

June 2023

Revision 23B

# MAGNASTOR<sup>®</sup>

(Modular Advanced Generation  
Nuclear All-purpose STORAGE)

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## FINAL SAFETY ANALYSIS REPORT

TMI Amendment 13  
RAI Response Submittal

NON-PROPRIETARY VERSION

Docket No. 72-1031



**Enclosure 1**

**Responses to MAGNASTOR RAIs**

**for**

**MAGNASTOR® FSAR  
Amendment 13 RAI Response Submittal  
Revision 23B**

**(Docket No 72-1031)**

**NAC International**

**June 2023**

**NAC INTERNATIONAL**

**PROPRIETARY RESPONSE TO THE**

**UNITED STATES**

**NUCLEAR REGULATORY COMMISSION**

**REQUEST FOR ADDITIONAL INFORMATION #1**

**March 2023**

**FOR REVIEW OF THE MAGNASTOR**

**(CoC NO. 1031, DOCKET NO. 72-1031)**

**June 2023**

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Attachment 1 - TMI2 Primary Water Treatment System Waste Handling and Disposal,  
TMI2-EN-EV A-M-0042, Revision 0

**NAC INTERNATIONAL RESPONSE  
TO  
REQUEST FOR ADDITIONAL INFORMATION**

**STRUCTURAL EVALUATION**

- 3-1. CC6 Concrete Cask Modification - The staff requires a summary of the load demands on the elements of the cask and the corresponding capacities or margins to the reduced strength of the concrete.

The concrete compressive strength for the reinforced concrete cask, CC6 of MAGNASTOR® design, is modified by Amendment No. 13 to the MAGNASTOR® final safety analysis report (FSAR). The required concrete compressive strength of the cask concrete is reduced. However, the loading demands on the cask, which are defined by the operating processes, environment, and load handling equipment, remain the same. Understanding of the demand verses the capacity of the cask elements is essential in establishing reasonable assurance that the design of the cask elements provide an adequate margin of safety.

This information is required to demonstrate compliance with 10 CFR 72.122.

NAC International Response to Structural Evaluation RAI 3-1:

Sections 3.11.1, 3.11.2, 3.11.3, and 3.11.4 provide the loadings and the associated evaluations and the Factors of Safety for each load evaluated for CC6 using a compressive strength of [REDACTED]. Section 3.11.5 contains the evaluations of the CC6 Concrete Cask with the compressive strength of [REDACTED]. The loadings for the CC6 with the [REDACTED] compressive strength are not changed from those defined in Section 3.11.1 through Section 3.11.4. Section 3.11.5 provides a review of each loading shown in Section 3.11.1 through Section 3.11.4 with the revised Factors of Safety confirming the adequacy of the CC6 using the [REDACTED] compressive strength concrete.

**NAC INTERNATIONAL RESPONSE  
TO  
REQUEST FOR ADDITIONAL INFORMATION**

**STRUCTURAL EVALUATION**

- 3-2. CC6 Concrete Density - Explain the process which ensures that the density of the concrete will remain the same even after the compressive strength of the concrete is reduced.

Change in concrete compressive strength is achieved by an appropriate change in the design of the concrete mix. Even though there is no direct relation between concrete compressive strength and density, changing the design of the mix has the potential for affecting the density of concrete. The density of concrete has short- and longer-term impacts. Short term impacts affect shielding and thermal characteristics and longer-term impacts are on aging degradation.

This information is required to demonstrate compliance with 10 CFR 72.24(4)(d) and (e).

NAC International Response to Structural Evaluation RAI 3-2:

NAC agrees with NRC review staff that the design mix of the concrete that reduces strength can and likely will impact other characteristics, not limited to, but including the concrete density. The minimum density is specified on NAC licensing drawings and must be met regardless of the strength requirement.

[REDACTED]

This process assures that strength and density requirement are met.

**NAC INTERNATIONAL RESPONSE  
TO  
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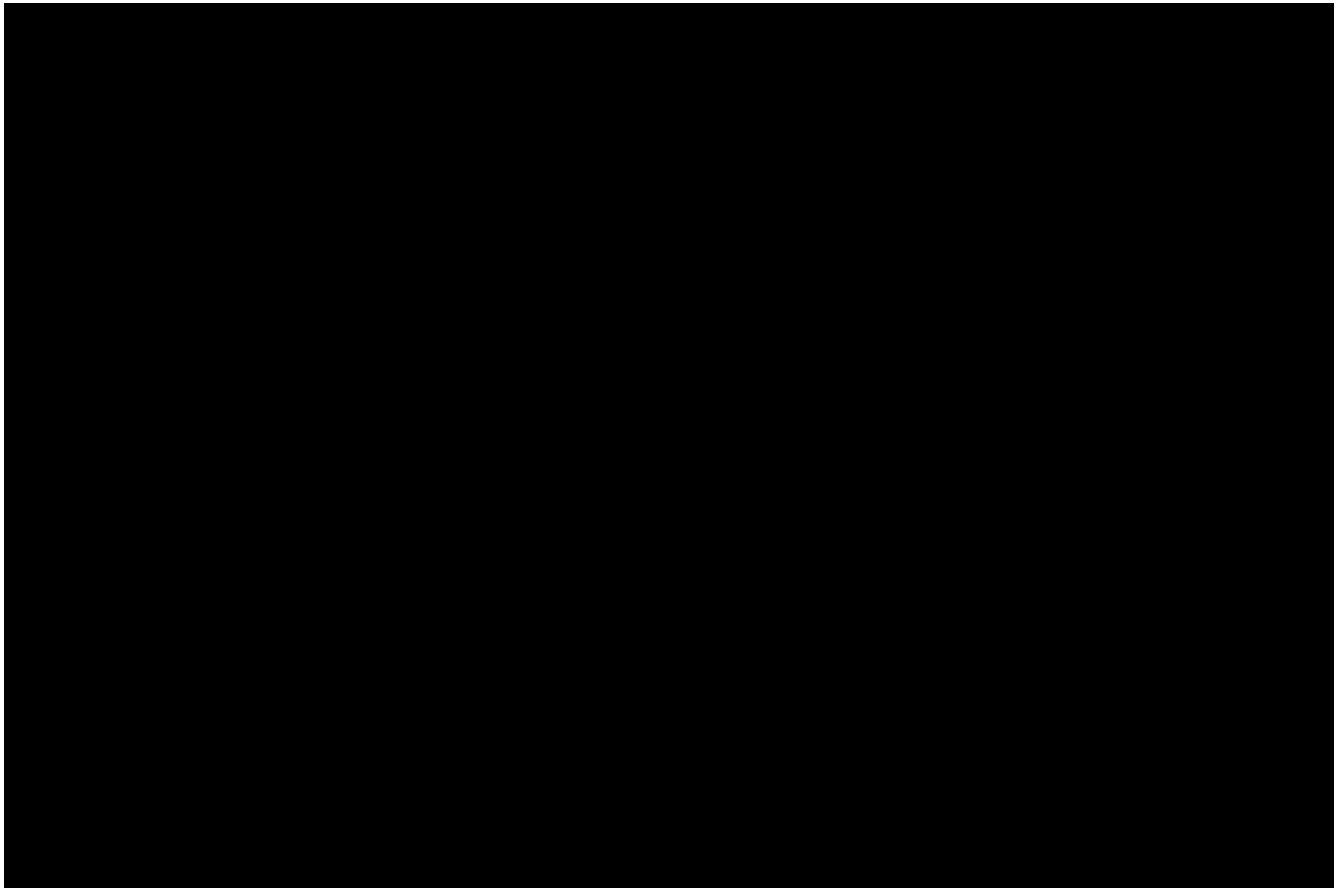
**STRUCTURAL EVALUATION**

- 3-3. Safety Classification of Structures Systems and Components (SSC's) - Provide a safety classification for the waste basket liner (WBL), segmented tube assembly (STA) and debris material container (DMC) and include these in the FSAR safety classification table.

The WBL containing fuel bearing material (FBM) is lifted into the transportable storage canister (TSC) using the lifting handles. In this, situation it is the sole container of the FBM radioactive material. Therefore, a safety designation is required and an analysis for safety during the lift needs to be performed. For the STA and DMC, NAC has identified these as assisting with the FBM loading, placement and retention, but without any specific safety functions. If so, they should be classified as such in the safety classification table. A note needs to be added that these elements have only non-structural functions.

This information is required to demonstrate compliance with 10 CFR 72.24(4)(d)(2).

NAC International Response to Structural Evaluation RAI 3-3:



**NAC INTERNATIONAL RESPONSE  
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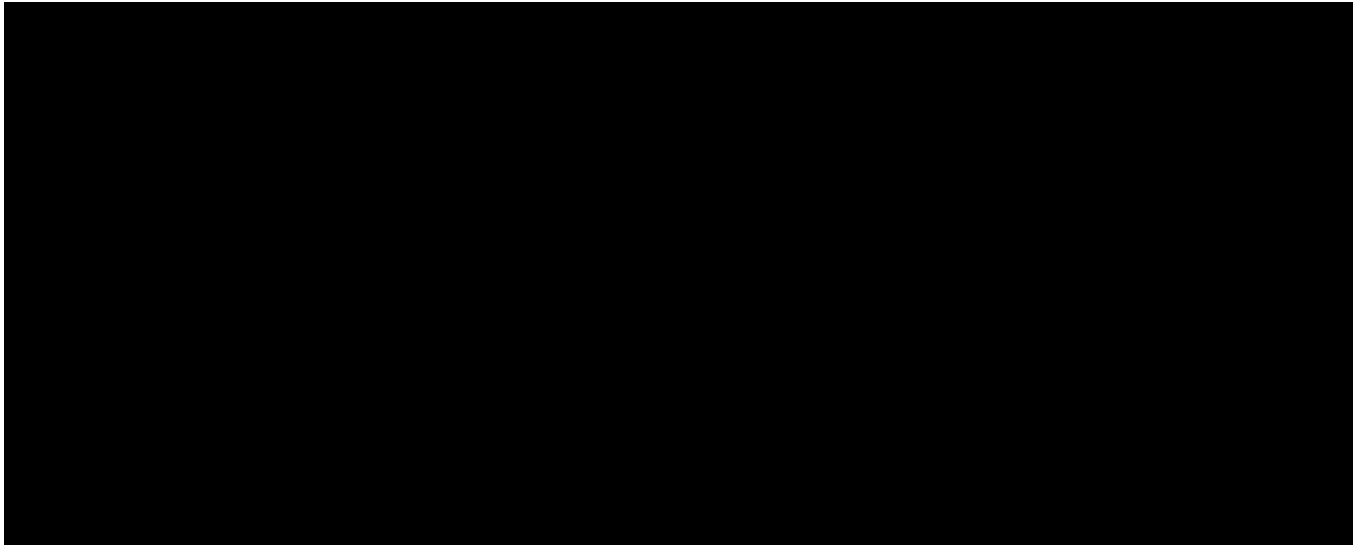
**STRUCTURAL EVALUATION**

- 3-4. Safety Closure Lid Thickness Reduction - Provide a summary table with the analyzed demands and margins of the 5-inch closure lid for the TSC.

Amendment No. 13 reduces the TSC closure lid thickness from 9 inches to 5 inches to increase the FBM carrying capacity of the TSC. This change in the lid thickness results in a change in the stress level within the lid when subject to the different environmental conditions, handling, and any internal pressure change.

This information is required to demonstrate compliance with 10 CFR 72.24(4)(d)(1).

NAC International Response to Structural Evaluation RAI 3-4:



**NAC INTERNATIONAL RESPONSE  
TO  
REQUEST FOR ADDITIONAL INFORMATION**

**Structural Evaluation**

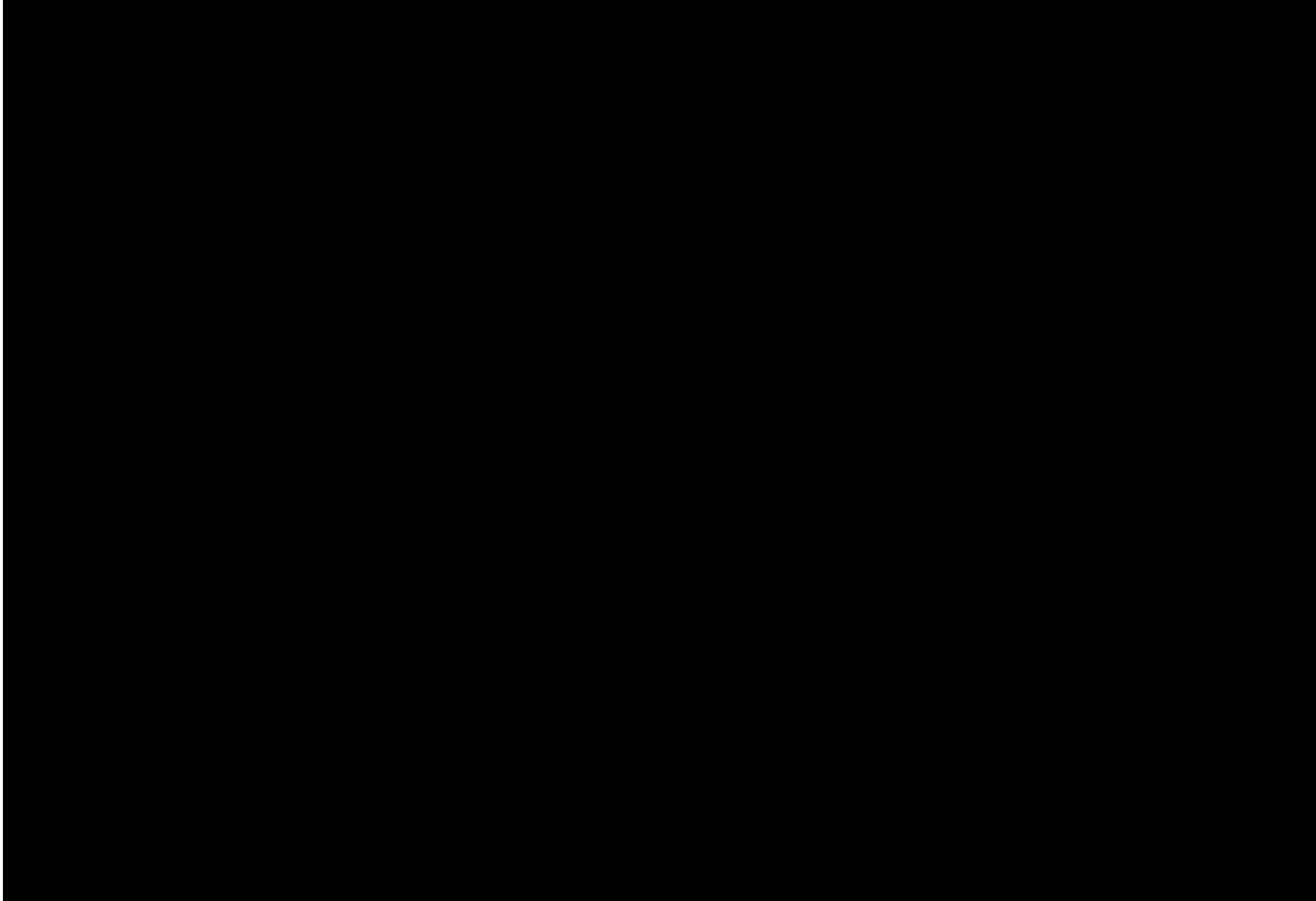
- 3-5. ELIMINATION OF HYDROSTATIC TESTING FOR THE NEW CONFIGURATION IN AMENDMENT NO. 13 - PROVIDE A table summarizing the evaluation of the closure weld of the lid, to establish the minimum weld size required for the loading demands.

