM is evaluated for the effects of the 4.6 m/sec (15 fps) water current impinging upon the side of the submerged EOS-HSM. The DSC is subjected to an external pressure equivalent to a 15-meter (50-foot) head of water. These evaluations are presented in Chapter 3 and Section 12.3.5. The effects of water reflection on DSC criticality safety are addressed in Chapter 7. Due to its short term infrequent use, the onsite EOS-TC is not explicitly evaluated for flood effects. ISFSI procedures should ensure that the EOS-TC is not used for DSC transfer during flood conditions.

The plant-specific design basis flood (if the possibility for flooding exists at a particular ISFSI site) should be evaluated by the licensee and shown to be enveloped by the flooding conditions used for this generic evaluation of the NUHOMS® EOS System.

2.3.4 Seismic Design

The seismic design criteria for the EOS-HSM are based on the NRC Regulatory Guide 1.60 [2-13] response spectra anchored at a zero period acceleration (ZPA) of 0.45g in the horizontal direction and 0.30g in the vertical direction and enhanced frequency content above 9 Hz. The horizontal and vertical components of the design response spectra correspond to a maximum horizontal ground acceleration of 1.0g are shown in Figure 2-1. The seismic structural evaluations consider both stability evaluation and stress qualification of the EOS-HSM. The structural stress qualifications of the HSM *concrete, steel, and SC* components are conservatively based on the spectra shown in Figure 2-1 anchored at 0.50g in the horizontal direction and 0.33g in the vertical direction. The stability criteria for seismic loading are based on the stability response of a single, freestanding EOS-HSM with an end shield wall.

The EOS-HSMs in the array have no anchorage to the concrete basemat and there are no positive structural connections between EOS-HSMs. The stability analyses consider the effects of sliding and rocking motions, and determine the sliding *potential* of a single module with *no end shield walls,* and *rocking potential of a single module with one* end shield wall. The EOS-HSM will neither slide nor overturn at design ZPA of 0.45g in the horizontal direction and 0.30g in the vertical direction.

Component	Weight (kips)	Thermal Heat Load
EOS-37PTH DSC (Loaded Weight)	134	50 kW
EOS-89BTH DSC (Loaded Weight)	120	*48.2 kW*
Bounding *EOS-HSM-RC*	135 (2)	50 kW (1)

Notes:

1. The thermal loading condition of the *EOS-HSM-RC* is based on the most conservative thermal loading configuration.
2. For stability evaluation, *the design weight of the governing DSC among those corresponding to the length of HSM being evaluated is* considered.

Detailed geometry descriptions, material properties, loadings, and structural evaluation for the *EOS-HSM-RC* is presented in Appendix 3.9.4.

For the structural evaluation of the EOS-HSM-SC, only the medium length model is evaluated using the bounding DSC weight of 135 kips and bounding thermal heat load of 50 kW. Detailed geometry descriptions, material properties, loadings, and structural evaluation for the EOS-HSM-SC are presented in Appendix 3.9.8.

3.6.3 EOS-TC

Details of the structural analysis of the EOS-TC are provided in Appendices 3.9.3 and 3.9.5.

The details of the structural analyses of the EOS-TC body, including the cylindrical shell assembly and bottom assembly, the top cover, and the local stresses at the trunnion/cask body interface are presented in Appendix 3.9.5. The specific methods, models and assumptions used to analyze the cask body for the various individual loading conditions specified in 10 CFR Part 72 [3-13] are described in that appendix.

The EOS-TC body structural analyses use static or quasistatic linear elastic methods. The stresses and deformations due to the applied loads are determined using the ANSYS [3-12] computer program.

Appendix 3.9.5 presents the evaluation of the trunnion stresses in the EOS-TC due to all applied loads during fuel loading and transfer operations.

Based on the loading and transfer scenario, the top trunnions are analyzed per ANSI N14.6 [3-7] for vertical lifting loads.

The evaluations summarized in Appendix 3.9.5 show that all calculated trunnion stresses are less than their corresponding allowable stresses. Therefore, the EOS-TC top and bottom trunnions are structurally adequate to withstand loads during lifting and transfer operations.

Table 3-7
Summary of EOS-89BTH DSC Component Weights

Component Description	Weight (lb)
DSC Shell	17,000
Basket Assembly	27,400
Dry/Unloaded/Open DSC	**44,400**
89 Fuel Assemblies	62,800
DSC Top Shield Plug	7,340
Flooding Water in Loaded DSC	15,900
Flooded/Loaded Open DSC	**131,000**
DSC Top Cover Plates	5060
Sealed/Loaded DSC Weight	**120,000**

Table 3-8
Summary of EOS-HSM Weight and Center of Gravity

Component	Description	Value
Empty *EOS-HSM-RC* Long	Total Weight (lb)	350,000
	Center of Gravity from Bottom in Vertical Direction	126.5 inches
EOS-HSM-RC Long Loaded with EOS-37PTH DSC	Maximum Weight (lb)	484,000
	Center of Gravity from Bottom in Vertical Direction	120.8 inches
Empty EOS-HSM-SC	*Total Weight (lb)*	*361,000*
	Center of Gravity from Bottom in Vertical Direction	*125.6 inches*
EOS-HSM-SC Loaded with EOS-37PTH DSC	*Maximum Weight (lb)*	*481,000*
	Center of Gravity from Bottom in Vertical Direction	*120.7 inches*

Notes:

1. The weight and center of gravity values listed in the table are corresponding to the maximum concrete density of 160 pcf.
2. *The loaded weight values listed consider the design weights of 134 kips for the longest EOS-DSC, and 120 kips for the medium length DSC respectively, corresponding to the listed HSM length.*

All Indicated Changes are in response to Revised RSI 3-1

3.9.7.1.8.1.4 Sliding Analysis for Tornado Wind Concurrent with Massive Missile Impact loading

The combined wind + missile impact case is considered for EOS-HSM sliding analysis based on the conservation of energy.

First, the conservation of momentum is used for the sliding analysis.

$$V = \frac{m \cdot v_i}{M/1.07 + m - F_{hw}/386.4}$$

Where,

V = Initial linear velocity of module after impact
v_i = Initial velocity of missile
m = Mass of the missile
M_1 = Mass of empty EOS-HSM Short
M_2 = Mass of *two* end shield wall*s*
M_3 = Mass of governing loaded EOS-89BTH DSC
M = Total mass = $M_1 + M_2 + M_3$
1.07 is the factor used to account for the uncertainty of the concrete density.

Then using the conservation of energy:

$$\begin{aligned} &\mathit{Friction\ Energy} \\ &\qquad = \mathit{Initial\ Kinetic\ Energy\ of\ System} + \mathit{Work\ done\ by\ Wind} \end{aligned}$$

$$\mu \cdot (gM/1.07 - F_{vw})d = \frac{(M/1.07 + m) \cdot V^2}{2} + F_{hw}d$$

Where,

μ = 0.6 coefficient of friction for concrete-to-concrete surfaces
F_{vw} = Uplift force generated by DBT wind pressure on the roof
d = Sliding distance of EOS-HSM
F_{hw} = Sliding force generated by DBT wind pressure

The sliding distance of the EOS-HSM module is calculated to be 1.62 inches.

3.9.7.1.8.1.5 Time-Dependent Sliding Analysis for Tornado Wind Concurrent with Massive Impact Loading

In addition to the dynamic sliding analysis, a time dependent analysis is used to provide a bounding sliding displacement.

The total force causing sliding is:

$$F_{slide} = F + F_{hw}$$

All Indicated Changes are in response to Revised RSI 3-2

The resisting force from friction is:

$$F_{resis} = \mu(W - F_{vw})$$

Therefore the force causing acceleration is:

$$F_{acc} = F_{slide} - F_{resis}$$

The velocity is:

$$v_i = \left[\frac{F_{acc,i} + F_{acc,i-1}}{2} \cdot (t_i - t_{i-1})\right] / m_{tot} + v_{i-1}$$

Where,

i = Index for current time step
i-1 = Index for previous time step
m_{tot} = Total mass of loaded EOS-HSM and both end shield walls including adjustment for density uncertainty

The sliding displacement is:

$$x_i = \left[\frac{v_i + v_{i-1}}{2} \cdot (t_i - t_{i-1})\right] + x_{i-1}$$

The sliding displacements resulting from these analyses are shown in Figure 3.9.7-5 through Figure 3.9.7-7. The governing sliding displacement is 1.30 inches which is bounded by sliding distance of 1.62 inches resulting from dynamic sliding analysis as calculated in Section 3.9.7.1.8.1.4.

3.9.7.1.8.2 Flood Loads

The EOS-HSM is designed for a flood height of 50 feet and water velocity of 15 fps. The module is evaluated for the effects of a water current of 15 fps impinging on the side of a submerged EOS-HSM. Under 50 feet of water, the inside of the module is rapidly filled with water. Therefore, the EOS-HSM components are not evaluated for the 50 feet static head of water.

Calculation of the drag pressure due to design flood is shown in Appendix 3.9.4.

3.9.7.1.8.2.1 Overturning Analysis

The factor of safety against overturning of a single EOS-HSM with *one* shield wall, for the postulated flooding conditions, is calculated by summing moments about the bottom outside corner of a single, freestanding EOS-HSM. The factors of safety against overturning for a single, freestanding EOS-HSM due to the postulated design basis flood water velocity are 1.14, 1.12, 1.11, and 1.13 for the EOS-HSM Short, EOS-HSM Medium, EOS-HSM-FPS Medium, and EOS-HSM Long, respectively.

3.9.7.1.8.2.2 Sliding Analysis

The factor of safety against sliding of a freestanding single EOS-HSM due to the maximum postulated flood water velocity of 15 fps is calculated using methods similar to those described above. The effective weight of the EOS-HSM including the DSC and *one* end shield wall acting vertically downward, less the effects of buoyancy acting vertically upward is calculated. The factors of safety against sliding for a single, freestanding EOS-HSM due to the postulated design basis flood water velocity are 1.12, 1.09, 1.08, and 1.11 for the EOS-HSM Short, EOS-HSM Medium, EOS-HSM-FPS Medium, and EOS-HSM Long, respectively.

3.9.7.1.8.3 Seismic Load

The EOS-HSM is evaluated for maximum values for seismic accelerations of 0.45g in the horizontal direction and 0.30g in the vertical direction. Both the loaded EOS-HSM and the empty EOS-HSM are considered for these loads. The EOS-HSM and one end shield wall rotate about B, shown in Figure 3.9.7-1. The other end shield wall, corner blocks and rear shield walls are conservatively ignored.

The combination of 100% of horizontal acceleration and 40% of vertical acceleration is used.

3.9.7.1.8.3.1 Static Overturning Analysis of the EOS-HSM due to Seismic Load

The stabilizing and overturning moments are calculated and compared, and the case considering the bounding 140 pcf concrete density and the minimum DSC weight to minimize the stabilizing moment is shown below. The stability overturning analysis shown is for the governing EOS-HSM Long model. A factor of 1.07 (150 pcf/140 pcf) reduces the considered mass to the 140 pcf lower bound case. The 160 pcf upper bound is also considered, but not shown here.

Stabilizing Moment = $M_{st} = (W_{HSM} + W_{DSC}) \times d_{HSM-B} + W_{end\_shield\_wall} \times d_{end\_shield\_wall-B}$

$$M_{st} = \left(\frac{330kip}{1.07} + 134kip\right) \times (48in) + \left(\frac{187.1kip}{1.07}\right) \times (124in)$$

$M_{st} = 42{,}900$ kip-in

Where a factor of 1.07 (150pcf/140pcf) is used to account for the uncertainty of the concrete density.

Overturning Moment =

$$M_{ot} = 0.4a_v \times (W_{HSM}x_{HSM} + W_{DSC}x_{DSC} + W_{wall}x_{wall}) \\ + a_h(W_{HSM}y_{HSM} + W_{DSC}y_{DSC} + (W_{wall}h_{wall})/2)$$

$$M_{ot} = 0.4 \times 0.30g \times \left[\frac{330kip}{1.07} \times 48in + 134kip \times 48in + \frac{187.1kip}{1.07} \times 124in\right]$$

3.9.7.1.8.3.2 Static Sliding Analysis of the EOS-HSM due to Seismic Load

The resisting friction force and horizontal seismic force are calculated and compared and the case considering the bounding 140 pcf concrete density and the minimum DSC weight to minimize the resisting friction force is shown below. The static sliding analysis is shown for the governing EOS-HSM Long model. Cases where the EOS-HSM is loaded, and has no shield walls are considered*, but the results are not sensitive to the weight of the HSM or its contents*.

Friction force resisting sliding = $F_{st} = \mu(W_{HSM}+W_{DSC})(1-0.40\ a_v)$

$$F_{st} = 0.6 \times \left(\frac{330kip}{1.07} + 134kip\right) \times (1 - 0.40 \times 0.30)$$

$$F_{st} = 233\text{kip}$$

Applied horizontal seismic force = $F_{hs} = a_h\ (W_{HSM}+W_{DSC})$

$$F_{hs} = 0.45 \times \left(\frac{330kip}{1.07} + 134kip\right)$$

$$F_{hs} = 199\text{kip}$$

Where,

μ = friction coefficient = 0.6

a_v, a_h = vertical and horizontal seismic accelerations = 0.30g, 0.45g respectively

x, y = are the horizontal and vertical distance between the CG and point of rotation B

The maximum acceptable acceleration values before sliding occurs are calculated below:

$$F_{st} = 0.6 \times \left(\frac{330kip}{1.07} + 134kip\right) \times \left(1 - 1.1 \times 0.40_{a_v}\right) \geq 1.1F_{hs}$$
$$= 1.1a_h \left(\frac{330kip}{1.07} + 134kip\right)$$

And assuming $a_v = \frac{2}{3}a_h$

$$\text{a} = 0.47\text{g}, \text{a}_\text{v} = 0.32\text{g}$$

The safety factor of $F_{st}/1.1F_{hs}$=1.07 and is greater than 1 and is the governing safety factor for all load cases. Therefore, it is concluded that the EOS-HSM is stable for seismic loads of up to 0.45g horizontal and 0.30g vertical.

APPENDIX 3.9.8
EOS-HSM-SC STRUCTURAL ANALYSIS

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3.9.8 EOS-HSM-SC STRUCTURAL ANALYSIS

The purpose of this appendix is to present the structural evaluation of the EOS-HSM-SC due to all applied loads during storage, and loading and unloading operations. The EOS-HSM-SC is an alternate horizontal storage module option that may be used in lieu of the EOS-HSM-RC as part of the NUHOMS® EOS System.

3.9.8.1 General Description

A general description and operational features for the NUHOMS® EOS System are provided in Chapter 1. Similar to the EOS-HSM-RC, the EOS-HSM-SC is a freestanding structure, designed to provide environmental protection and radiological shielding for the EOS-37PTH DSC or EOS-89BTH dry shielded canister (DSC). In contrast to the EOS-HSM-RC, the EOS-HSM-SC is a steel-plate composite (SC) structure consisting of two steel plates (faceplates) with structural concrete between them, with the faceplates attached to the concrete using steel-headed stud anchors, and connected to each other using steel tie bars. Different components and overall dimensions of the EOS-HSM-SC are shown in Drawing EOS01-3300-SAR, which is provided in Chapter 1.