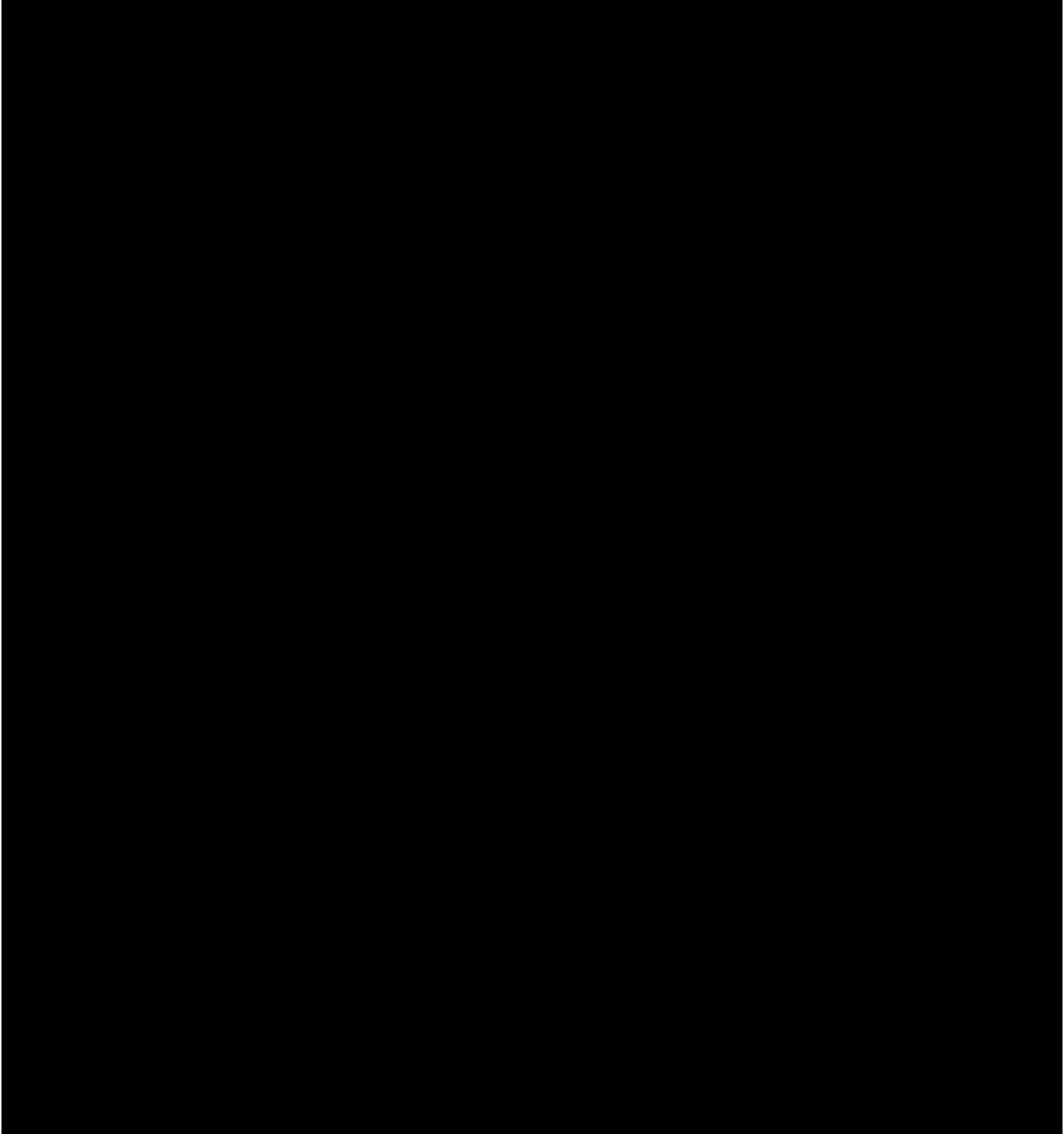
In Amendment No. 13, NAC has opted to eliminate the need for a hydrostatic test to demonstrate that the weld has sufficient margin against failure. To have reasonable assurance on the adequacy of the margin in the weld design the staff needs to know the minimum computed weld size and the provided weld size along with full compliance with required NDE and required documentation.

This information is required to demonstrate compliance with 10 CFR 72.122.

NAC International Response to Structural Evaluation RAI 3-5:

The TSC structural analyses have been reviewed and the tables below define the minimum closure weld thickness. These thicknesses were determined using the current TSC analyses.





Given that testing that is performed on the weld passes for an austenitic material in conjunction with the minimal stresses, the hydrostatic testing does not offer any additional confirmation of weld integrity.

**NAC INTERNATIONAL RESPONSE  
TO  
REQUEST FOR ADDITIONAL INFORMATION**

**THERMAL EVALUATION**

- 4-1. Provide justification/explanation for the exclusion of the STA, dunnage, and WBL in thermal evaluations of normal, off-normal, and accident conditions of storage.

The applicant stated, in FSAR section 1.3.1.1, that a WBL is used to replace the fuel basket structure for storage of FBM. FBM is permitted to be loaded loose into the WBL or within other internal structures (dunnage) loaded into the WBL. WBL internal structures such as the STA or the DMC are handling/placement devices and are not credited within the safety evaluations.

The applicant needs to justify/explain that exclusion of the STA, dunnage, and WBL in the modeling is credited for thermal analyses of normal, off-normal, and accident conditions of storage.

The staff needs this information to determine compliance with 10 CFR 72.236(f).

NAC International Response to Thermal Evaluation RAI 4-1:

FSAR Section 1.3.1.1 has been changed to provide the following clarification.

For FBM, the WBL is the means to lift the FBM and position it inside the TSC during loading operations. FBM is permitted to be loaded loose into the WBL or within other internal structures loaded into the WBL. Table 2.4-1 shows that the WBL is required for shielding and had been conservatively included in the thermal model having the properties of the medium inside the TSC. WBL internal structures such as the segmented tube assembly (STA) or the debris material container (DMC) are handling/placement devices and are considered to be dunnage. Chapter 4 has been revised to describe how the WBL and the FBM were included in the model. To account for the FBM and the internal structures, the 2D axisymmetric model contains a cylindrical section of stainless steel having the equivalent mass of the FBM.

[REDACTED]

[REDACTED] The thermal summary in Chapter 4 was revised to include the WBL temperatures.

**NAC INTERNATIONAL RESPONSE  
TO  
REQUEST FOR ADDITIONAL INFORMATION**

**MATERIALS EVALUATION**

- 8-1. Physical and Chemical Form of Filter Media: Please supplement the application to specify the physical and chemical form of the filter media associated with the FBM contents by including the following information:
- A. Describe the components, parts, and/or materials that constitute the filter media.
  - B. Describe the physical and chemical form of the filter media (e.g., solids, liquids, gases, metallic materials and items, organic compounds, hydrogenous materials, water, etc.).
  - C. Describe how the filter media originated and are associated with FBM. For example, address whether the filter media were used during reactor operation; during the reactor accident; or whether they were used to facilitate removal of the damaged fuel and/or FBM from the reactor during the post-accident cleanup and decontamination.
  - D. Clarify whether the filter media are categorized as part of the FBM contents; whether they are considered separate from the FBM contents; whether they contain or are attached to the FBM contents; or whether they are categorized as WBL-internal dunnage components similar to the STA and DMC.
  - E. Clarify whether the filter media to be stored inside the FBM TSC and WBL are authorized for storage only with FBM or whether they may also be stored with actual intact spent fuel rods or segments of spent fuel rods.

FSAR section 1.4.2 states that “filter media containing FBM or used fuel [[emphasis added]] may be loaded into the FBM TSC provided the filter media is metallic”. The application then states that “non-metallic media [[emphasis added]] may be permitted subject to gas generation limitations.” The application states that filter media may account for potential sources of gas, in particular hydrogen, as a result of water retention. The application states that any potential retention must be accounted for within total allowed hydrogen generation; maximum hydrogen generation during storage and transportation will not exceed the lower explosive limit (4 percent molar volume). FSAR section 7.2.2 states that a limited quantity of moisture may remain trapped within the FBM, or within the filter media, post vacuum drying.

Based on review of this description of filter media, the staff identified that physical and chemical form of the filter media contents are not sufficiently described in the application such that staff can adequately evaluate physical and chemical stability of the filter media and their chemical compatibility with the FBM and the TSC internal components (WBL and dunnage) in the nitrogen gas environment.

The NRC staff is requesting this information to verify that the application includes an adequate description of the contents such that the staff can fully evaluate the physical and chemical stability of the filter media and FBM contents and verify that there will be no adverse reactions amongst the FBM and filter media contents, or between the contents and the TSC internal components (WBL and dunnage) in the nitrogen gas environment. The staff determined that this information is needed to evaluate the compliance of the MAGNASTOR® FBM

NAC International Response to Materials Evaluation RAI 8-1:

- A. Descriptions of the components, parts, and materials that constitute the filter media are provided in Attachment 1 of this RAI response (“TMI2 Primary Water Treatment System Waste Handling and Disposal”, TMI2-EN-EV A-M-0042, Revision 0.”).
- B. Descriptions of the physical and chemical form of the filter media are provided in Attachment 1.
- C. The filter media discussed in this application will have originated and are associated with post-accident cleanup and decontamination activities.
- D. After the filter media can no longer be used for cleanup and decontamination activities, it will be considered FBM contents.
- E. If it is determined during loading operations any of the materials are not associated with the TMI-2 cleanup and decontamination activities this would fall under proposed LCO 3.4.1 and would not be permitted to be loaded into and FBM TSC.

**NAC INTERNATIONAL RESPONSE  
TO  
REQUEST FOR ADDITIONAL INFORMATION**

**MATERIALS EVALUATION**

- 8-2 Chemical Reactions in the Nitrogen Gas Environment: Considering the elemental and molecular contents of the FBM and filter media, please justify why nitrogen is an acceptable environment for the interior of the cask and provide information to demonstrate that the use of nitrogen as the TSC fill gas will not result in adverse chemical reactions with and amongst the FBM and filter media contents inside the WBL.

FSAR section 1.4.2 of the application includes a description of the physical and chemical form of the FBM contents and describes FBM as consisting of components or pieces of components associated with reactor operations that have been contaminated by spent nuclear fuel and/or the associated isotopes of spent nuclear fuel, including fission product contamination. The detailed description of the FBM in FSAR section 1.4.2 addresses a number of potential metallic materials, non-metallic materials, organic compounds, and hydrogenous compounds that may be intermixed with fission products and other radioisotopes from damaged fuel and activated non-fuel materials. The application states that non-metallic FBM may be loaded into the FBM TSC provided that maximum hydrogen generation during storage and transportation will not exceed the lower explosive limit (4 percent molar volume) and system pressure is evaluated as acceptable. As addressed above for Materials Review RAI 8-1, the application also includes some description of filter media associated with the FBM; however, per RAI 8-1, the staff identified that the physical and chemical form of the filter media are not sufficiently described in the application.

FSAR section 8.10.1 of the application discusses the interior storage environment inside the sealed TSC. The TSC containing FBM is to be backfilled with nitrogen gas. This section of the application indicates that nitrogen backfill gas displaces oxygen inside the TSC, similar to how helium is used in backfilling the TSC. However, the application does not include specific information that demonstrates that adverse chemical reactions in the nitrogen environment are not a concern for the chemical elements and compounds that constitute the FBM and filter media. The staff noted that, while nitrogen gas is sufficiently inert for many applications, unlike helium gas it cannot be assumed to be completely unreactive when used as a cover gas for all types of contents. Therefore, the staff determined that additional information is needed to evaluate the chemical stability of FBM and filter media contents in the nitrogen gas environment.

The NRC staff is requesting this information to verify that the application includes an adequate description of the contents such that the staff can fully evaluate the physical and chemical stability of the FBM and filter media contents and verify that there will be no adverse reactions amongst the FBM and filter media contents, or between the contents and the TSC internal components (WBL and dunnage) in the nitrogen gas environment. The staff determined that this information is needed to evaluate the compliance of the MAGNASTOR FBM storage system with the regulatory requirements of 10 CFR sections 72.120(d) and 72.236(h).

NAC International Response to Materials Evaluation RAI 8-2:

NAC has chosen to use a helium, inert gas, environment in the TSC and made the appropriate modification in FSAR Sections. Further information on the filter media is included as a response to RAI 8-1.