As with any EOS-HSM option in the NUHOMS® EOS System, the EOS-HSM-SC consists of a base unit and a roof unit. The EOS-HSM-SC is a multi-segment design, which consists of two segments of the base unit like the EOS-HSMS-RC and the EOS-HSMS-FPS-RC. The EOS-37PTH DSC or the EOS-89BTH DSC are supported inside the EOS-HSM-SC by the flat plate support (FPS) DSC support structure, which is supported by pedestals spaced along the length of the DSC support structure. The configuration of the EOS-HSM-SC, in terms of component dimensions and thicknesses, is essentially the same as that of the EOS-HSMS-FPS-RC. The configuration of the DSC support structure of the EOS-HSM-SC is identical to that of the FPS DSC support structure for the EOS-HSMS-FPS-RC. As such, only the medium length option is evaluated for the EOS-HSM-SC.

Like the EOS-HSM-RC, the EOS-HSM-SC storage modules can be arranged in either a single-row array, or back-to-back double-row arrays. The front wall of the EOS-HSM-SC has a round access door opening provided for transferring the EOS-37PTH DSC or EOS-89BTH DSC into the module or for retrieving it from the module. The door opening is closed by a shield door after the DSC insertion. The EOS-HSM-SC shield door is also an SC component and provides environmental protection, including missile and shielding protection.

End shield walls are installed at each end of a module array to provide the required missile and shielding protection. Similarly, a rear shield wall is installed at the rear of each module of the single-row module array for the same purpose. Both the end shield wall and rear shield wall are also SC components.

For thermal protection of the EOS-HSM-SC components, thin stainless steel heat shields are installed inside the EOS-HSM-SC. The configurations of the roof and side heat shields for the EOS-HSM-SC are identical with those for the EOS-HSMS-FPS-RC.

The EOS-HSM-SC is also provided with cask restraint embedments in the front wall to secure the EOS-TC during DSC insertion and retrieval operations.

3.9.8.2 Material Properties

The material properties used in the analysis and design of the EOS-HSM-SC and its components are discussed in detail in Chapter 8.

3.9.8.3 Design Criteria

The SC components, FPS DSC support structure, heat shields, and axial retainer are important-to-safety components of the EOS-HSM-SC. Consequently, they are designed and analyzed to perform their intended functions under the extreme environmental and natural phenomena specified in 10 CFR 72.122 [3.9.8-1] and American National Standards Institute (ANSI) 57.9 [3.9.8-2], which are the same criteria used for the EOS-HSM-RC in Appendix 3.9.4.

The SC components are designed to the requirements of American Institute of Steel Construction (AISC) N690-18 [3.9.8-3], using the load combinations prescribed by ANSI 57.9 [3.9.8-2]. N690-18 is compatible with ANSI/AISC 360-16 [3.9.8-6], provisions of which are applicable as well unless stated otherwise. Guidelines of the U.S. NRC Regulatory Guide 1.243 [3.9.8-4] are also considered. The FPS DSC support structure, heat shields, and axial retainer are designed to the requirements of the AISC *Specification for Structural Steel Buildings [3.9.8-5] using the Allowable Strength Design (ASD) methodology* as in Appendix 3.9.4. *The load combinations used for the steel components are those prescribed by ANSI 57.9 as detailed in Table 2-7.*

The load and resistance factor design (LRFD) method of N690-18 [3.9.8-3] is used for the design of the EOS-HSM-SC components. The faceplate and ties are provided to meet the minimum flexural and shear requirement of N690-18 and to ensure that the provided design strength exceeds the required strength. The steel headed stud anchors, or studs, are provided to ensure composite action of the steel faceplates and concrete.

All Indicated Changes are in response to Revised RSI 3-10

The available strength of SC components, as well as the strength under combined forces, is calculated based on the provisions of Section N9.3 of N690-18 [3.9.8-3] except for the thin walls of the EOS-HSM-SC including the rear wall, middle/front pedestal, lower side wall bottom (14 inches), and upper side wall. The provisions of N690-18 [3.9.8-3] are primarily intended for the thick walls of nuclear power plant structures that provide radiation shielding and resistance to severe and extreme loads. Modified provisions of N690-18, based on nonlinear inelastic finite element analyses and physical test results, are used for the thin walls of the EOS-HSM-SC. *The available strengths of SC components as detailed in Table 3.9.8-3 are calculated using the following equations:*

Per Section N9.3.1 of N690-18, the uniaxial tensile strength per unit width of SC sections, $\phi P_{n,ten}$, is determined in accordance with equations D2-1 and D2-2 in Chapter D of AISC 360-16 [3.9.8-6]:

$$\phi P_{n,ten} = min(0.9F_yA_g,\ 0.75F_uA_g)$$

where

F_y: *Faceplate yield stress*

F_u: *Faceplate tensile strength*

$A_g = 2t_pl$ (in^2/ft): *Gross area of the faceplate per unit width*

t_p: *Faceplate Thickness*

$l = 12$ (in/ft): *Unit width*

Per Section N9.3.2 of N690-18, the compressive strength per unit width of SC sections, $\phi P_{n,com}$, is determined in accordance with equations I2-2 and I2-3 in Section I2.1b of AISC 360-16 with the faceplates taking the place of the steel shape:

$$\phi P_{n,com} = 0.75P_{n0}[0.658^{(Pn0/Pe)}] \qquad \text{if } P_{n0}/P_e \le 2.25$$

$$\phi P_{n,com} = 0.75(0.877P_e) \qquad \text{if } P_{n0}/P_e > 2.25$$

where

$P_{n0} = F_yA_{sn} + 0.85f_c'A_c$: *Nominal compressive strength per unit width*

$A_{sn} = 2t_pl$: *Net area of faceplates per unit width*

f'_c: *Concrete compressive strength*

$A_c = t_cl$: *Area of the concrete infill per unit width*

t_c: *Concrete infill thickness*

$P_e = \pi^2(EI_{eff})/L^2$: *Elastic critical buckling load per unit width*

L: Laterally unbraced length of the member

All Indicated Changes are in response to Revised RSI 3-9

$EI_{eff} = E_sI_s + 0.60E_cI_c$: *Effective SC stiffness per unit width for buckling evaluation*

E_s: *Modulus of elasticity of steel*

E_c: *Modulus of elasticity of concrete*

$I_s = l[t_p(t_{sc} - t_p)^2/2]$: *Moment of inertia of the faceplates per unit width*

$I_c = lt_c^3/12$: *Moment of inertia of concrete infill per unit width*

Per Section N9.3.3 of N690-18, the out-of-plane flexural strength per unit width of SC sections, $\phi_b M_n$*, is determined by equation A-N9-19 of the code as follows:*

$$\phi_b M_n = 0.90F_y(A_s^F)(0.9t_{sc})$$

where

$A_s^F = lt_p$: *Gross cross-section area of faceplate in tension due to flexure per unit width*

t_{sc}: *SC section thickness*

Per Section N9.3.4 of N690-18, the in-plane shear strength per unit width of SC sections, $\phi_{vi} V_{ni}$*, is determined by equation A-N9-20 of the code as follows:*

$$\phi_{vi} V_{ni} = 0.90\kappa F_y A_s$$

where

$A_s = 2t_p l$: *Gross area of the faceplate per unit width*

$$\kappa = 1.11 - \frac{5.16A_sF_y}{31.6A_c\sqrt{f_c'}} \leq 1.0$$

Per Section N9.3.5 of N690-18, the out-of-plane shear strength per unit width of SC sections, $\phi_{vo} V_{no}$*, is determined as follows:*

Equation A-N9-21 of the code is used if the shear reinforcement (tie) spacing (= $\max(s_{tt}, s_{tl})$*) is no greater than* $t_{sc}/2$*, where* s_{tt} *and* s_{tl} *are the tie spacing along the direction of one-way shear and transverse to the direction of one-way shear, respecitvely:*

$$\phi_{vo} V_{no} = 0.75(V_{conc} + V_s)$$

where

$V_{conc} = 0.05(f_c')^{0.5}t_cl$

$V_s = \xi p_sF_t(l/s_{tt}) \leq 0.25(f_c')^{0.5}t_cl$

F_t: *Nominal tensile strength of ties*

$p_s = t_c/s_{tl}$

ξ = 1.0 for yielding shear reinforcement and 0.5 for non-yielding shear reinforcement

If the shear reinforcement spacing is greater than $t_{sc}/2$:

$$V_{no} = max(V_{conc}, V_s)$$

where V_s is calculated taking both ξ and p_s as 1.0.