**NAC INTERNATIONAL RESPONSE  
TO  
REQUEST FOR ADDITIONAL INFORMATION**

**OPERATING PROCEDURES EVALUATION**

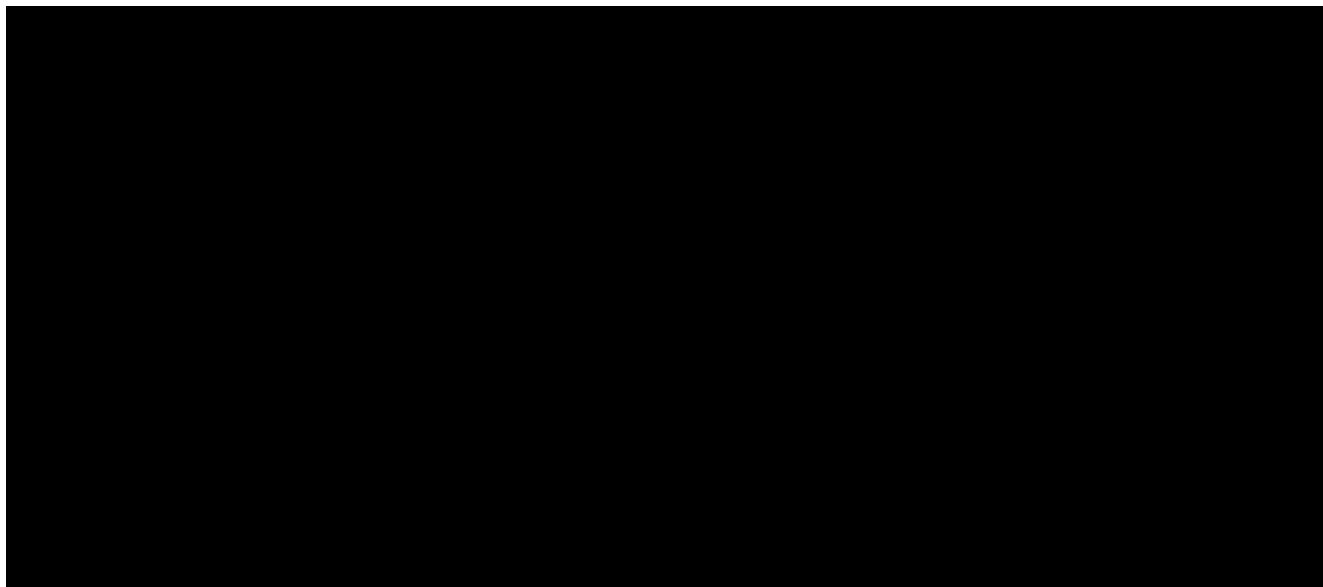
9-1. Provide information for justification on using heated nitrogen in the vacuum drying.

The applicant performed thermal analyses of vacuum drying using non-heated nitrogen gas in the TSC and presented the maximum temperatures in FSAR table 4.12-2 and then notes, in step 56 of FSAR section 9.7.1, that vacuum drying efficiency may be improved by injection of heated nitrogen followed by re-establishment of vacuum condition. This process may be repeated as needed.

Injection of heated nitrogen in loading operations may result in the temperatures greater than the maximum temperatures, as shown in FSAR table 4.12-2, which were calculated assuming non-heated nitrogen for vacuum phase. The applicant may need to setup a temperature limit of heated nitrogen and limit the number of repeated cycles.

The staff needs this information to determine compliance with 10 CFR 72.236(f).

NAC International Response to Operating Procedures Evaluation RAI 9-1:



**NAC INTERNATIONAL RESPONSE  
TO  
REQUEST FOR ADDITIONAL INFORMATION**

**OPERATING PROCEDURES EVALUATION**

- 9-2. Provide information to items (A), (B) and (C) below to ensure safe storage of the FBM contents in MAGNASTOR® TSC.

The applicant stated, in FSAR section 1.4, that non-metallic FBM may be loaded into the FBM TSC provided maximum hydrogen generation during storage and transportation will not exceed the lower explosive limit (4% molar volume). Any potential retention must be accounted for within total hydrogen generation.

The applicant described, in FSAR section 9.7, that to ensure dryness of FBM TSC during vacuum drying operation, (1) FBM TSC is evacuated to less than 10 torr at the end of 10 minutes (a minimum period of 10 minutes) to ensure the FBM TSC cavity is dry of free water and (2) upon satisfactory completion of the dryness verification, the FBM TSC is further evacuated to less than 3 torr (without providing the required time period).

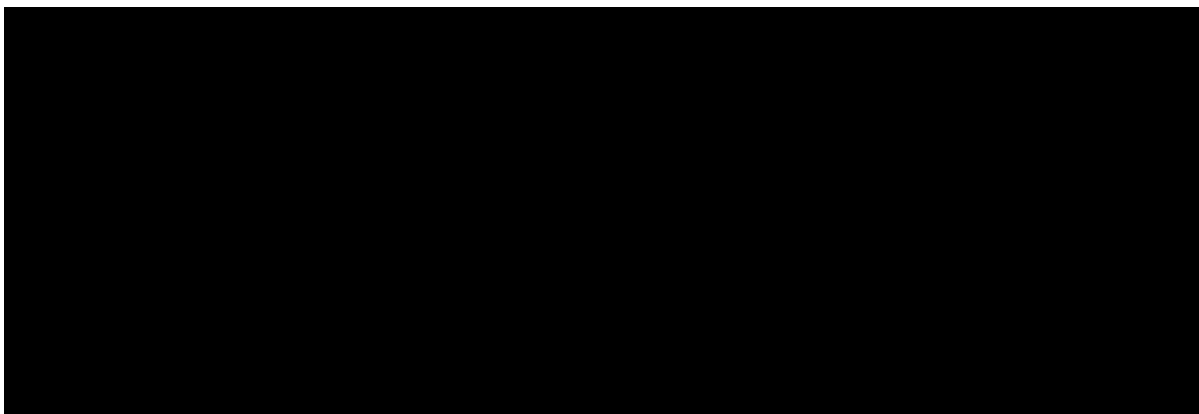
- A. Provide self-ignition points and/or melting points of the FBM contents (e.g., contaminated FBM, non-metallic FBM, activated non-fuel materials, etc.) to ensure no significant combustion, reaction, or activation under storage of normal, off-normal and accident conditions of storage.
- B. The staff recognizes that the decay heat of the FBM TSC is bounded by the spent fuel TSC which was approved by the NRC, therefore the FBM TSC may be bounded by the spent fuel TSC too in hydrogen generation. However, given that the non-metallic FBM/media may be included within the contents of the FBM DSC, the applicant needs to provide information or evaluation (e.g., amount and G-value of the non-metallic materials) to demonstrate that hydrogen generation of the FBM TSC would be limited to less than 4%.
- C. Clarify whether a minimum period (e.g., greater than 30 minutes) is required to maintain a vacuum pressure less than 3 Torr for dryness verification of the FBM TSC?

The staff needs this information to determine compliance with 10 CFR 72.236(h).

NAC International Response to Operating Procedures Evaluation RAI 9-2:

A.

B.



C.



**NAC INTERNATIONAL RESPONSE  
TO  
REQUEST FOR ADDITIONAL INFORMATION**

**OPERATING PROCEDURES EVALUATION**

- 9-3. Correct step references in section 9.7.1 to ensure that the user can perform the operational steps as directed.

Many of the step references in section 9.7.1 refer the user to incorrect steps that cannot be performed as directed. The following is a list of examples but is not all inclusive. All step references should be reviewed and corrected as necessary.

- A. Steps 69 and 70 references in the step 26 note, which do not refer to ACWS or alternative annulus flush/circulating water system actions.
- B. Step 60 reference in the step 49 note, nitrogen backfill is not performed at step 60.
- C. Step 70 reference to table 9.1-1, which does not list bolt torque values.

This information is needed to determine compliance with 10 CFR 72.234 and 72.236.

NAC International Response to Operating Procedures Evaluation RAI 9-3:

Changes were made to correct step references between sections. The following changes were made:

- a. Step 26 note, last sentence; “Steps 27 and 28 and Steps 69 and 70...” was changed to “Steps 27, 28 and 68...”
- b. Step 49 note; “...(Step 60)...” was changed to “...(Step 58)...”
- c. Step 70; “...Table 9.1-1.” Was changed to “...Table 9.1-2.”

Other changes

Added note to Step 48:

“Note: At the option of the user, the installation and tacking of the closure ring may be performed immediately after helium backfill (Step 58) or after completion of the welding, testing, and NDE of the vent and drain inner or outer port covers (Step 63 or 66).”

Changed note in Step 58

“At the option of the user, Steps 50 and 51 can alternatively be performed at this point or immediately following Steps 63 or 67.” was changed to “At the option of the user, Steps 48 and 49 can alternatively be performed at this point or immediately following Steps 63 or 66.”

**NAC INTERNATIONAL RESPONSE  
TO  
REQUEST FOR ADDITIONAL INFORMATION**

**OPERATING PROCEDURES EVALUATION**

- 9-4. Modify the note in step 58 and action in step 64 to ensure that there is only one step to install and weld the inner port cover on the drain port opening.

This information is needed to determine compliance with 10 CFR 72.234 and 72.236.

NAC International Response to Operating Procedures Evaluation RAI 9-4:

Changes were made to Step 58 note and Step 64 to only direct installation and welding of the inner port cover on the drain port opening one time. The following changes were made:

- a. Step 58; Delete “Install and weld the inner port cover on the drain port opening.”
- b. Step 64: Change from “...FBM TSC drain port.” to “...FBM TSC inner port cover on the drain port opening.”

**NAC INTERNATIONAL RESPONSE  
TO  
REQUEST FOR ADDITIONAL INFORMATION**

**OPERATING PROCEDURES EVALUATION**

- 9-5. Include a step or direction to the user in section 9.7.5 to provide the option to use ACWS or R-ACWS or remove the reference to ACWS and R-ACWS in step 29.

Step 29 directs the user to terminate ACWS or R-ACWS, if used, however, the user is not directed or given the option in the section 9.7.5 operational sequence to install and use the ACWS or R-ACWS system.

This information is needed to determine compliance with 10 CFR 72.234 and 72.236.

NAC International Response to Operating Procedures Evaluation RAI 9-5:

Added note after steps 12 and 17 in Section 9.7.6 (formerly section 9.7.5) that reads:

"Note: Initial TSC cooling can be performed by an external TSC cooling system prior to port cover removal."

**NAC INTERNATIONAL RESPONSE  
TO  
REQUEST FOR ADDITIONAL INFORMATION**

**OBSERVATION**

**OPERATING PROCEDURES**

- 9-1. 9.7.1, step 63: remove “each of” as only the vent port inner cover is being referred to in this sentence.

NAC International Response to Operating Procedures Observation

Deleted “each of” from step 63.

Attachment 1

TMI2 Primary Water Treatment System Waste Handling and Disposal  
TMI2-EN-EV A-M-0042, Revision 0

ATTACHMENT WITHHELD IN THEIR ENTIRETY PER 10 CFR 2.390

**Enclosure 2**

**Proposed Changes**

**for**

**MAGNASTOR® FSAR  
Amendment 13 RAI Response Submittal  
Revision 23B**

**(Docket No 72-1031)**

**NAC International**

**June 2023**

**APPENDIX A**

**PROPOSED TECHNICAL SPECIFICATIONS AND DESIGN FEATURES  
FOR THE MAGNASTOR SYSTEM**

**AMENDMENT 13**

**Appendix A  
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1.0 USE AND APPLICATION

1.1 Definitions

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NOTE

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

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<u>Term</u>	<u>Definition</u>
ACTIONS	ACTIONS shall be that part of a Specification that prescribes Required Actions to be taken under designated Conditions within specified Completion Times.
ASSEMBLY AVERAGE FUEL ENRICHMENT	Value calculated by averaging the <sup>235</sup> U wt % enrichment over the entire fuel region (UO <sub>2</sub> ) of an individual fuel assembly, including axial blankets, if present.
BREACHED SPENT FUEL ROD	Spent fuel with cladding defects that permit the release of gas from the interior of the fuel rod. A fuel rod breach may be a minor defect (i.e., hairline crack or pinhole), allowing the rod to be classified as undamaged, or be a gross breach requiring a damaged fuel classification.
BURNUP	<p>a) Assembly Average Burnup: Value calculated by averaging the burnup over the entire fuel region (UO<sub>2</sub>) of an individual fuel assembly, including axial blankets, if present. Assembly average burnup represents the reactor record, nominal, value. The assembly average burnup is equal to the reactor record, nominal, energy production (MWd) over the life of the fuel assembly divided by the fuel assembly pre-irradiation heavy metal (U) mass in metric tons.</p> <p>b) Nonfuel Hardware Burnup: Equivalent accumulated irradiation exposure for activation evaluation.</p>
COMPOSITE CLOSURE LID	A closure lid assembly, consisting of a stainless steel TRANSPORTABLE STORAGE CANISTER closure lid and a separate shield plate bolted together, that provides closure of a TRANSPORTABLE STORAGE CANISTER.

(continued)

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CONCRETE CASK	The CONCRETE CASK is the vertical storage module that receives, holds and protects the sealed TSC for storage at the ISFSI. The CONCRETE CASK passively provides the radiation shielding, structural protection, and heat dissipation capabilities for the safe storage of spent fuel in a TSC. Closure for the CONCRETE CASK is provided by the CONCRETE CASK LID.
CONCRETE CASK LID	The CONCRETE CASK LID is a thick concrete and steel closure for the CONCRETE CASK. The CONCRETE CASK LID precludes access to the TSC and provides radiation shielding.
DAMAGED FUEL	<p>SPENT NUCLEAR FUEL (SNF) assembly that cannot fulfill its fuel-specific or system-related function. SNF is classified as damaged under the following conditions.</p> <ol style="list-style-type: none"><li>1. There is visible deformation of the rods in the SNF assembly. Note: This is not referring to the uniform bowing that occurs in the reactor; this refers to bowing that significantly opens up the lattice spacing.</li><li>2. Individual fuel rods are missing from the SNF assembly and the missing rods are not replaced by a solid stainless steel or zirconium dummy rod that displaces a volume equal to, or greater than, the original fuel rod.</li><li>3. The SNF assembly has missing, displaced or damaged structural components such that:<ol style="list-style-type: none"><li>3.1. Radiological and/or criticality safety is adversely affected (e.g., significantly changed rod pitch); or</li><li>3.2. The SNF assembly cannot be handled by normal means (i.e., crane and grapple); or</li><li>3.3. The SNF assembly contains fuel rods with damaged or missing grids, grid straps, and/or grid springs producing an unsupported length greater than 60 inches.</li></ol>Note: SNF assemblies with the following structural defects meet MAGNASTOR system-related functional requirements and are, therefore, classified as undamaged: Assemblies with missing or damaged grids, grid straps and/or grid springs resulting in an unsupported fuel rod length not to exceed 60 inches.</li><li>4. Any SNF assembly that contains fuel rods for which reactor operating records (or other records or tests) cannot support the conclusion that they do not contain gross breaches. Note: BREACHED SPENT FUEL RODs with minor</li></ol>

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(continued)

DAMAGED FUEL  
(CONTINUED)

cladding defects (i.e., pinhole leaks or hairline cracks that will not permit significant release of particulate matter from the spent fuel rod) meet MAGNASTOR system-related functional requirements and are, therefore, classified as undamaged.

5. FUEL DEBRIS such as ruptured fuel rods, severed rods, loose fuel pellets, containers or structures that are supporting loose PWR fuel assembly parts.

FUEL BEARING MATERIAL  
(FBM)

Fuel Bearing Material (FBM) is any component or pieces of components associated with Three Mile Island Unit 2 (TMI-2) reactor operations that have been contaminated by used (spent) nuclear fuel and or the associated isotopes in used (spent) nuclear fuel. The FBM is not capable of being separated between SNF and GTCC material, and the FBM contains fuel fragments with non-trivial quantities of SNF. Fission product contamination is included in the definition of FBM regardless of the location of the fission products (either associated with used fuel or has separated from used fuel within facilities via material volatility during and post reactor fuel melt). FBM may be associated with fuel assembly hardware components, non-fuel hardware (i.e., fuel assembly control components), or significantly activated non-fuel materials (e.g., reactor barrel) or be located away from the high activation region (e.g., heat exchangers). The FBM used fuel component may be present in forms ranging from thin coatings to chips and fines and up to larger adhered or loose debris. FBM may contain limited amount of non-metallic, non-spent fuel components (e.g., seals/wiring within pump or valves that have been contaminated).

Fuel Bearing Material (FBM)  
TSC

TSC that contains FBM

DAMAGED FUEL CAN  
(DFC)

A specially designed stainless steel screened can sized to hold UNDAMAGED PWR FUEL, DAMAGED PWR FUEL, and/or FUEL DEBRIS. The screens preclude the release of gross particulate from the DFC into the canister cavity. DFCs are only authorized for loading in specified locations of a DF Basket Assembly.

FUEL DEBRIS

FUEL DEBRIS is ruptured fuel rods, severed rods, loose fuel pellets, containers or structures that are supporting loose PWR fuel assembly parts.

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GROSSLY BREACHED SPENT FUEL ROD	A breach in the spent fuel cladding that is larger than a pinhole or hairline crack. A gross cladding breach may be established by visual examination with the capability to determine if the fuel pellet can be seen through the cladding, or through a review of reactor operating records indicating the presence of heavy metal isotopes.
INDEPENDENT SPENT FUEL STORAGE INSTALLATION (ISFSI)	The facility within the perimeter fence licensed for storage of spent fuel within MAGNASTOR SYSTEMS (see also 10 CFR 72.3).
INITIAL PEAK PLANAR-AVERAGE ENRICHMENT	The INITIAL PEAK PLANAR-AVERAGE ENRICHMENT is the maximum planar-average enrichment at any height along the axis of the fuel assembly. The INITIAL PEAK PLANAR-AVERAGE ENRICHMENT may be higher than the bundle (assembly) average enrichment.
LOADING OPERATIONS	LOADING OPERATIONS include all licensed activities while a MAGNASTOR SYSTEM is being loaded with fuel assemblies. LOADING OPERATIONS begin when the first assembly is placed in the TSC and end when the TSC is lowered into a CONCRETE CASK or MSO.
MAGNASTOR SYSTEM (MAGNASTOR)	The MAGNASTOR (Modular Advanced Generation Nuclear All-purpose STORAGE) SYSTEM includes the components certified for the storage of spent fuel assemblies at an ISFSI. The MAGNASTOR SYSTEM consists of a STORAGE CASK and a TSC. A MAGNASTOR TRANSFER CASK (MTC), Passive MAGNASTOR TRANSFER CASK (PMTC), or Lightweight MTC (LMTC) is provided and utilized to load and place a TSC in a CONCRETE CASK or MSO, or to remove a TSC from a CONCRETE CASK or MSO.
MSO (Metal Storage Overpack)	The MSO is the vertical storage module that receives, holds and protects the sealed TSC for storage at the ISFSI. The MSO passively provides the radiation shielding, structural protection, and heat dissipation capabilities for the safe storage of spent fuel in a TSC.

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NONFUEL HARDWARE

NONFUEL HARDWARE is defined as reactor control components (RCCs), burnable poison absorber assemblies (BPAAs), guide tube plug devices (GTPDs), neutron sources/neutron source assemblies (NSAs), hafnium absorber assemblies (HFRAs), instrument tube tie components, guide tube anchors or other similar devices, in-core instrument thimbles, steel rod inserts (used to displace water from lower section of guide tube), and components of these devices such as individual rods. All nonfuel hardware, with the exception of instrument tube tie components, guide tube anchors or other similar devices, and steel rod inserts, may be activated during in-core operations.

RCCs are commonly referred to as rod cluster control assemblies (RCCAs), control rod assemblies (CRAs), or control element assemblies (CEAs). RCCs are primarily designed to provide reactor shutdown reactivity control, are inserted into the guide tubes of the assembly, and are typically employed for a significant number of operating cycles. Burnup poison absorber assemblies (BPAAs) are commonly referred to as burnup poison rod assemblies (BPRAs), but may have vendor specific nomenclature such as BPRA, Pyrex BPRA or WABA (wet annular burnable absorber). BPAAs are used to control reactivity of fresh fuel or high reactivity fuels and are commonly used for a single cycle, but may be used for multiple cycles. GTPDs are designed to block guide tube openings when no BPAA is employed and are commonly referred to as thimble plugs (TPs), thimble plug devices (TPDs), flow mixers (FMs), water displacement guide tube plugs, or vibration suppressor inserts. GTPDs may be employed for multiple cycles. NSAs are primary and secondary neutron sources used during reactor startup and may be used for multiple cycles.

Integral fuel burnable absorbers, either integral to a fuel rod or as a substitution for a fuel rod, and fuel replacement rods (fueled, stainless steel, or zirconium alloy) are considered components of spent nuclear fuel (SNF) assemblies and are not considered to be nonfuel hardware.

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OPERABLE	A system, component, or device is OPERABLE when it is capable of performing its specified safety functions.
PARTIAL LENGTH SHIELD ASSEMBLIES (PLSA)	PWR fuel assemblies that contain stainless steel inserts in the bottom of each fuel rod, reducing the active fuel length, and a natural uranium blanket at the top of the active core. PLSAs are sometimes used in reactors to reduce fast neutron fluence reaching the pressure vessel wall.
SPENT NUCLEAR FUEL (SNF)	Irradiated fuel assemblies consisting of end-fittings, grids, fuel rods and integral hardware. Integral hardware for PWR assemblies primarily consists of guide/instrument tubes, but may contain integral fuel burnable absorbers, either integral to a fuel rod or as a fuel rod substitution, and fuel replacement rods (another fuel rod, stainless steel rod, or zirconium alloy rod). For BWR fuel, integral hardware may consist of water rods in various shapes, inert rods, fuel rod cluster dividers, and/or fuel assembly channels (optional). PWR SNF may contain NONFUEL HARDWARE.
STORAGE CASK	A STORAGE CASK is either a CONCRETE CASK with a CONCRETE CASK LID or an MSO.
STORAGE OPERATIONS	STORAGE OPERATIONS include all licensed activities that are performed at the ISFSI following placement of a STORAGE CASK containing a loaded TSC at its designated storage location on the storage pad.
TRANSFER CASK	TRANSFER CASK is a shielded lifting device designed to hold the TSC during LOADING OPERATIONS, TRANSFER OPERATIONS, and UNLOADING OPERATIONS. Either an MTC, PMTC, or LMTC may be used.
TRANSFER OPERATIONS	TRANSFER OPERATIONS include all licensed activities involved in using a MTC, PMTC, or LMTC to move a loaded and sealed TSC from a CONCRETE CASK to another CONCRETE CASK or from an MSO to another MSO or from either a CONCRETE CASK or MSO to a TRANSPORT CASK.
TRANSPORT CASK	TRANSPORT CASK is the transport packaging system for the high-capacity MAGNASTOR System TSCs that consists of a MAGNATRAN transport cask body, a bolted closure lid, and energy-absorbing upper and lower (front and rear) impact limiters. The MAGNATRAN packaging is used to transport a TSC containing spent fuel assemblies or Greater Than Class C (GTCC) waste.

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TRANSPORT OPERATIONS	TRANSPORT OPERATIONS include all licensed activities performed on a loaded MAGNASTOR STORAGE CASK when it is being moved to and from its designated location on the ISFSI. TRANSPORT OPERATIONS begin when the loaded STORAGE CASK is placed on or lifted by a transporter and end when the STORAGE CASK is set down in its storage position on the ISFSI pad.
TRANSPORTABLE STORAGE CANISTER (TSC)	The TRANSPORTABLE STORAGE CANISTER (TSC) is the welded container consisting of a basket in a weldment composed of a cylindrical shell welded to a baseplate. The TSC includes a closure lid, a shield plate (optional), a closure ring, and redundant port covers at the vent and the drain ports. The closure lid is welded to the TSC shell and the closure ring is welded to the closure lid and the TSC shell. The port covers are welded to the closure lid. The TSC provides the confinement boundary for the radioactive material contained in the TSC cavity. The FBM TSC contains a waste basket liner rather than a spent fuel basket.
TSC TRANSFER FACILITY	The TSC TRANSFER FACILITY includes: 1) a transfer location for the lifting and transfer of a TRANSFER CASK and placement of a TSC into or out of a CONCRETE CASK or MSO; and 2) either a stationary lift device or a mobile lifting device used to lift the TRANSFER CASK and TSC, but not licensed as part of the 10 CFR 50 facility.
UNDAMAGED FUEL	SNF that can meet all fuel specific and system-related functions. UNDAMAGED FUEL is SNF that is not DAMAGED FUEL, as defined herein, and does not contain assembly structural defects that adversely affect radiological and/or criticality safety. As such, UNDAMAGED FUEL may contain: <ul style="list-style-type: none"><li>a) BREACHED SPENT FUEL RODS (i.e, rods with minor defects up to hairline cracks or pinholes) but cannot contain grossly breached fuel rods;</li><li>b) Grid, grid strap, and/or grid spring damage provided that the unsupported length of the fuel rod does not exceed 60 inches.</li></ul>
UNLOADING OPERATIONS	UNLOADING OPERATIONS include the activities required to remove the fuel assemblies from a sealed TSC. UNLOADING OPERATIONS begin with the movement of the TSC from a CONCRETE CASK or MSO into a TRANSFER CASK in an unloading facility and end when the last fuel assembly has been removed from the TSC.

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1.0 USE AND APPLICATION

1.2 Logical Connectors

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**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 Technical Specifications are “AND” and “OR”. 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 indentations 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.

EXAMPLE 1.2-1

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. LCO not met	A.1 Verify . . . <u>AND</u> A.2 Restore . . .	

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

(continued)

EXAMPLES  
(continued)

EXAMPLE 1.2-2

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. LCO not met	A.1 Stop . . . <u>OR</u> A.2.1 Verify . . . <u>AND</u> A.2.2 A.2.2.1 Reduce . . . <u>OR</u> A.2.2.2 Perform . . . <u>OR</u> 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 can fail to be met. Specified with each stated Condition are Required Action(s) and Completion Time(s).

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**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, provided that MAGNASTOR 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 MAGNASTOR 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 not 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.

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(continued)

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	12 hours
	<u>AND</u> B.2 Perform Action B.2	36 hours

Condition B has two Required Actions. Each Required Action has its own 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 six 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.

(continued)

EXAMPLES  
(continued)

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 Complete action B.1	12 hours
	<u>AND</u> B.2 Complete action B.2	36 hours

When a system is determined not to 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, Conditions A and B are exited, and therefore, the Required Actions of Condition B may be terminated.

(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 Complete action B.1	6 hours
	<u>AND</u> B.2 Complete 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 to be 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 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.

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**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.

Each “specified Frequency” is referred to throughout this section and each of the Specifications of Section 3.0, Surveillance Requirement (SR) Applicability. The “specified Frequency” consists of requirements of the Frequency column of each SR.

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 an SR satisfied, SR 3.0.4 imposes no restriction.

The use of “met” or “performed” in these instances conveys specific meanings. Surveillance is “met” only after the acceptance criteria are satisfied. Known failure of the requirements of Surveillance, even without Surveillance specifically being “performed”, constitutes a Surveillance not “met”.

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(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 interval specified in the 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 or variables are outside specified limits, or the facility 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)

EXAMPLES

(continued)

EXAMPLE 1.4-2

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
Verify flow is within limit	Once within 12 hours prior to starting activity  <u>AND</u> 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 within 12 hours 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.

2.0 [Reserved]



3.0 LIMITING CONDITION FOR OPERATION (LCO) APPLICABILITY

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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	<p>Upon failure to meet an LCO, the Required Actions of the associated Conditions shall be met, except as provided in LCO 3.0.5.</p> <p>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.</p>
LCO 3.0.3	Not applicable to MAGNASTOR.
LCO 3.0.4	<p>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 MAGNASTOR.</p> <p>Exceptions to this Condition are stated in the individual Specifications. These exceptions allow entry into specified conditions in the Applicability where the associated ACTIONS to be entered allow operation in the specified conditions in the Applicability only for a limited period of time.</p>
LCO 3.0.5	This exception to LCO 3.0.2 is not applicable for the MAGNASTOR SYSTEM to return to service under administrative control to perform the testing.

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3.0 SURVEILLANCE REQUIREMENT (SR) APPLICABILITY

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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 Surveillance, whether such failure is experienced during the performance of the Surveillance or between performances of the Surveillance, shall be a failure to meet the LCO. Failure to perform Surveillance within the specified Frequency shall be a 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.

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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 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 MAGNASTOR.