Per Section N9.3.6a of N690-18, the interaction of out-of-plane shear forces is limited as follows:

If the required out-of-plane shear strength per unit with (both V_{rx} and V_{ry}) is greater than the available out-of-plane shear strength contributed by the concrete per unit width ($\phi_{vo}V_{conc}$), and the out-of-plane shear reinforcement is spaced no greater than half the section thickness, equation A-N9-24 of the code needs to be satisfied:

$$\left[\left(\frac{V_{rx}-V_{c\,conc}}{V_c-V_{c\,conc}}\right)+\left(\frac{V_{ry}-V_{c\,conc}}{V_c-V_{c\,conc}}\right)\right]^{\frac{5}{3}}+\left[\frac{\frac{\sqrt{V_{rx}^2+V_{ry}^2}}{0.9t_{sc}}}{\Psi\frac{IQ_{cv}^{avg}}{s^2}}\right]^{\frac{5}{3}} \leq 1$$

where

$V_{c\,conc} = \phi_{vo}V_{conc}$

$V_c = \phi_{vo}V_{no}$

Ψ = 1.0 for yielding shear reinforcement and yielding steel anchors.

Q_{cv}^{avg}: Weighted average of the available interfacial shear strength of ties and steel anchors accounting for their respective tributary areas and numbers

If V_c is governed by the steel contribution alone and the out-of-plane shear reinforcement is spaced greater than half the section thickness, $V_{c\,conc}$ = 0 is used.

Per Section N9.3.6b of N690-18, the interaction of the three in-plane required membrane strengths (S_{rx}, S_{ry}, S_{rxy}) and three out-of-plane required flexural or twisting strengths (M_{rx}, M_{ry}, M_{rxy}) is evaluated using equations A-N9-25 through A-N9-27 of the code as follows:

(a) For $S_{r,max} + S_{r,min} \geq 0$:

$$\alpha\left(\frac{S_{r,max}+S_{r,min}}{2V_{ci}}\right) + \left(\frac{S_{r,max}-S_{r,min}}{2V_{ci}}\right) \leq 1.0$$

(b) For $S_{r,max} > 0$ and $S_{r,max} + S_{r,min} < 0$:

$$\left(\frac{S_{r,max}}{V_{ci}}\right) - \beta\left(\frac{S_{r,max}+S_{r,min}}{V_{ci}}\right) \leq 1.0$$

(c) For $S_{r,max} \leq 0$ and $S_{r,min} \leq 0$:

$$-\beta\left(\frac{S_{r,min}}{V_{ci}}\right) \leq 1.0$$

where

$$S_{r,max},\ S_{r,min} = \frac{S'_{rx}+S'_{ry}}{2} \pm \sqrt{\left(\frac{S'_{rx}-S'_{ry}}{2}\right)^2 + \left(S'_{rxy}\right)^2}$$

$S'_{rx} = \frac{S_{rx}}{2} \pm \frac{M_{rx}}{j_x t_{sc}}$*: Required membrane axial strength per unit width in direction x for each notional half of SC panel section*

$S'_{ry} = \frac{S_{ry}}{2} \pm \frac{M_{ry}}{j_y t_{sc}}$*: Required membrane axial strength per unit width in direction y for each notional half of SC panel section*

$S'_{rxy} = \frac{S_{rxy}}{2} \pm \frac{M_{rxy}}{j_{xy} t_{sc}}$*: Required membrane in-plane shear strength per unit width for each notional half of SC panel section*

$j_x = 0.9$ *if* $S_{rx} > -0.6P_{n0}$ *and* $j_x = 0.67$ *if* $S_{rx} \leq -0.6P_{n0}$

$j_y = 0.9$ *if* $S_{ry} > -0.6P_{n0}$ *and* $j_y = 0.67$ *if* $S_{ry} \leq -0.6P_{n0}$

$j_{xy} = 0.67$

$\alpha = V_{ci}/T_{ci}$

$\beta = V_{ci}/P_{ci}$

Revised RSI 3-9

$P_{ci} = 0.80P_{no}/2$: Available compressive strength per unit width for each notional half of SC panel section

$T_{ci} = 1.00T_{ni}/2$: Available tensile strength per unit width for each notional half of SC panel section ($T_{ni} = \min(F_yA_g, F_uA_g)$)

$V_{ci} = 0.95V_{ni}/2$: Available in-plane shear strength per unit width for each notional half of SC panel section

The following modifications of N690-18 provisions are considered:

- *Section N9.1.1(a) of N690-18 specifies minimum thicknesses of 18 inch and 12 inch, respectively, for exterior and interior SC walls, which are not met by the 10.25-inch and 14.5-inch thick sections of the door and 11.38-inch section of the OVC. As presented in Commentary Section N9.1.1(a) of N690-18, the minimum thickness of 18 inch for exterior SC walls is based on the minimum thickness of 16.9 inch reinforced concrete walls to resist a tornado missile per Table 1 of NUREG-0800, Section 3.5.3 [3.9.8-14]. Since the 10.25 inch and 14.5 inch sections of the door are supported by the front wall of the EOS-HSM-SC during missile impact, the door is appropriate as an exterior wall. Since the specified minimum thickness of 12 inches for interior walls, based on the maximum reinforcement ratio and minimum faceplate thickness, is conservatively rounded up from the actual minimum of 10 inches as presented in Commentary Section N9.1.1(a) of N690-18, the OVC thickness is appropriate.*
- *Section N9.1.1(c) of N690-18 specifies the reinforcement ratio of SC sections to be no less than 0.015 and no greater than 0.050. According to AISC Steel Design Guide 32 [3.9.8-15], high reinforcement ratios can potentially result in higher concrete stresses and change the governing in-plane shear limit state from steel faceplate yielding to concrete compression strut failure, which can potentially reduce the strength and ductility of SC walls. The reinforcement ratio for the thin walls of the EOS-HSM-SC minimally (less than 5%) exceeds the ratio of 0.050 and this exceedance facilitates compliance with the faceplate slenderness requirement in Section N9.1.3 of N690-18, per Section 3.4.2.1 and Appendix A of [3.9.8-19]. The reinforcement ratio of 0.0149 for the top segment of the front wall is less than the minimum reinforcement ratio of 0.015 when the effective thickness of 0.3125 inch is considered. Per Commentary Section N9.1.1(c) of N690-18, use of a very low reinforcement ratio poses concerns regarding handling strength and stiffness in addition to residual stresses due to fabrication operations and concrete casting. These concerns are not applicable because the actual thickness is twice as large as the effective thickness and the reinforcement ratio of 0.0149 is less than the ratio of 0.015 minimally.*