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3.1 MAGNASTOR SYSTEM Integrity

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3.1.1 Transportable Storage Canister (TSC)

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LCO 3.1.1

The TSC shall be dry and helium filled, as applicable. The following vacuum drying times, helium backfill and TSC transfer times shall be met as appropriate to the fuel content type and heat load:

1. The time durations covering the beginning of canister draining through completion of vacuum drying and helium backfill, minimum helium backfill times, and TSC transfer times shall meet the following:

**A. PWR TSC Transfer Using MTC or LMTC Reduced Helium Backfill Time**

Heat Load (kW)	Maximum Vacuum Time Limit (hours)	Minimum Helium Backfill Time (hours)	Maximum TSC Transfer Time (hours)
≤ 20	No limit	0	600
≤ 25	50	0	70.5
≤ 30	19	7	8
≤ 35.5	15	7	8

**B. PWR Using MTC or LMTC with Maximum TSC Transfer**

Heat Load (kW)	Maximum Vacuum Time Limit (hours)	Minimum Helium Backfill Time (hours)	Maximum TSC Transfer Time (hours)
≤ 25	No limit	24	48
≤ 30	32	24	22
≤ 35.5	24	24	22

**C. BWR Using MTC or LMTC with 8 Hours TSC Transfer**

Heat Load (kW)	Maximum Vacuum Time Limit (hours)	Minimum Helium Backfill Time (hours)	Maximum TSC Transfer Time (hours)
≤ 25	No limit	0	8
≤ 29	34	6	8
≤ 30	31	6	8
≤ 33	26	6	8

(continued)

**D. BWR Using MTC or LMTC with Maximum TSC Transfer**

Heat Load (kW)	Maximum Vacuum Time Limit (hours)	Minimum Helium Backfill Time (hours)	Maximum TSC Transfer Time (hours)
≤ 25	No limit	24	65
≤ 29	No limit	24	32
≤ 30	44	24	32
≤ 33	33	24	32

**E. PWR TSC Transfer Using PMTC<sup>1</sup>**

Heat Load (kW)	Maximum Vacuum Time Limit (hours)	Minimum Helium Backfill Time (hours)	Maximum TSC Transfer Time (hours)
≤ 20	No limit	0	600
≤ 25	54	0	600
≤ 30	32	0	600

**F. PWR TSC Transfer Using LMTC**

Heat Load (kW)	Maximum Vacuum Time Limit (hours)	Minimum Helium Backfill Time (hours)	Maximum TSC Transfer Time (hours)
> 35.5 - ≤ 42.5	19	12	16

**G. BWR TSC Transfer Using LMTC**

Heat Load (kW)	Maximum Vacuum Time Limit (hours)	Minimum Helium Backfill Time (hours)	Maximum TSC Transfer Time (hours)
> 33.0 - ≤ 42.0	27	12	22

(continued)

<sup>1</sup> CE 16 × 16 fuel only, with a maximum storage cell location heat load of 811 watts.

**H. BWR-DF TSC Transfer Using LMTC**

Heat Load (kW)	Maximum Vacuum Time Limit (hours)	Minimum Helium Backfill Time (hours)	Maximum TSC Transfer Time (hours)
≤ 41.0	24	12	22

2. The time duration from the end of TSC annulus cooling, either by 24 hours in the pool or by the annulus circulating water system, through completion of vacuum drying and helium backfill using a MTC shall not exceed the following:

	Heat Load	Time Limit (hours)
PWR	35.5	11
BWR	33	16
PWR (LMTC)	> 35.5 - ≤ 42.5	9
BWR (LMTC)	> 33.0 - ≤ 42.0	14
BWR- DF (LMTC)	≤ 41.0	13

Notes: For PWR TSC's with heat loads ≤ 35.5 kW using the MTC or LMTC Transfer Cask, the approved minimum helium backfill and transfer times shown in Table 1.B shall be used for operations for second and subsequent vacuum drying cycles.

For BWR TSC's with heat loads ≤ 33.0 kW using the MTC or LMTC Transfer Cask, the approved minimum helium backfill and transfer times shown in Table 1.D shall be used for operations for second and subsequent vacuum drying cycles.

For PWR TSCs with heat loads > 35.5 kW the approved minimum helium backfill and transfer times shown in Tables 1.F are applicable for second and subsequent vacuum drying cycles.

For BWR and BWR-DF TSCs with heat loads > 33.0 kW the approved minimum helium backfill and transfer times shown in Tables 1.G and 1.H respectively are applicable for second and subsequent vacuum drying cycles.

The FBM TSC has been evaluated at steady state conditions through all operations steps from canister draining through ISFSI placement LCO 3.1.1 time limits are not applicable to the FBM TSC.

(continued)

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3. The time duration from the end of TSC annulus cooling, either by 24 hours in the pool or by the annulus circulating water system, through completion of vacuum drying and helium backfill using a PMTC shall not exceed the following:

	<b>Heat Load</b>	<b>Time Limit (hours)</b>
PWR	≤ 25	34
PWR	≤ 30	17

Note: The helium backfill times and TSC transfer times provided in Table 1.E shall be used for operations following the second or subsequent vacuum drying cycles using the PMTC.

APPLICABILITY: Prior to TRANSPORT OPERATIONS

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(continued)

ACTIONS

NOTE

Separate Condition entry is allowed for each TSC.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. TSC cavity vacuum drying pressure limit not met.	A.1 Perform an engineering evaluation to determine the quantity of moisture remaining in the TSC.	7 days
	<u>AND</u> A.2 Develop and initiate corrective actions necessary to return the TSC to an analyzed condition.	30 days
B. TSC helium backfill density limit not met. FBM TSC is pressure backfilled and backfill density limit is not applicable.	B.1 Perform an engineering evaluation to determine the effect of helium density differential.	72 hours
	<u>AND</u> B.2 Develop and initiate corrective actions necessary to return the TSC to an analyzed condition.	14 days
C. Required Actions and associated Completion Times not met.	C.1 Remove all fuel assemblies from the TSC. (not applicable to FBM)	30 days

(continued)

SURVEILLANCE REQUIREMENTS		
SURVEILLANCE		FREQUENCY
SR 3.1.1.1	Verify TSC cavity vacuum drying pressure is less than or equal to 10 torr for greater than or equal to 10 minutes with the vacuum pump turned off and isolated.	Once, prior to TRANSPORT OPERATIONS.
SR 3.1.1.2	<p>For spent fuel following vacuum drying and evacuation to &lt; 3 torr, backfill the cavity with high purity helium until a mass <math>M_{\text{helium}}</math> corresponding to the free volume of the TSC measured during draining (<math>V_{\text{TSC}}</math>), multiplied by the helium density (<math>L_{\text{helium}}</math>) required for the design basis heat load and specified in Table A3-1, is reached.</p> <p>For FBM following vacuum drying and evacuation to &lt; 3 torr, backfill the cavity with helium to 1 atm (0 +1/-0psig)</p>	Once, prior to TRANSPORT OPERATIONS.

**Table A3-1 Helium Mass per Unit Volume for MAGNASTOR TSCs**

	<b>Fuel Type &amp; Heat Load</b>	<b>Helium Density (g/liter)</b>
PWR	$\leq 35.5$ kW	0.694 – 0.802
	$> 35.5$ kW - $< 42.5$ kW	0.760 – 0.802
BWR	$\leq 33.0$ kW	0.704 – 0.814
	$> 33.0$ kW - $< 42.0$ kW	0.760 – 0.802

3.1 MAGNASTOR SYSTEM Integrity

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3.1.2 STORAGE CASK Heat Removal System

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LCO 3.1.2 The STORAGE CASK Heat Removal System shall be OPERABLE.

APPLICABILITY: During STORAGE OPERATIONS

ACTIONS

NOTES

Separate Condition entry is allowed for each MAGNASTOR SYSTEM.

LCO 3.1.2 is not applicable to FBM TSC CONCRETE CASKS because an OPERABLE Heat Removal System is not required.

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CONDITION	REQUIRED ACTION	COMPLETION TIME
A. STORAGE CASK or Heat Removal System inoperable.	A.1 Ensure adequate heat removal to prevent exceeding short-term temperature limits.	Immediately
	<u>AND</u> A.2 Restore STORAGE CASK Heat Removal System to OPERABLE status.	30 days

SURVEILLANCE REQUIREMENTS

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SURVEILLANCE		FREQUENCY
SR 3.1.2.1	Verify that the difference between the average STORAGE CASK air outlet temperature and ISFSI ambient temperature indicates that the STORAGE CASK Heat Removal System is OPERABLE in accordance with the FSAR thermal evaluation.	24 hours
	<u>OR</u> Visually verify all STORAGE CASK air inlet and outlet screens are free of blockage.	24 hours

3.2 MAGNASTOR SYSTEM Criticality Control for PWR Fuel

3.2.1 Dissolved Boron Concentration

LCO 3.2.1 The dissolved boron concentration in the water in the PWR TSC cavity shall be greater than, or equal to, the concentration specified in Appendix B, Table B2-4. A minimum concentration of 1,500 ppm is required for all PWR fuel types. Higher concentrations are required, depending on the fuel type and enrichment.

APPLICABILITY: During LOADING OPERATIONS and UNLOADING OPERATIONS with water and at least one fuel assembly in the TSC.

ACTIONS

NOTE

Separate Condition entry is allowed for each TSC.

LCO 3.2.1 is not applicable to the FBM TSC.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Dissolved boron concentration not met.	A.1 Suspend LOADING OPERATIONS or UNLOADING OPERATIONS  <u>AND</u>	Immediately
	A.2 Suspend positive reactivity additions.  <u>AND</u>	Immediately
	A.3 Initiate action to restore boron concentration to within limits.	Immediately

(continued)

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SURVEILLANCE REQUIREMENTS

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SURVEILLANCE	FREQUENCY
SR 3.2.1.1      Verify the dissolved boron concentration is met using two independent measurements.	Once within 4 hours prior to commencing LOADING, UNLOADING OPERATIONS, or adding/recirculating water through the TSC.  <u>AND</u> Every 72 hours thereafter while the TSC contains water and is submerged in the spent fuel pool.

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3.3 MAGNASTOR SYSTEM Radiation Protection

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3.3.1 STORAGE CASK Maximum Surface Dose Rate

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LCO 3.3.1 The maximum surface dose rates for the STORAGE CASK (Reference Figure A3-1) or (Reference Figure A3-2), shall not exceed the following limits:

- a. PWR, BWR and FBM – 120 mrem/hour gamma and 5 mrem/hour neutron on the vertical surfaces (at locations specified on Figures A3-1 and A3-2); and
- b. PWR, BWR and FBM – 900 mrem/hour (neutron + gamma) on the top.

APPLICABILITY: Prior to start of STORAGE OPERATIONS

ACTIONS

-----NOTE-----

Separate Condition entry is allowed for each MAGNASTOR® SYSTEM.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. STORAGE CASK maximum surface dose rate limits not met	A.1 Administratively verify correct fuel loading	24 hours
	<u>AND</u> A.2 Perform analysis to verify compliance with the ISFSI radiation protection requirements of 10 CFR 20 and 10 CFR 72	7 days
B. Required Action and associated Completion Time not met	B.1 Perform (and document) an engineering assessment and take appropriate corrective action to ensure the dose limits of 10 CFR 20 and 10 CFR 72 are not exceeded	60 days

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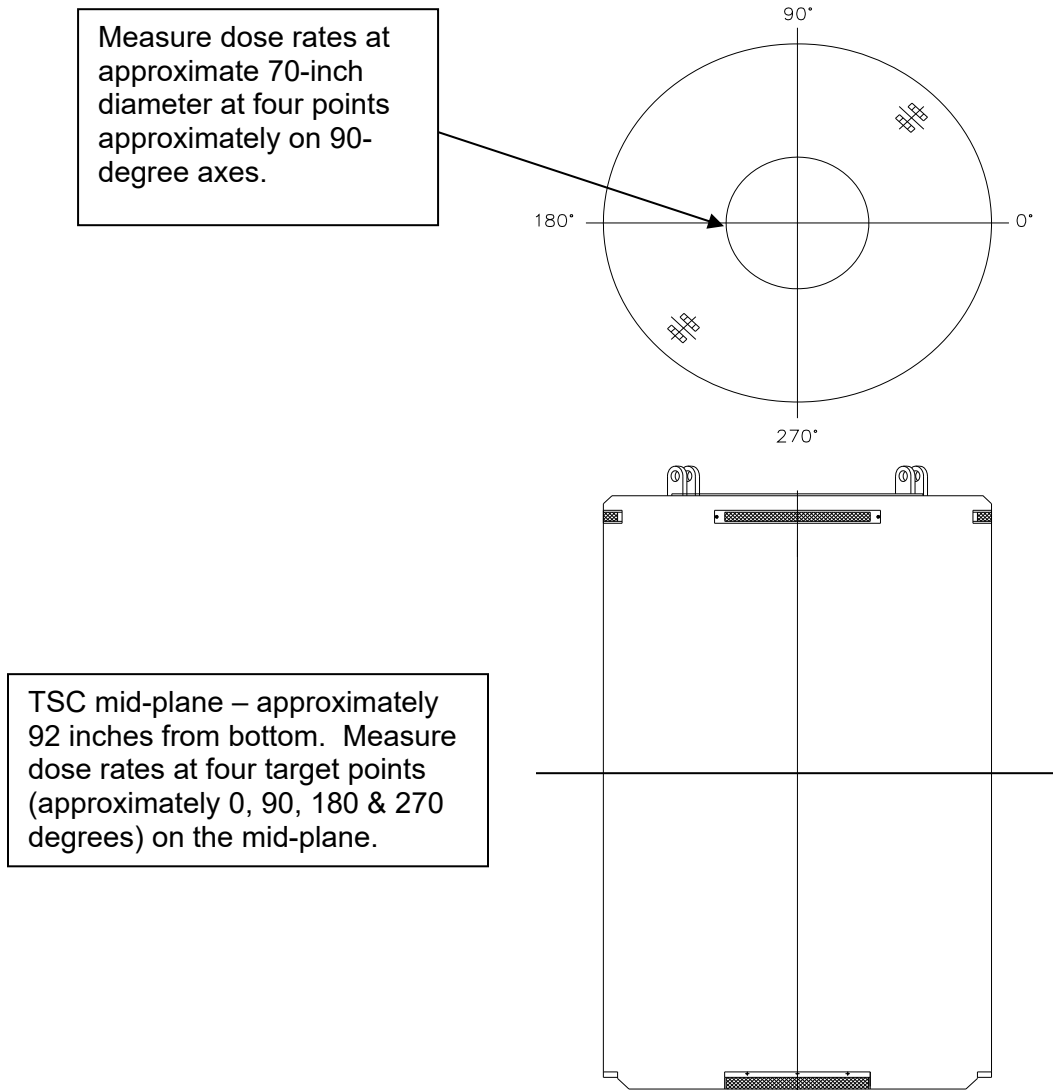
SURVEILLANCE REQUIREMENTS

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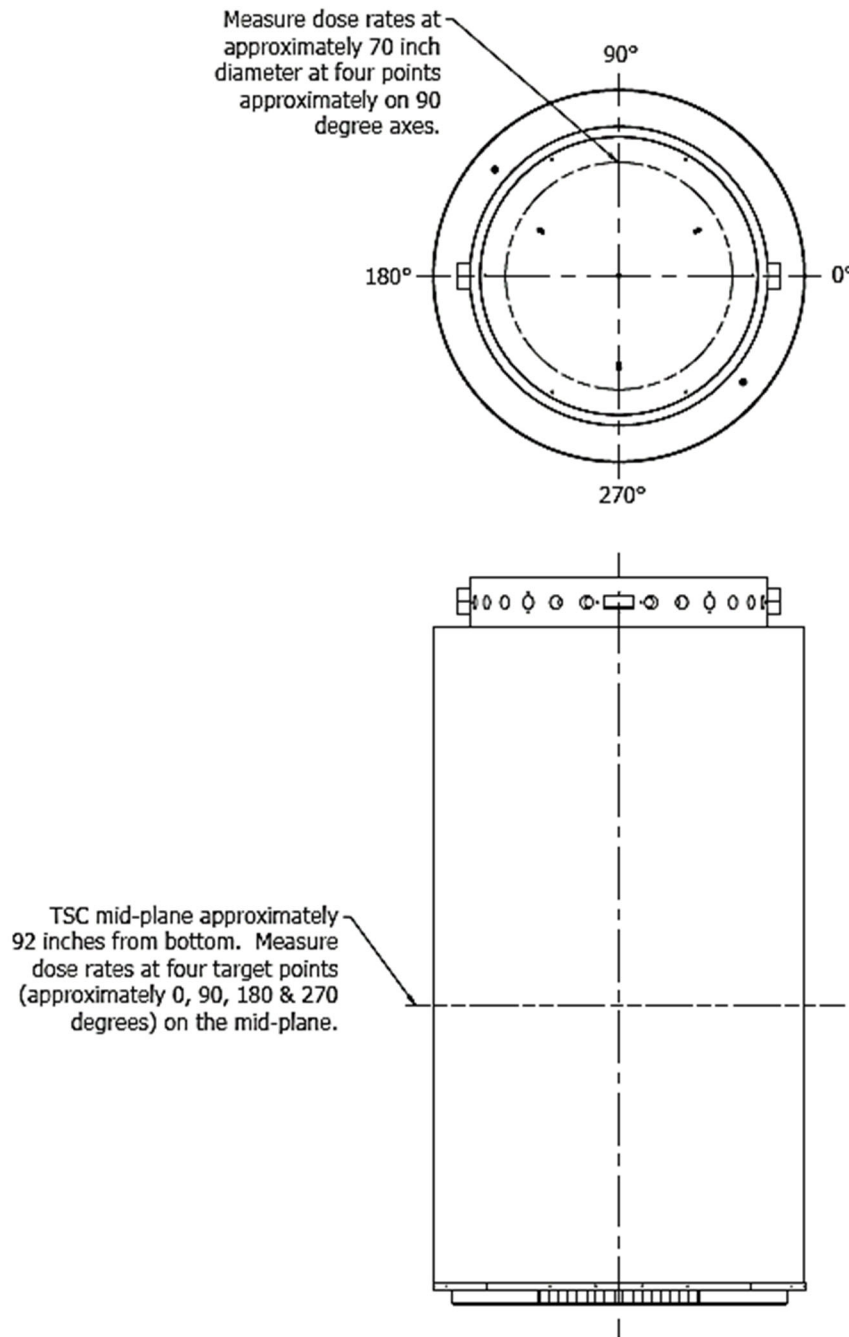
SURVEILLANCE	FREQUENCY
SR 3.3.1.1      Verify maximum surface dose rates of STORAGE CASK loaded with a TSC containing fuel assemblies are within limits. Dose rates shall be measured at the locations shown in Figure A3-1 or A3-2.	Prior to start of STORAGE OPERATIONS of each loaded STORAGE CASK before or after placement on the ISFSI pad.

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**Figure A3-1 CONCRETE CASK Surface Dose Rate Measurement**



**Figure A3-2 MSO Surface Dose Rate Measurement**



3.3 MAGNASTOR SYSTEM Radiation Protection

3.3.2 TSC Surface Contamination

LCO 3.3.2 Removable contamination on the exterior surfaces of the TSC shall not exceed:

- a. 20,000 dpm/100 cm<sup>2</sup> from beta and gamma sources; and
- b. 200 dpm/100 cm<sup>2</sup> from alpha sources.

APPLICABILITY: During LOADING OPERATIONS

ACTIONS

-----NOTE-----  
Separate Condition entry is allowed for each MAGNASTOR SYSTEM.  
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CONDITION	REQUIRED ACTION	COMPLETION TIME
A. TSC removable surface contamination limits not met	A.1 Restore TSC removable surface contamination to within limits	Prior to TRANSPORT OPERATIONS

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 3.3.2.1 Verify by either direct or indirect methods that the removable contamination on the exterior surfaces of the TSC is within limits	Once, prior to TRANSPORT OPERATIONS

3.4 MAGNASTOR SYSTEM TMI-2 Fuel Bearing Material (FBM)

3.4.1 FBM TSC Loading

LCO 3.4.1 Non-TMI-2 originating fuel bearing material loaded into a TMI-2 FBM TSC.

APPLICABILITY: During LOADING OPERATIONS for TMI-2 Decommissioning Activities.

ACTIONS

-----NOTE-----  
LCO is only applicable to TMI-2 FBM TSCs

Separate Condition entry is allowed for each MAGNASTOR SYSTEM.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Non-TMI-2 originating fuel bearing material loaded into a TMI-2 FBM TSC	A.1 Suspend LOADING OPERATIONS	Immediately
	<u>AND</u> A.2 Remove material from FBM TSC and disposed of in accordance with applicable regulations	Immediately

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 3.4.1.1 None Required	None

4.0 DESIGN FEATURES

4.1 Design Features Significant to Safety

4.1.1 Criticality Control

a) Minimum <sup>10</sup>B loading in the neutron absorber material:

Neutron Absorber Type	Required Minimum Effective Areal Density ( <sup>10</sup> B g/cm <sup>2</sup> )		% Credit Used in Criticality Analyses	Required Minimum Actual Areal Density ( <sup>10</sup> B g/cm <sup>2</sup> )	
	PWR Fuel	BWR Fuel		PWR Fuel	BWR Fuel
Borated Aluminum Alloy	0.036	0.027	90	0.04	0.03
	0.030	0.0225		0.0334	0.025
	0.027	0.020		0.03	0.0223
Borated MMC	0.036	0.027	90	0.04	0.03
	0.030	0.0225		0.0334	0.025
	0.027	0.020		0.03	0.0223
Boral	0.036	0.027	75	0.048	0.036
	0.030	0.0225		0.04	0.030
	0.027	0.020		0.036	0.0267

Enrichment/soluble boron limits for PWR systems and enrichment limits for BWR systems are incorporated in Appendix B Section 2.0.

b) Acceptance and qualification testing of borated aluminum alloy and borated MMC neutron absorber material shall be in accordance with Sections 10.1.6.4.5, 10.1.6.4.6 and 10.1.6.4.7. Acceptance testing of Boral shall be in accordance with Section 10.1.6.4.8. These sections of the FSAR are hereby incorporated into the MAGNASTOR CoC.

c) Soluble boron concentration in the PWR fuel pool and water in the TSC shall be in accordance with LCO 3.2.1, with a minimum water temperature 5-10°F higher than the minimum needed to ensure solubility.

d) Minimum fuel tube outer diagonal dimension

PWR basket — 13.08 inches

BWR basket — 8.72 inches

Note: Not applicable to DFC locations of the DF Basket Assembly.

4.1.2 Fuel Cladding Integrity

The licensee shall ensure that fuel oxidation and the resultant consequences are precluded during canister loading and unloading operations.

4.1.3 Transfer Cask Shielding

For the MTC and PMTC Transfer Casks, the nominal configuration transfer cask radial bulk shielding (i.e., shielding integral to the transfer cask; excludes

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supplemental shielding) must provide a minimum radiation shield equivalent to 2 inches of carbon steel or stainless steel and 3.2 inches of lead gamma shielding and 2.25 inches of NS-4-FR (with 0.6 wt % B4C and 6.0 wt % H) neutron shielding. Material and dimensions of the individual shield layers may vary provided maximum calculated radial dose rates of 1100 mrem/hr (PWR system) and 1600 mrem/hr (BWR system) are maintained on the vertical surface (not including doors or vent shielding).

For the LMTC Transfer Cask the nominal configuration transfer cask radial bulk shielding (i.e., shielding integral to the transfer cask, excludes supplemental shielding) is variable to permit maximizing the LMTC shielding configuration to take advantage of the Site's architecture while complying with the host Site's ALARA evaluation as required in Section 5.5 – Radiation Protection Program. This design and evaluation approach permits the quantity of shielding around the body of the transfer cask to be maximized for a given length and weight of fuel specific to the host Site.

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#### 4.1.4 TSC Confinement Integrity

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The TSC shell, bottom plate, all confinement welds, the COMPOSITE CLOSURE LID and the FBM TSC lid shall be fabrication helium leak-tested in accordance with ANSI N14.5 to leaktight criterion.

The closure lid shall be helium leak-tested during fabrication (in accordance with ANSI N14.5 to leaktight criterion) if it is constructed with a lid thickness less than 9 inches (nominal).

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#### 4.2 Codes and Standards

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The American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), 2001 Edition with Addenda through 2003, Section III, Subsection NB, is the governing Code for the design, material procurement, fabrication, and testing of the TSC.

The ASME Code, 2001 Edition with Addenda through 2003, Section III, Subsection NG, is the governing Code for the design, material procurement, fabrication and testing of the spent fuel baskets.

The American Concrete Institute Specifications ACI-349 and ACI-318 govern the CONCRETE CASK design and construction, respectively.

The concrete used in the construction of the CONCRETE CASK LID, at minimum, shall be of a commercial grade ready-mix type that can develop a density of 140 pcf. The mix and batching should meet the purchaser's requirement of unit weight (i.e., density) and any additional purchaser indicated attributes (e.g., air content), as allowed by ASTM C94.

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The unit weight (i.e., density) of the concrete in the CONCRETE CASK LID can be verified by either test method ASTM C138 or an approved shop fabrication procedure by following the basic equation of  $\rho=W/V$ . The shop procedure shall include steps to weigh the lid before and after concrete placement and in calculating the actual volume (V) of the cavity to be filled with a record of the weight (W) of concrete placed into the cavity.

The CONCRETE CASK LID concrete placement shall be in a dry and clean cavity or form with procedures and equipment that ensure the concrete placed is thoroughly consolidated and worked around any reinforcement and/or embedded fixtures and into the corners of the cavity or form.

The CONCRETE CASK LID concrete shall be protected from the environment during curing to minimize development of cracks by one or more of various methods such as moist cure or liquid membrane forming chemicals. Type II Portland cement may be substituted by an alternate cement type for the CONCRETE CASK LID if the density requirement can be met.

The American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), 2001 Edition with Addenda through 2003, Section III, Subsection NF, is the governing Code for the design of the MSO. The applicable standards of the American Society for Testing and Materials (ASTM) govern material procurement and the American Welding Society (AWS) D1.1 or ASME Code Section VIII govern fabrication of the MSO.

The American National Standards Institute ANSI N14.6 (1993) and NUREG-0612 govern the TRANSFER CASK design, operation, fabrication, testing, inspection, and maintenance.

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4.2.1 Alternatives to Codes, Standards, and Criteria

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Table 2.1-2 of the FSAR lists approved alternatives to the ASME Code for the design, procurement, fabrication, inspection and testing of MAGNASTOR SYSTEM TSCs and spent fuel baskets.

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4.2.2 Construction/Fabrication Alternatives to Codes, Standards, and Criteria

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Proposed alternatives to ASME Code, Section III, 2001 Edition with Addenda through 2003, other than the alternatives listed in Table 2.1-2 of the FSAR, may be used when authorized by the Director of the Office of Nuclear Material Safety and Safeguards or designee. The request for such alternatives should demonstrate that:

1. The proposed alternatives would provide an acceptable level of quality and safety, or
2. Compliance with the specified requirements of ASME Code, Section III, Subsections NB and NG, 2001 Edition with Addenda through 2003, would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Requests for alternatives shall be submitted in accordance with 10 CFR 72.4.

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4.3 Site-Specific Parameters and Analyses

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This section presents site-specific parameters and analytical bases that must be verified by the MAGNASTOR SYSTEM user. The parameters and bases presented in Section 4.3.1 are those applied in the design bases analysis.

4.3.1 Design Basis Specific Parameters and Analyses

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The design basis site-specific parameters and analyses that require verification by the MAGNASTOR SYSTEM user are:

- a. A temperature of 76°F is the maximum average yearly temperature. The three-day average ambient temperature shall be  $\leq 106^{\circ}\text{F}$ .
- b. The allowed temperature extremes, averaged over a three-day period, shall be  $\geq -40^{\circ}\text{F}$  and  $\leq 133^{\circ}\text{F}$ .
- c. The analyzed flood condition of 15 fps water velocity and a depth of 50 ft of water (full submergence of the loaded cask) are not exceeded.
- d. The potential for fire and explosion shall be addressed, based on site-specific considerations. This includes the condition that the fuel tank(s) of the cask handling equipment used to move the loaded STORAGE CASK onto or from the ISFSI site contains a total of no more than 50 gallons of fuel.
- e. In cases where engineered features (i.e., berms, shield walls) are used to ensure that 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 on a site-specific basis.
- f. The TRANSFER CASK shall not be operated and used when surrounding air temperature is  $< 0^{\circ}\text{F}$ . This limit is NOT applicable to the stainless steel MTC or PMTC.
- g. The STORAGE CASK shall not be lifted by the lifting lugs with surrounding air temperatures  $< 0^{\circ}\text{F}$ .
- h. Loaded STORAGE CASK lifting height limit  $\leq 24$  inches.

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- i. The maximum design basis earthquake acceleration of 0.37g in the horizontal direction (without cask sliding) and 0.25g in the vertical direction at the ISFSI pad top surface do not result in cask tip-over.

For design basis earthquake accelerations up to and greater than 0.37g in the horizontal direction and 0.25g in the vertical direction at the ISFSI pad top surface, site-specific cask sliding is permitted with validation by the cask user that the cask does not slide off the pad and that the g-load resulting from the collision of two sliding casks remains bounded by the cask tip-over accident condition analysis presented in Chapter 3 of the FSAR.