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- *Section N9.1.1(d) of N690-18 specifies the yield stress of faceplates to be no less than 50 ksi and no more than 65 ksi. The door and OVC steel plates are constructed from ASTM A36. As presented in Commentary Section N9.1.1(d) of N690-18, the minimum yield strength of faceplates is intended to prevent premature yielding due to residual stresses from concrete casting and thermally induced stresses. The door and OVC are free to grow when subjected to thermal loads and require a concrete volume of relatively low height resulting in insignificant pressure on the faceplates during casting as compared to a large EOS-HSM-SC wall. Therefore, stresses due to thermal growth and residual stress from concrete casting will not contribute to premature yielding of the faceplates in these components. Additionally, the margins for the door thickness to withstand local damage due to missile attack, ductile capacity for missile impact, and structural adequacy for punching shear are sufficiently large. The margins for the OVC are sufficiently large as well. Therefore, the door and OVC faceplates constructed from ASTM A36 have sufficient strength.*
- *Section N9.1.4b(a) of N690-18 provides a requirement on the spacing of steel anchors to develop the yield strength of the faceplates over the development length. This requirement ensures that sufficient composite action exists between the steel faceplate and concrete. However, the requirement does not consider the contribution of ties to available shear strength of the SC component, leading to inefficient designs for those components such as thin walls, for which the density of ties tends to be high. Studies based on finite element analysis in [3.9.8-18] demonstrate the contribution of ties to the composite action and show that composite action is adequate for the thin walls of the EOS-HSM-SC.*
- *Section N9.1.4b(b) of N690-18 provides the requirement on the spacing of steel anchors to prevent interfacial shear failure before out-of-plane shear failure of the SC section. This requirement does not consider the required strength of the SC component but the available out-of-plane strength, leading to inefficient designs in those cases where the demand-to-capacity ratio for out-of-plane shear interaction is low. For the design of the EOS-HSM-SC, this criterion is modified such that the spacing of steel anchors required to prevent interfacial shear failure is deemed adequate if the demand-to-capacity ratio for out-of-plane shear interaction (presented in Section N9.3.6a of N690-18) is below 1.0 when required strength at least 1/3 greater than that determined by structural analysis is used. This approach is presented in Section 3.4.2.2.3 of [3.9.8-19] and validated by laboratory test results in [3.9.8-20].*

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- *Section N9.1.7 of N690-18 provides requirements on design and detailing around openings. The design of the front wall opening in the top segment of the EOS-HSM-SC follows the requirements to the maximum practical extent possible to achieve a fully developed edge at the opening perimeter: a sufficiently fine finite element mesh is employed for the front wall and around its opening; a sleeve spanning across the opening from the front faceplate to the back faceplate is provided; and an equivalent flange is provided by thickening the front wall faceplate to provide additional strength in the stress concentration region. In addition, the requirements aim at reducing the effects of stress concentrations around an opening, which are of minor concern for the EOS-HSM-SC because stress concentration significantly affect the limit state of fatigue, and fatigue is not a concern for the EOS-HSM-SC. For the EOS-HSM-SC front wall, it is impractical to provide a flange plate extending a distance of at least the section thickness beyond the opening perimeter as specified in Section N9.1.7a(b) of N690-18 because of the proximity of the front wall opening to the side walls.*
- *Section N9.3.6a of N690-18 specifies an interaction equation that out-of-plane shear forces are required to meet. The interaction of out-of-plane shear forces for the thin walls of the EOS-HSM-SC is considered based on a modified approach described in the above discussion on Section N9.1.4b(b) of N690-18.*

3.9.8.4 Load Cases

The design load cases for EOS-HSM-SC component evaluation are the same as the load cases for EOS-HSM-RC concrete component evaluation provided in Table 3.9.4-4 except for the earthquake load, which depends on the frequencies and damping value for the EOS-HSM-SC as described in Section 3.9.8.9. The EOS-HSM-SC dead load also includes the self-weight of the faceplate based on the sheet weight density of 490 lb/ft^3. The design load cases for the FPS DSC support structure, heat shields, and axial retainer of the EOS-HSM-SC are also the same as the load cases for the EOS-HSM-RC except for the earthquake load.

Revised RSI 3-7 and 3-11

3.9.8.5 Load Combination

The load combinations used in the structural analysis of the EOS-HSM-SC are the same as the combinations for the EOS-HSM-RC. The load combinations used for the FPS DSC support structure, heat shields, and axial retainer of the EOS-HSM-SC are also the same as the combinations used for the EOS-HSM-RC. *These load combinations, as detailed in Table 3.9.4-5 for the SC components, in Table 3.9.4-16 for the DSC support structure and in Table 2-7 for the other steel components, are prescribed by ANSI 57.9 [3.9.8-2], and considered by NUREG-1536 [3.9.8-16] (and the more current NUREG-2215 [3.9.8-17]) as the most applicable for the design of dry storage structures.*

3.9.8.6 Finite Element Models

Finite element models (FEMs) for the EOS-HSM-SC and heat shields are described in this section. The FPS DSC support structure and axial retainer are evaluated by hand calculation methodologies. *Connection and embedment loads are either extracted from applicable FEMs or calculated by hand.*

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3.9.8.7 Normal Operation Structural Analysis

The same normal operating loads described in Section 3.9.4.7 for the EOS-HSM-RC are used to evaluate the EOS-HSM-SC. *The same DSC weight of 135 kips as specified in Table 3.9.4-4 is used conservatively.* The same thermal load for the EOS-HSM-FPS is applicable to the EOS-HSM-SC because, as discussed in Section 4.4.12, the SC construction does not impact the thermal performance of the horizontal storage module.

3.9.8.8 Off-Normal Operation Structural Analysis

The same off-normal operating loads described in Section 3.9.4.8 for the EOS-HSM-RC are applicable to the EOS-HSM-SC.

All Indicated Changes are in response to Revised RSI 3-2

3.9.8.9 Accident Condition Structural Analysis

The same accident condition loads described in Section 3.9.4.9 for the EOS-HSM-RC, except for the seismic load, are used to evaluate the EOS-HSM-SC.

The design basis seismic load used for analysis of the EOS-HSM-SC components is as discussed in Section 2.3.4. Based on N690-18 [3.9.8-3], a damping value of five percent is used for seismic analysis of SC components of the EOS-HSM-SC. An evaluation of the frequency content of the loaded EOS-HSM-SC is performed to determine the amplified accelerations associated with the design basis seismic response spectra for the EOS-HSM-SC. Modal frequencies and mass participation factors of the EOS-HSM-SC are shown in Table 3.9.8-1. The results of the frequency analysis yield a lowest frequency of 18.29 Hz in the transverse direction and 30.12 Hz in the longitudinal direction. Because the lowest vertical frequency exceeds 45 Hz, the spectral acceleration is not amplified in the vertical direction. Therefore, based on the Regulatory Guide 1.60 response spectra amplifications, and conservatively using zero period acceleration (ZPA) accelerations of 0.50g and 0.33g in the horizontal and vertical directions, respectively, the corresponding seismic accelerations used for the design of the EOS-HSM-SC are 1.073g and 0.703g in the transverse and longitudinal directions, respectively, and 0.333g in the vertical direction. The resulting amplified accelerations are given in Table 3.9.8-2. *An equivalent static analysis of the EOS-HSM-SC is performed by applying the amplified seismic acceleration loads as described in Section 3.9.4.9.2 for the EOS-HSM-RC.*

Like the EOS-HSM-RC, for sites where the response spectra at the base of the HSM are larger than analyzed, more than one module may need to tie together to prevent significant sliding or to prevent the modules from banging into each other causing unacceptable damage. The requirements on the faceplate, stud, and tie may also need to be reviewed, and the faceplate thickness and tie size may be increased for such sites. The tie and stud spacing may be adjusted as well.

The stability evaluation of the EOS-HSM-SC due to a 0.45g Horizontal/0.30g Vertical seismic load is discussed in Section 3.9.8.11. The stability evaluation by dynamic analysis shall be performed using the analysis methodology described in CoC 1029 [3.9.8-10].