An alternative to crediting site-specific cask sliding for design basis earthquake accelerations up to and greater than 0.37g in the horizontal direction and 0.25g in the vertical direction at the ISFSI pad top surface, the use of the MAGNASTOR system is permitted provided the ISFSI pad has bollards and the cask user validates that the cask does not overturn, g-loads resulting from the cask contacting the bollard is bounded by the cask tip-over accident condition presented in Chapter 3 of the FSAR, and the ISFSI pad and bollards are designed, fabricated and installed such that they are capable of handling the combined loading of the design basis earthquake and any contact between the bollard and cask during the design basis earthquake.

- j. In cases where the TRANSFER CASK or STORAGE CASK containing the loaded TSC must be tilted or down-ended to clear an obstruction (e.g., a low door opening) during on-site transport operations, a site specific safety evaluation of the system in the non-vertical orientation is required in accordance with 10 CFR 72.212 to demonstrate compliance with the thermal limits of ISG-11.

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4.4 TSC Handling and Transfer Facility

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The TSC provides a leaktight confinement boundary and is evaluated for normal and off-normal handling loads. A handling and transfer facility is not required for TSC and TRANSFER CASK handling and transfer operations within a 10 CFR 50 licensed facility or for utilizing an external crane structure integral to a 10 CFR 50 licensed facility.

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Movements of the TRANSFER CASK and TSC outside of a 10 CFR 50 licensed facility are not permitted unless a TSC TRANSFER FACILITY is designed, operated, fabricated, tested, inspected, and maintained in accordance with the following requirements. These requirements do not apply to handling heavy loads under a 10 CFR 50 license.

The permanent or stationary weldment structure of the TSC TRANSFER FACILITY shall be designed to comply with the stress limits of ASME Code, Section III, Subsection NF, Class 3 for linear structures. All compression loaded members shall satisfy the buckling criteria of ASME Code, Section III, Subsection NF.

The reinforced concrete structure of the facility shall be designed in accordance with ACI-349 and the factored load combinations set forth in ACI-318 for the loads defined in Table A4-1 shall apply. TRANSFER CASK and TSC lifting devices installed in the handling facility shall be designed, fabricated, operated, tested, inspected, and maintained in accordance with NUREG-0612, Section 5.1.

If mobile load lifting and handling equipment is used at the facility, that equipment shall meet the guidelines of NUREG-0612, Section 5.1, with the following conditions:

- a. The mobile lifting device shall have a minimum safety factor of two over the allowable load table for the lifting device in accordance with the guidance of NUREG-0612, Section 5.1.6 (1)(a), and shall be capable of stopping and holding the load during a design earthquake event;
- b. The mobile lifting device shall contain  $\leq 50$  gallons of fuel during operation inside the ISFSI;
- c. Mobile cranes are not required to meet the guidance of NUREG-0612, Section 5.1.6(2) for new cranes;
- d. The mobile lifting device shall conform to the requirements of ASME B30.5, "Mobile and Locomotive Cranes";
- e. Movement of the TSC or STORAGE CASK in a horizontal orientation is not permitted.

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(continued)

**Table A4-1 Load Combinations and Service Condition Definitions for the TSC Handling and Transfer Facility Structure**

Load Combination	ASME Section III Service Condition for Definition of Allowable Stress	Note
$D^*$ $D + S$	Level A	All primary load bearing members must satisfy Level A stress limits
$D + M + W'^1$ $D + F$ $D + E$ $D + Y$	Level D	Factor of safety against overturning shall be $\geq 1.1$ , if applicable.

- D = Crane hook dead load
- $D^*$  = Apparent crane hook dead load
- S = Snow and ice load for the facility site
- M = Tornado missile load of the facility site<sup>1</sup>
- $W'$  = Tornado wind load for the facility site<sup>1</sup>
- F = Flood load for the facility site
- E = Seismic load for the facility site
- Y = Tsunami load for the facility site

1. Tornado missile load may be reduced or eliminated based on a Probabilistic Risk Assessment for the facility site.



**5.0 ADMINISTRATIVE CONTROLS AND PROGRAMS****5.1 Radioactive Effluent Control Program**

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- 5.1.1 A program shall be established and maintained to implement the requirements of 10 CFR 72.44 (d) or 10 CFR 72.126, as appropriate.
- 5.1.2 The MAGNASTOR SYSTEM does not create any radioactive materials or have any radioactive waste treatment systems. Therefore, specific operating procedures for the control of radioactive effluents are not required. LCO 3.3.2, TSC Surface Contamination, provides assurance that excessive surface contamination is not available for release as a radioactive effluent.
- 5.1.3 This program includes an environmental monitoring program. Each general license user may incorporate MAGNASTOR SYSTEM operations into their environmental monitoring program for 10 CFR Part 50 operations.

**5.2 TSC Loading, Unloading, and Preparation Program**

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A program shall be established to implement the FSAR, Chapter 9 general procedural guidance for loading fuel and components into the TSC, unloading fuel and components from the TSC, and preparing the TSC and STORAGE CASK for storage. The requirements of the program for loading and preparing the TSC shall be completed prior to removing the TSC from the 10 CFR 50 structure. The program requirements for UNLOADING OPERATIONS shall be maintained until all spent fuel is removed from the spent fuel pool and TRANSPORT OPERATIONS have been completed on the last STORAGE CASK. The program shall provide for evaluation and control of the following requirements during the applicable operation:

- a. Verify that no TRANSFER CASK, STORAGE CASK handling using the lifting lugs occurs when the ambient temperature is  $< 0^{\circ}\text{F}$ . This limit is NOT applicable to the stainless steel MTC or PMTC.
- b. The water temperature of a water-filled, or partially filled, loaded TSC shall be shown by analysis and/or measurement to be less than boiling at all times. This does not apply to the FBM TSC.
- c. Verify that the drying time, cavity vacuum pressure, and component and gas temperatures ensure that the fuel cladding temperature limit of  $400^{\circ}\text{C}$  is not exceeded during TSC preparation activities, including TRANSFER OPERATIONS, and that the TSC is adequately dry. For fuel with burnup  $> 45 \text{ GWd/MTU}$ , limit cooling cycles to  $\leq 10$  for temperature changes greater than  $65^{\circ}\text{C}$ . This does not apply to the FBM TSC.
- d. Verify that the helium backfill purity and mass assure adequate heat transfer and preclude fuel cladding corrosion. This does not apply to the FBM TSC.
- e. The integrity of the inner port cover welds to the closure lid at the vent port and at the drain port shall be verified in accordance with the procedures in Section 9.1.1.

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- f. Verify that the time to complete the transfer of the TSC from the TRANSFER CASK to the CONCRETE CASK or MSO and from a CONCRETE CASK to another CONCRETE CASK and from an MSO to another MSO assures that the fuel cladding temperature limit of 400°C is not exceeded. This does not apply to the FBM TSC.
  - g. The surface dose rates of the STORAGE CASK are adequate to allow proper storage and to assure consistency with the offsite dose analysis.
  - h. The equipment used to move the loaded STORAGE CASK onto or from the ISFSI site contains no more than 50 gallons of fuel.

This program will control limits, surveillances, compensatory measures and appropriate completion times to assure the integrity of the fuel cladding at all times in preparation for and during LOADING OPERATIONS, UNLOADING OPERATIONS, TRANSPORT OPERATIONS, TRANSFER OPERATIONS and STORAGE OPERATIONS, as applicable.

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### 5.3 Transport Evaluation Program

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A program that provides a means for evaluating transport route conditions shall be developed to ensure that the design basis impact g-load drop limits are met. For lifting of the loaded TRANSFER CASK, STORAGE CASK, using devices that are integral to a structure governed by 10 CFR 50 regulations, 10 CFR 50 requirements apply. This program evaluates the site-specific transport route conditions and controls, including the transport route road surface conditions; road and route hazards; security during transport; ambient temperature; and equipment operability and lift heights. The program shall also consider drop event impact g-loading and route subsurface conditions, as necessary.

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### 5.4 ISFSI Operations Program

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A program shall be established to implement FSAR requirements for ISFSI operations.

At a minimum, the program shall include the following criteria to be verified and controlled:

- a. Minimum STORAGE CASK center-to-center spacing.
- b. ISFSI pad parameters (i.e., thickness, concrete strength, soil modulus, reinforcement, etc.) are consistent with the FSAR analyses.
- c. Maximum STORAGE CASK lift heights ensure that the g-load limits analyzed in the FSAR are not exceeded.

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**5.5 Radiation Protection Program**

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- 5.5.1 Each cask user shall ensure that the 10 CFR 50 radiation protection program appropriately addresses dry storage cask loading and unloading, and ISFSI operations, including transport of the loaded STORAGE CASK outside of facilities governed by 10 CFR 50 as applicable. The radiation protection program shall include appropriate controls and monitoring for direct radiation and surface contamination, ensuring compliance with applicable regulations, and implementing actions to maintain personnel occupational exposures ALARA. The actions and criteria to be included in the program are provided as follows.
- 5.5.2 Each user shall perform a written evaluation of the TRANSFER CASK and associated operations, 30 days prior to first use, to verify that it meets public, occupational, and ALARA requirements (including shielding design and dose characteristics) in 10 CFR Part 20, and that it is consistent with the program elements of each user's radiation protection program. The evaluation should consider both normal operations and unanticipated occurrences, such as handling equipment malfunctions, during use of the transfer cask.
- 5.5.3 As part of the evaluation pursuant to 10 CFR 72.212(b)(5)(iii), the licensee shall perform an analysis to confirm that the dose limits of 10 CFR 72.104(a) will be satisfied under actual site conditions and ISFSI configuration, considering the number of casks to be deployed and the cask contents.
- 5.5.4 Each user shall establish limits on the surface contamination of the STORAGE CASK, TSC and TRANSFER CASK, and procedures for the verification of meeting the established limits prior to removal of the components from the 10 CFR 50 structure. Surface contamination limits for the TSC prior to placement in STORAGE OPERATIONS shall meet the limits established in LCO 3.3.2.
- 5.5.5 The nominal configuration transfer cask radial bulk shielding (i.e., shielding integral to the transfer cask, excludes supplemental shielding) is variable to permit maximizing the LMTC shielding configuration to take advantage of the Site's architecture while complying with the host Site's ALARA evaluation as required in Section 5.5 – Radiation Protection Program. This design and evaluation approach permits the quantity of shielding around the body of the transfer cask to be maximized for a given length and weight of fuel specific to the host Site.
- 5.5.6 Supplemental shielding used, credited, or otherwise incorporated into the analysis as the basis of complying with the LMTC surface dose rate analysis in section 5.5.5 shall be referenced in the licensee's evaluation and required for use. This shall include material, thickness, specific shape and configuration and location the Supplemental Shielding was used in the evaluation.
- 5.5.7 Supplemental shielding used for the LMTC dose rate analysis as described in 5.5.6 shall be implemented by the licensee for the condition(s) it was evaluated for.

- 5.5.8 If draining the LMTC Neutron Shield is required to meet the plant architectural limits, the LMTC Neutron Shield shall be verified to be filled after completion of the critical lift. If TSC cavity draining or TC/DSC annulus draining operations, as applicable, are initiated after the completion of the critical lift, the LMTC Neutron Shield shall be verified to be filled before these draining operations are initiated and continually monitored during the first five minutes of the draining evolution to ensure the Neutron Shield remains filled. Observation of water level in the expansion tank or some other means can be used to verify compliance to this requirement.

5.6 [Deleted]

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5.7 Training Program

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A training program for the MAGNASTOR system shall be developed under the general licensee's systematic approach to training (SAT). Training modules shall include comprehensive instructions for the operation and maintenance of the MAGNASTOR system and the independent spent fuel storage installation (ISFSI) as applicable to the status of ISFSI operations.

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(continued)

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**5.8 Preoperational Testing and Training Exercises**

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A dry run training exercise on loading, closure, handling, unloading, and transfer of the MAGNASTOR system shall be conducted by the licensee prior to the first use of the system to load spent fuel assemblies. The training exercise shall not be conducted with spent fuel in the TSC. The dry run may be performed in an alternate step sequence from the actual procedures, but all steps must be performed. The dry run shall include, but is not limited to, the following:

- a. Moving the CONCRETE CASK or MSO into its designated loading area
- b. Moving the TRANSFER CASK containing the empty TSC into the spent fuel pool or fuel transfer canal, as applicable. The FBM TSCs may be loaded at a location not within the spent fuel pool or fuel transfer canal.
- c. Loading one or more dummy fuel assemblies into the TSC, (or WBL into FBM TSC) including independent verification
- d. Selection and verification of fuel assemblies to ensure conformance with appropriate loading configuration requirements or proper load distribution, as applicable.
- e. Installing the closure lid
- f. Removal of the TRANSFER CASK from the spent fuel pool or fuel transfer canal, as applicable. The FBM TSCs may be loaded at a location not within the spent fuel pool or fuel transfer canal.
- g. Closing and sealing of the TSC to demonstrate pressure testing, vacuum drying, helium backfilling, welding, weld inspection and documentation, and leak testing
- h. TRANSFER CASK movement through the designated load path
- i. TRANSFER CASK installation on the CONCRETE CASK or MSO
- j. Transfer of the TSC to the CONCRETE CASK or MSO
- k. CONCRETE CASK or MSO lid assembly installation
- l. Transport of the STORAGE CASK to the ISFSI
- m. TSC removal from the STORAGE CASK
- n. TSC unloading, including reflooding and weld removal or cutting

Appropriate mock-up fixtures may be used to demonstrate and/or to qualify procedures, processes or personnel in welding, weld inspection, vacuum drying, helium backfilling, leak testing and weld removal or cutting. Previously completed and documented demonstrations of specific processes and procedures may be used, as applicable, for implementation of the MAGNASTOR SYSTEM at a specific loading facility.



**Enclosure 3**

**List of Changes**

**for**

**MAGNASTOR® FSAR  
Amendment 13 RAI Response Submittal  
Revision 23B**

**(Docket No 72-1031)**

**NAC International**

**June 2023**

## **List of Changes for the MAGNASTOR® FSAR, Revision 23B**

**Note:** The List of Effective Pages and the Chapter Table of Contents, List of Figures, and List of Tables have been revised accordingly to reflect the list of changes detailed below.

### **Chapter 1**

- Page 1.1-6, modified text near the top of the page where indicated.
- Pages 1.3-1 thru 1.3-2, modified text in the second and fifth paragraphs of Section 1.3.1.1 where indicated.
- Page 1.3-3, modified text in the first paragraph of Section 1.3.1.2 where indicated.