Seismic analysis of the EOS-HSM-SC heat shields consists of a modal time-history analysis of the EOS-HSM-SC for obtaining four percent damped in-structure response spectra (ISRS) at heat shields support locations *as shown in Figure 3.9.8-5 through Figure 3.9.8-10*. The earthquake time histories compatible with the RG 1.60 spectra, described in Section 3.9.4.9.2 for the EOS-HSM-RC, are used as seismic input motion. The ISRS for the *h*eat shields is conservatively determined using ground motion based on the RG 1.60 spectra anchored at 0.50g and 0.33g in the horizontal and vertical directions, respectively. The modal frequencies and mass participation factors *o*f the heat shields, described in Section 3.9.4.9.2 for the *EOS-HSM-FPS-RC*, are applicable to the EOS-HSM-SC. *The results of an equivalent static analysis of the EOS-HSM-SC heat shields using the seismic acceleration load corresponding to the previously obtained ISRS are discussed in Section 3.9.8.10.4.*

3.9.8.10 Structural Evaluation

The load combination results of the EOS-HSM-SC components are presented in this section.

3.9.8.10.1 EOS-HSM-SC SC Components

The *governing load demands and capacities, and corresponding* load combinations for each of the SC components of the EOS-HSM-SC are presented in Table 3.9.8-3. The demand-to-capacity ratios for all component categories are less than one for all strength categories.

3.9.8.10.2 FPS DSC Support Structure

The FPS DSC support structure of the EOS-HSM-SC is identical with the support structure for the EOS-HSM-FPS-RC, and the load combination results for the FPS DSC support structure provided in Table 3.9.4-17a, Table 3.9.4-21a, and Table 3.9.4-22a are applicable to the FPS DSC support structure of the EOS-HSM-SC except for the results for the stop plate, which are affected by *the accident earthquake load combination*. The demand-to-capacity ratio for the stop plate of the EOS-HSM-SC is 0.98. Therefore, the DSC support structure is adequate to resist the foreseeable loads applied to it.

3.9.8.10.3 EOS-HSM-SC Shield Door

The shield door is free to grow in the radial direction when subjected to thermal loads. Therefore, there are no stresses in the door due to thermal growth. The dead weight, tornado wind, differential pressure, and flood loads cause insignificant stresses in the door compared to stresses due to missile impact load. The evaluation of the door for the missile impact load is presented in Section 3.9.8.10.6.2. For the door anchorage, the controlling load due to tornado-generated differential pressure drop load, calculated for the EOS-HSM-RC in Section 3.9.4.10.3, is applicable.

3.9.8.10.4 Heat Shield

The heat shield design of the EOS-HSM-SC is identical with the heat shield design for the EOS-HSM-FPS-RC described in Section 3.9.4.10.4.

For the roof heat shield, the maximum interaction ratio for combined axial and bending stress in the connection bolts is 0.509, which is less than 1.0. The maximum bending moment in the roof heat shield panel is 26.2 in-lb/in, which is also less than the panel moment capacity of 59.59 in-lb/in.

For the side heat shield, the maximum interaction ratio for combined axial and bending stress in connection bolts is 0.272, which is less than 1.0. The maximum bending moment in side heat shield panel is 27.2 in-lb/in, which is also less than the panel moment capacity of 59.59 in-lb/in.

The thermal expansion evaluation of the heat shields for the EOS-HSM-RC is also applicable to the EOS-HSM-SC and, therefore, neither the roof heat shield panel and side wall heat shield panel is subjected to thermal stress.

3.9.8.10.5 DSC Axial Restraint

The DSC axial retainer of the EOS-HSM-SC is identical with the axial retainer for the EOS-HSM-RC described in Section 3.9.4.10.5. The maximum seismically induced shear load in the retainer is 140.2 kips, and the allowable shear strength of the axial retainer is 196.0 kips. The maximum seismically induced moment in the retainer is 280.4 in-kips, taking a moment arm of 2 inches, conservatively. The allowable flexural strength of axial retainer is 344.9 in-kips. Hence, the DSC axial retainer design is adequate to perform its intended function.

3.9.8.10.6 Evaluation of SC Components for Missile Loading

Missile impact effects are assessed in terms of local damage and overall structural response. As per [3.9.8-11], the local failure modes of SC components subjected to missile impact differ from those for reinforced concrete components in that SC components may experience penetration, bulging, splitting and perforation sequentially. Generally, scabbing is prevented by steel plates and perforation is considered to be the governing local failure mode for SC components. Evaluation of local effects is essential to ensure that protected items (the DSC and fuel) would not be damaged by a missile perforating a protective barrier. Evaluation of overall structural response is essential to ensure that protected items are not damaged or functionally impaired by deformation or collapse of the impacted structure.

The tornado-generated missiles are conservatively assumed to strike normal to the surface with the long axis of the missile parallel to the line of flight to maximize the local effects. Plastic deformation to absorb the energy input by the tornado-generated missile load is desirable and acceptable, provided that the overall integrity of the structure is not impaired. Due to complex physical processes associated with missile impact effects, the EOS-HSM-SC structure is primarily evaluated conservatively by application of empirical formulae.

The end shield wall, rear shield wall, base front wall, roof, and door of the EOS-HSM-SC are evaluated since these components may interface with missile loading. The end and rear shield walls, respectively, serve as missile barriers for the side and rear walls, which are therefore not evaluated for missile loading. No credit is taken for the contiguous walls behind the shield walls in the evaluations of the end and rear shield walls other than as simple supports.

All Indicated Changes are in response to Revised RSI 3-8

3.9.8.10.6.1 Local Damage Evaluation

The required thickness for concrete targets to prevent perforation is 18.5 inches, as calculated in Section 3.9.4.10.6.1. Since the minimum concrete thickness of the SC components is greater, perforation of the SC components of the EOS-HSM-SC do not occur due to missile impact. *The relevant thicknesses and lengths of the EOS-HSM-SC components which may be subjected to local damage due to missile impact are summarized below.*

Component	***t (in)***	***L (in)***
End Wall	*36*	*248*
Rear Wall	*36*	*222*
Base Front Wall	*42*	*92*
Roof	*44*	*221*
Door	*31.5*	*74.5*

3.9.8.10.6.2 Global Structural Response

The overall structural response of each SC component is determined by single DOF analysis using the response charts solution method of [3.9.8-12] as described in Section 3.9.4.10.6.2 for the EOS-HSM-RC considering the same enveloping missiles. *For the 12-inch diameter schedule 40 steel pipe, an additional approach is also considered, where the impulse-momentum theorem is applied directly without the modifications presented in Section 2.3.2 of [3.9.8-12]. This approach results in a greater peak force, but shorter impact duration than that calculated in Section 3.9.4.10.6.2.C. Both approaches are considered and the bounding resultant ductility ratio is taken.*

The rear wall and door are idealized as simply supported plates while the end wall, base front wall and roof are idealized as simply supported beams for structural response. The yield resistance and fundamental period of vibration of SC components are then determined based on the assumed idealized boundary condition. The calculated value of yield resistance, R_y, and fundamental period of vibration, T_n, are tabulated below.

Component	**R_y (kip)**	**T_n (sec)**
End Wall	1624	0.0300
Rear Wall	4680	0.00626
Base Front Wall	3174	0.00471
Roof	1648	0.0264
Door	*1299*	*0.00163*

The maximum value of ductility ratio of all five components is found to be less than 1.0, which *meets* the allowable ductility ratio of *1.0* for shear-controlled SC components with shear reinforcement spaced more than half the section thickness as per *RG 1.243 [3.9.8-4]*. Therefore, the global response of the EOS-HSM-SC is within the deformation limit meeting the ductility requirement. Per [3.9.8-11], punching shear as a failure mode is inherently prevented by an SC wall designed to resist local failure. Therefore, no additional evaluation of the EOS-HSM-SC is required for punching shear.

3.9.8.10.7 Connections and Embedments

The structural fasteners, connections, and concrete embedments used in the EOS-HSM-SC are in general identical to those for the EOS-HSM-RC. **[**

] *The connections are designed to the requirements of ACI 349-06, Appendix D [3.9.8-13] and AISC Specification for Structural Steel Buildings [3.9.8-5] using the Allowable Strength Design (ASD) methodology, in accordance with the guidance of N690-18 [3.9.8-3]. The load combinations used for concrete embedments and steel fasteners and connections are those prescribed by ANSI 57.9 as detailed in Table 2-7 for concrete components and steel components, respectively. The demands, capacities, and demand-to-capacity ratios of the connections and embedments are presented in Table 3.9.8-5 and Table 3.9.8-6.*

3.9.8.11 Stability Evaluation

The sliding and overturning stability analyses of the EOS-HSM-SC due to design basis wind, flood, seismic, and massive missile impact loads are performed using hand calculations.

3.9.8.11.1 General Description

The stability of the EOS-HSM-SC unit is evaluated for the same four load cases that are considered for the EOS-HSM-RC in Appendix 3.9.7, namely, tornado-generated wind loads, massive missile impact loads, flood loads, and seismic loads. The weight of an empty EOS-HSM-SC is between *306.8* kips minimum and *360.8* kips maximum. As in the stability evaluation of the EOS-HSM-RC, bounding upper and lower values of concrete density are considered; a concrete-to-concrete friction coefficient of 0.6 is used; the stability analysis considers rigid body motions; and the differential pressure load caused by the tornado pressure drop is ignored. Consideration is also given to partial steel-to-concrete friction at the base of the HSM resulting in an effective friction coefficient of 0.576. The stability is evaluated using the same methodologies described in Appendix 3.9.7.

3.9.8.11.2 Design Basis Tornado (Wind and Missile)

Revised RAI 3-2

The tornado wind speed and resulting wind pressures on the module considered in the stability analysis are described in Section 3.9.7.1.8.1. *Conservatively, a single loaded module (including door, roof, and OVC) with one end shield wall is considered for overturning analyses. A single loaded module with two end shield walls is considered for sliding analyses. The HSM is taken at the bounding minimum weight of 306.8 kips to minimize resistances to sliding and overturning.* Results of stability evaluations for the design basis tornado are summarized below.

- Static Overturning Analysis due to Tornado Wind: The safety factor against overturning computed for the EOS-HSM-SC due to tornado wind is 1.61.

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- Dynamic Overturning Analysis of Tornado Wind Concurrent with Massive Missile Impact Loading: *A loaded EOS-HSM-SC rotates a maximum of 0.5 degrees, which is less than the 21.8 degrees required to overturn the module.*
- Time-Dependent Overturning Analysis of Tornado Wind Concurrent with Massive Missile Impact Loading: *A loaded EOS-HSM-SC rotates a maximum of 2.91 degrees, which is less than the 21.8 degrees required to overturn the module.*
- Sliding Analysis for Tornado Wind Concurrent with Massive Missile Impact loading: The sliding distance of the EOS-HSM-SC is calculated to be 1.09 inches.
- Time-Dependent Sliding Analysis for Tornado Wind Concurrent with Massive Impact Loading: The governing sliding displacement is 1.10 inch.

3.9.8.11.3 Flood Loads

Revised RAI 3-2

The flood load on the module considered in the stability analysis is described in Section 3.9.7.1.8.2. *Conservatively, a single loaded module (including door, roof, and OVC) with one end shield wall is considered for the overturning analysis. A single loaded module with two end shield walls is considered for the sliding analysis. The HSM is taken at the bounding minimum weight of 306.8 kips to minimize resistances to sliding and overturning.* Results of stability evaluations for the flood loads are summarized below.

- Overturning Analysis: The factor of safety against overturning for a single, freestanding EOS-HSM-SC due to the postulated design basis flood water velocity is 1.15.
- Sliding Analysis: The factor of safety against sliding for a single, freestanding EOS-HSM-SC due to the postulated design basis flood water velocity is 1.37.

All Indicated Changes are in response to Revised RSI 3-2

3.9.8.11.4 Seismic Load

The seismic load on the module considered in the stability analysis is described in Section 3.9.7.1.8.3. *Conservatively, a single loaded module (including door, roof, and OVC) with one end shield wall is considered for the overturning analysis. Both the bounding upper and lower weights of the module are considered. A single loaded module with no end shield walls is considered for the sliding analysis, as it is not sensitive to the weight of the module or its contents.* Results of stability evaluations for the seismic load are summarized below.

- Static Overturning Analysis of the EOS-HSM-SC due to Seismic Load: The safety factor against overturning is 1.02 and is greater than 1. *The difference in safety factors between the maximum and minimum concrete density cases is negligibly small.* The maximum acceptable acceleration values before tipping occurs are 0.45g horizontal and 0.30g vertical.
- Static Sliding Analysis of the EOS-HSM-SC due to Seismic Load: The safety factor against sliding is 1.02 and is greater than 1. *There is no difference in safety factors between the maximum and minimum concrete density cases as this result is not sensitive to the weight of the EOS-HSM-SC or its contents.* The maximum acceptable acceleration values before sliding occurs are 0.45g horizontal and 0.30g vertical.
- Seismic Stability of the DSC on DSC Support Structure inside the EOS-HSM-SC: The safety factor against DSC lift off from the DSC support is 1.01. The maximum acceptable acceleration values before any uplift occurs are 0.455g horizontal and 0.303g vertical.

3.9.8.11.5 Interaction of EOS-HSM-SC with Adjacent Modules

When interaction of the EOS-HSM-SC with adjacent modulus is considered, the maximum displacement obtained in this section is conservative and bounding and this conservatism also applies to overturning, as described in Section 3.9.7.1.8.4 for the EOS-HSM-RC.

3.9.8.11.6 Results

For the maximum seismic acceleration of 0.45g horizontal and 0.30g vertical, no sliding will occur. Also, there will be no overturning at this set of seismic accelerations.

For flood, wind, and missile impact, it is also determined that the uplift values are small and so the DSC remains stable on the support rails. For seismic loading, it is also determined that there is no uplift of the DSC.

Table 3.9.8-4 shows a summary of the bounding results from the analyses in this section. Therefore, a maximum horizontal acceleration of 0.45g and a vertical acceleration of 0.30g can be exerted on the EOS-HSM-SC before any uplift or sliding occurs. Additionally, there is no DSC lift-off due to this seismic loading.

3.9.8.12 References

3.9.8-1 Code of Federal Regulation Title 10, Part 72 (10CFR Part 72), "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater than Class C Waste."

3.9.8-2 ANSI/ANS 57.9-1984, "Design Criteria for an Independent Spent Fuel Storage Installation (Dry Storage Type)," American National Standards Institute, American Nuclear Society.

3.9.8-3 AISC (2018), Specification for Safety-Related Steel Structures for Nuclear Facilities, ANSI/AISC N690-18, American Institute of Steel Construction.

3.9.8-4 U.S. Nuclear Regulatory Commission, Regulatory Guide 1.243, "Safety-Related Steel Structures and Steel-plate Composite Walls for other than Reactor Vessels and Containments," Rev. 0, August 2021.

Revised RAI 3-10

3.9.8-5 American Institute of Steel Construction, *Specification for Structural Steel Buildings, ANSI/AISC 360-05 or Later*.

3.9.8-6 AISC (2016), Specification for Structural Steel Buildings, ANSI/AISC 360-16, American Institute of Steel Construction.

3.9.8-7 Not used.

3.9.8-8 Not used.

3.9.8-9 "ANSYS Computer Code and User's Manual," Release 17.1.

3.9.8-10 AREVA Inc., "Updated Final Safety Analysis Report for The Standardized Advanced NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel," Revision 11, US NRC Docket Number 72-1029, November 2021.

3.9.8-11 J. M. Kim, J. Bruhl, and A. Varma, "Design of SC Walls Subjected to Impactive Loading for Local and Global Demands," 23rd Conference on Structural Mechanics in Reactor Technology, 2015.

3.9.8-12 Bechtel Corporation, "Design Guide Number C-2.45 for Design of Structures for Tornado Missile Impact," Revision 0, April 1982.

3.9.8-13 *ACI 349-06, "Code Requirements for Nuclear Safety Related Concrete Structures," American Concrete Institute.*

Revised RAI 3-7

3.9.8-14 NUREG-0800, Standard Review Plan, Section 3.5.3 "Barrier Design Procedures," Revision 3, U.S. Nuclear Regulatory Commission, March 2007.

3.9.8-15 AISC Design Guide 32, "Design of Modular Steel-Plate Composite Walls for Safety-Related Nuclear Facilities," American Institute of Steel Construction, 2017.

3.9.8-16 NUREG-1536, "Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility," Revision 1, U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, July 2010.

3.9.8-17 *NUREG-2215, "Standard Review Plan for Spent Fuel Dry Storage Systems and Facilities," U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, April 2020.*

3.9.8-18 *INGECID Document 00624IT003, "Effect of the Partial Composite Action on the Flexure Stiffness of the SC Sections."*

3.9.8-19 *INGECID Document 00624IT004, "Optimized Design of the EOS-HSM Steel-Plate Composite Structure."*

3.9.8-20 *INGECID Document 00624IT005, "Structural Assessment of the Laboratory Testing Results."*

Table 3.9.8-1
Modal Frequencies and Mass Participation of EOS-HSM-SC

Mode	Frequency (Hz)	X-Direction		Y-Direction		Z-Direction	
		Mass (kip-s^2/in)	%	Mass (kip-s^2/in)	%	Mass (kip-s^2/in)	%
1	18.29	0.685	54.7	0.000	0.0	0.000	0.0
2	30.12	0.000	0.0	0.000	0.0	0.822	65.6
3	30.74	0.000	0.0	0.000	0.0	0.019	1.5
4	32.97	0.001	0.1	0.000	0.0	0.000	0.0
5	35.62	0.003	0.2	0.000	0.0	0.000	0.0
6	42.26	0.000	0.0	0.002	0.1	0.173	13.8
7	45.74	0.350	28.0	0.000	0.0	0.000	0.0
8	48.61	0.000	0.0	0.002	0.1	0.000	0.0
9	48.69	0.003	0.2	0.000	0.0	0.000	0.0
10	56.29	0.000	0.0	0.366	29.2	0.000	0.0
11	70.28	0.000	0.0	0.000	0.0	0.000	0.0
12	71.36	0.002	0.2	0.000	0.0	0.000	0.0
13	78.53	0.000	0.0	0.001	0.0	0.003	0.2
14	81.43	0.000	0.0	0.279	22.3	0.007	0.6
15	81.53	0.000	0.0	0.000	0.0	0.000	0.0
16	94.03	0.000	0.0	0.065	5.2	0.006	0.4
17	95.40	0.000	0.0	0.000	0.0	0.000	0.0

Table 3.9.8-2
Spectral Acceleration Applicable to Different Components of EOS-HSM-SC for Seismic Analysis

Direction	Frequency (Hz)	Spectral Acceleration (g) Corresponding to Design ZPA		
		At 3% Damping (for DSC)	At 4% Damping (Steel Structures)	At 5% Damping (for SC Components)
X (Transverse)	18.29	1.257	1.154	1.073
Y (Vertical)	56.29	0.333	0.333	0.333
Z (Longitudinal)	30.12	0.754	0.726	0.703

Proprietary Information on Pages 3.9.8-26 and 3.9.8-27
Withheld Pursuant to 10 CFR 2.390

All Indicated Changes are in response to Revised RSI 3-7

Table 3.9.8-4
Summary of EOS-HSM-SC Stability Results

Loading	Result	EOS-HSM-SC
Tornado Wind + Missile	Maximum Sliding Distance (in)	1.10
	Maximum Rocking Uplift Angle(1) (°)	2.8
Flood	Safety Factor against Sliding	1.37
	Safety Factor against Tipping	1.15
Seismic for Loaded EOS-HSM-SC with End Shield Wall	Maximum Acceleration before Sliding (horiz / vert) (g)	0.45 / 0.30
	Maximum Acceleration before Tipping (horiz / vert) (g)	0.45 / 0.30

Note:

(1) A 1.1 required factor is included in the angles.

Proprietary Information on Pages 3.9.8-29 through 3.9.8-40
Withheld Pursuant to 10 CFR 2.390

Corrective Actions

After a seismic event, all components are inspected for damage. Any debris is removed. An evaluation is performed to verify that the system components are still within the licensed design basis.

12.3.3 Tornado Wind and Tornado Missiles Effect on EOS-HSM

Cause of Accident

In accordance with ANSI-57.9 [12-2] and 10 CFR 72.122 [12-1], the NUHOMS® EOS System is designed for tornado effects, including tornado wind loads. In addition, the NUHOMS® EOS System is designed to withstand tornado missile effects. The NUHOMS® EOS System is designed to be located anywhere within the United States. Therefore, the most severe tornado wind and missile loadings specified by NUREG-0800 [12-7] and NRC Reg. Guide 1.76 [12-8] are selected as a design basis for this postulated accident. The determination of the tornado wind pressures and tornado missile loads acting on the NUHOMS® EOS System are detailed in Chapter 2, Section 2.3.1.

Accident Analysis

Stability and stress analyses are performed to determine the response of the EOS-HSM to tornado wind pressure loads. The stability analyses are performed using closed-form calculation methods to determine the sliding and overturning response of the EOS-HSM array. A single EOS-HSM with *two* end shield walls is conservatively selected for the *sliding* analyses*, and a single EOS-HSM with one end shield wall is considered for the overturning analyses*. The stress analyses are performed using the ANSYS [12-9] finite element model of a single EOS-HSM to determine design forces and moments. These conservative generic analyses envelop the effects of wind pressures on the EOS-HSM array. These analyses are described in Appendix 3.9.7, Section 3.9.7.1. Thus, the requirements of 10 CFR 72.122 are met.

In addition, the EOS-HSM is evaluated for tornado missiles. The adequacy of the EOS-HSM to resist tornado missile loads is also addressed in Appendix 3.9.7.

Accident Dose Calculation

As shown in the above evaluations, the tornado wind and tornado missiles do not breach the EOS-HSM such that the DSC confinement boundary is *compromised*. Localized scabbing of the end shield wall of an EOS-HSM array may be possible.

The EOS-HSM outlet vent covers and wind deflectors (if required) may be lost due to a tornado or tornado missile event. Only the dose rates on the roof are affected, since the front, rear, and side dose rates remain the same. Information in Chapters 6 and 11 is used to determine that the EOS-HSM accident increases the average dose rate on the roof of the module to *~18,800* mrem/hr.

All Indicated Changes are in response to Revised RSI 3-2

Enclosure 9 to E-62384

CoC 1042 Amendment 4, Revision 2

Supporting Calculations

Withheld Pursuant to 10 CFR 2.390

1. Calculation EOS01-0262, Rev. 0, “Finite Element Model and ANSYS Structural Analysis of the EOS-HSM Steel-Plate Composite Structure”
2. Calculation EOS01-0263, Rev. 1, “Design of the EOS-HSM Steel-Plate Composite Structure”
3. Calculation EOS01-0265, Rev. 1, “Tornado Missile Evaluation of EOS-HSM Steel-Plate Composite (EOS-HSM-SC) Structure”
4. Calculation EOS01-0268, Rev. 1, “EOS-HSM-SC Stability Evaluation”
5. Calculation EOS01-0320, Rev. 1, “EOS-HSM-SC Heat Shield, Door, and other Miscellaneous Hardware”
6. Calculation EOS01-0330, Rev. 0, “Connection Bolts and Embedments Evaluation of EOS-HSM-SC”