### **Chapter 2**

- Page 2.4-1, modified text in the last bullet in Section 2.1.1 where indicated.
- Page 2.4-6, deleted text in the first paragraph of Section 2.4.10 where indicated.
- Page 2.4-8, added three rows and two Notes to the end of Table 2.4-1 where indicated.

### **Chapter 3**

- No changes

### **Chapter 4**

- Page 4.12-1, added text in the middle of Section 4.12 where indicated.
- Pages 4.12.1-1 thru 4.12.1-2, modified text throughout Sections 4.12.1, 4.12.1.1 and 4.12.1.2 where indicated.
- Page 4.12.1-3, text flow changes.
- Page 4.12.2-1, modified and added text to the beginning of Section 4.12.2.3 where indicated.
- Page 4.12.2-2, text flow changes.
- Page 4.12.3-1, added new row and two notes to the embedded table in Section 4.12.3.1 where indicated.
- Page 4.12.4-1, added new row and two notes to the embedded table in Section 4.12.4.1 where indicated.
- Page 4.12.4-2, text flow changes.
- Page 4.12.4-3, added label to Figure 4.12-1 where indicated.
- Page 4.12.4-5, added new row and note to Table 4.12-1 and asterisk (\*) and note to table 4.12-2 where indicated.

### **Chapter 5**

- No changes

## **Chapter 6**

- Page 6.1-3, modified text in the last paragraph on the page where indicated.

## **Chapter 7**

- Page 7-1, modified text in the second paragraph of Section 7 where indicated.
- Page 7.1-2, modified text throughout the page in Section 7.1.1 where indicated.
- Page 7.1-4, modified text in the second paragraph of Section 7.1.2 and the third paragraph of Section 7.1.3 where indicated.
- Pages 7.2-1 thru 7.2-2, modified text in the first, second and fifth paragraphs of Section 7.2.2 where indicated.

## **Chapter 8**

- Pages 8.10-1 thru 8.10-2, modified text in the first, second and last paragraphs of Section 8.10.1 where indicated.
- Page 8.10-4, modified text near the end of the first paragraph of Section 8.10.2.2 where indicated.
- Page 8.10-7, modified text in the first paragraph of Section 8.10.3.2 where indicated.

## **Chapter 9**

- Pages 9.7-1 thru 9.7-2, modified and added text throughout Section 9.7 where indicated.
- Page 9.7-3, modified the heading title for Section 9.7.1 and modified the first paragraph of that section where indicated.
- Page 9.7-4, text flow changes.
- Page 9.7-5, modified text in the note following Item 26 where indicated.
- Page 9.7-6, text flow changes.
- Pages 9.7-7 thru 9.7-8, added or modified text and Notes to Items 48, 49, 56, 57, 58, 63 and 64 where indicated.
- Pages 9.7-9 thru 9.7-13, inserted new Section 9.7.2 and renumbered Section 9.7.3 where indicated.
- Pages 9.7-14 thru 9.7-17, renumbered Sections 9.7.4, 9.4.5 and 9.7.6 where indicated.
- Page 9.7-18, added Notes to Items 12 and 17 where indicated.
- Pages 9.7-19 thru 9.7-20, text flow changes.

## **Chapter 10**

- Page 10.1-7, modified text at the bottom of the page in the first paragraph of Section 10.1.4.1 where indicated.
- Page 10.1-8, text flow changes.

## **Chapter 11**

- No changes

## **Chapter 12**

- No changes

## **Chapter 13**

- Page 13C-10 thru 13C-11, modified text near the end of the first paragraph on the page in Section 3.1.1 where indicated.
- Page 13C-12, text flow changes.
- Page 13C-13, modified text in the bottom half of the page in Section 3.1.1 where indicated.
- Page 13C-14, modified text in the bottom half of the page in Section 3.1.1 where indicated.
- Page 13C-15, modified text in the first two paragraphs on the page near the end of Section 3.1.1 where indicated.

## **Chapter 14**

- No changes

## **Chapter 15**

- No changes

**Enclosure 4**

**FSAR Changed Pages and LOEP**

**for**

**MAGNASTOR® FSAR  
Amendment 13 RAI Response Submittal  
Revision 23B**

**(Docket No 72-1031)**

**NAC International**

**June 2023**

June 2023

Revision 23B

# MAGNASTOR<sup>®</sup>

(Modular Advanced Generation  
Nuclear All-purpose STORAGE)

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## FINAL SAFETY ANALYSIS REPORT

NON-PROPRIETARY VERSION

Docket No. 72-1031





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substitution, and fuel replacement rods (fueled, stainless steel, or zirconium alloy). For BWR fuel, integral hardware may consist of water rods in various shapes, inert rods, fuel rod cluster dividers, and/or fuel assembly channels (optional). PWR SNF may contain nonfuel hardware.

### **Transfer Cask**

A shielded device used to lift and handle the TSC during fuel loading and closure operations, as well as to transfer the TSC in/out of the concrete cask during storage or in/out of a transport cask. The transfer cask includes two lifting trunnions and two shield doors that can be opened to permit the vertical transfer of the TSC. There are two types of transfer cask, the first is the standard MAGNASTOR Transfer Cask (MTC) with solid neutron shielding. The MTC can be supplied fabricated from high-strength carbon steel (MTC1) or stainless steel (MTC2). The second type is the Passive MTC (PMTC) with demineralized water filled shield tank. The PMTC is specifically designed for use in a high ambient temperature environment ( $\leq 104^{\circ}\text{F}$ ) and to passively cool the loaded TSC during transfer operations by convective air cooling equivalent to that provided by the concrete cask. The PMTC is fabricated from stainless steel.

### **Lifting Trunnions**

Two low-alloy steel components used to lift the transfer cask in a vertical orientation via a lifting assembly.

### **TSC (Transportable Storage Canister)**

The stainless steel cylindrical shell, bottom-end plate, closure lid, closure ring, and redundant port covers that contain the fuel basket structure and the spent fuel contents.

### **Closure Lid**

A thick, stainless steel disk or a composite closure lid consisting of stainless steel and carbon steel plates bolted together and installed directly above the fuel basket following fuel loading. The closure lid is welded to the TSC shell and provides the confinement boundary for storage and operational shielding during TSC closure.

### **Drain and Vent Ports**

Penetrations located in the closure lid to permit draining, drying, and helium backfilling of the TSC.

### **Port Cover**

The stainless steel plates covering the vent and drain ports that are welded in place following draining, drying, and backfilling operations.

### **Shield Plate**

An electroless nickel-plated carbon steel disk that is bolted to the bottom of the closure lid of the composite closure lid assembly. The shield plate is installed directly above the fuel basket following fuel loading. The shield plate provides operational shielding during TSC closure.

#### Closure Ring

A stainless steel ring welded to the closure lid and TSC shell to provide a double weld redundant sealing closure of the TSC satisfying 10 CFR 72.236(e) requirements.

#### Fuel Bearing Material (FBM) TSC

TSC that contains FBM.

#### Waste Basket Liner (WBL)

The structure inside the FBM TSC that provides the means to position the FBM inside the FBM TSC .

#### Undamaged Fuel

SNF that can meet all fuel-specific and system-related functions. Undamaged fuel is SNF that is not Damaged Fuel, as defined herein, and does not contain assembly structural defects that adversely affect radiological and/or criticality safety. As such, undamaged fuel may contain:

- a) Breached spent fuel rods (i.e, rods with minor defects up to hairline cracks or pinholes), but cannot contain grossly breached fuel rods;
- b) Grid, grid strap and/or grid spring damage, provided that the unsupported length of the fuel rod does not exceed 60 inches.

### **1.3 General Description of MAGNASTOR**

MAGNASTOR provides for the long-term storage of PWR and BWR fuel assemblies and FBM as listed in Chapter 2. During long-term storage, the system provides an inert environment, passive structural shielding, cooling and criticality control, and a welded confinement boundary. The structural integrity of the system precludes the release of contents in any of the design basis normal conditions and off-normal or accident events, thereby assuring public health and safety during use of the system.

#### **1.3.1 MAGNASTOR Components**

The design and operation of the principal components of MAGNASTOR and the associated auxiliary equipment are described in this section. The design characteristics of the principal components of the system are presented in Table 1.3-1.

This list shows the auxiliary equipment generally needed to use MAGNASTOR.

- automated, remote, and /or manual welding equipment to perform TSC field closure welding operations
- an engine-driven or towed frame or a heavy-haul trailer to move the concrete cask to and from the storage pad and to position the concrete cask on the storage pad
- draining, drying, hydrostatic testing, helium backfill, and water cooling systems for preparing the TSC and contents for storage
- hydrogen monitoring equipment to confirm the absence of explosive or combustible gases during TSC closure welding
- an adapter plate and a hydraulic supply system
- a lifting yoke for lifting and handling the transfer cask and rigging equipment for lifting and handling system components

In addition to these items, the system requires utility services (electric, helium, air, clean borated water, etc.), standard torque wrenches, tools and fittings, and miscellaneous hardware.

##### **1.3.1.1 Transportable Storage Canister (TSC)**

Two lengths of TSCs accommodate all evaluated PWR and BWR fuel assemblies and FBM. The TSC is designed for transport per 10 CFR 71 [3]. The load conditions in transport produce higher stresses in the TSC than are produced during storage conditions, except for TSC lifting. Consequently, transport load conditions establish the design basis for the TSC and, therefore, the TSC design is conservative with respect to storage conditions.

The stainless steel TSC assembly holds the fuel basket structure for PWR and BWR fuel assemblies and confines the contents as shown in Figure 1.3-2. The TSC is defined as the confinement boundary during storage. The welded TSC weldment, closure lid, closure ring, and redundant port covers prevent the release of contents under normal conditions and off-normal or

accident events. The fuel basket assembly provides the structural support and a heat transfer path for the fuel assemblies, while maintaining a subcritical configuration for all of the evaluated normal conditions and off-normal or accident events. For FBM, the waste basket liner (WBL) is the means to lift the FBM and position it inside the TSC during loading operations. FBM is permitted to be loaded loose into the WBL or within other internal structures (dunnage) loaded into the WBL. WBL internal structures such as the segmented tube assembly (STA) or the debris material container (DMC) are handling/placement devices and are not credited within the safety evaluations.

The major components of the TSC assembly are the shell, base plate, closure lid assembly, closure ring, and redundant port covers for the vent and drain ports, which provide the confinement boundary during storage. TSCs are provided in five configurations designated TSC1 through TSC4 and FBM TSC. The design characteristics, overall dimensions and materials of fabrication for the different TSC configurations are provided in Table 1.3-1.

The TSC consists of a cylindrical stainless steel shell with a welded stainless steel bottom plate and a closure lid assembly at its top end. The stainless steel shell and bottom plate are dual-certified Type 304/304L. TSC1 and TSC2 include a 9-inch thick solid stainless steel closure lid assembly. TSC3 and TSC4 include a composite lid assembly consisting of a 4-inch thick stainless steel closure lid and a 5-inch thick carbon steel shield plate that is coated using electroless nickel plating. The FBM TSC includes a 5-inch thick solid stainless steel closure lid assembly. Closure ring alternative designs for all TSC configurations are defined on the applicable drawings. The closure lid, closure rings and port covers are dual certified Type 304/304L stainless steel.

Following loading of FBM into the fuel basket assembly or WBL inside the TSC, the closure lid assembly is lowered into the top end of the TSC and positioned and supported by the TSC lifting lugs. After the closure lid assembly is placed on the TSC, the TSC is moved to a workstation, and the closure lid is welded to the TSC. After nondestructive examination and pressure testing of the closure lid weld, the closure ring is welded to the closure lid and TSC shell. The vent and drain ports are penetrations through the lid, which provide access for auxiliary systems to drain, dry, and backfill the TSC. The drain port has a threaded fitting for installing the drain tube. The drain tube extends the full length of the TSC and ends in a sump in the bottom plate. The vent port also provides access to the TSC cavity for draining, drying, and backfilling operations. Following completion of backfilling, the inner port covers at the vent and drain ports are installed and welded in place. The final surface of the inner port cover weld is visually and nondestructively examined. The inner vent and drain port cover welds are then helium leak tested to verify the absence of helium leakage past the port cover welds. The outer port covers are then installed and welded, and the final weld surfaces are nondestructively examined.

The TSC confinement boundary is designed, fabricated and inspected to the requirements of the ASME Boiler and Pressure Vessel Code (ASME Code), Section III, Division 1, Subsection NB [8], except as noted in the Alternatives to the ASME Code as provided in Table 2.1-2.

Refer to Table 1.3-2 for a summary of the TSC fabrication requirements.

### **1.3.1.2 Fuel Baskets**

TSC1 through TSC4 contain either a PWR or BWR fuel basket, which positions and supports the stored fuel. As described in the following sections, the design of the basket is similar for the PWR and BWR configurations. The fuel basket for each fuel type is designed, fabricated, and inspected to the requirements of the ASME Code, Section III, Division 1, Subsection NG [9], except as noted in Table 2.1-2. The FBM TSC contains a WBL. The WBL is the means to lift the FBM and position it inside the TSC during loading operations. The WBL is designed, fabricated, and inspected to the requirements of the ASME Code, Section III, Division 1, Subsection NF [25], except as noted in Table 2.1-2.

The structural components of both the PWR and BWR baskets are fabricated from ASME SA537, Class 1, carbon steel. To minimize corrosion and preclude significant generation of combustible gases during fuel loading, the assembled basket is coated with electroless nickel plating using an immersion process. Following plating of the structural components, the neutron absorber panels and the stainless steel retainers are installed on the basket structure as shown on the License Drawings. The principal dimensions and materials of fabrication of the fuel basket and PWR damaged fuel cans are provided in Table 1.3-1.

Both fuel basket designs minimize horizontal surfaces that could entrain water and provide an open path for water flow to the drain tube and sump in the bottom of the TSC. The fuel baskets are supported from the TSC bottom plate by 3-in high standoffs at the corner of the fuel tubes enabling the TSC to fill and drain evenly.

Spacers may be used to facilitate the loading of the spent fuel assemblies, or damaged fuel cans, during storage operations.

#### **PWR Fuel Basket**

The PWR fuel basket design is an arrangement of square fuel tubes held in a right-circular cylinder configuration using support weldments that are bolted to the outer fuel tubes. The design parameters for the two lengths of PWR fuel baskets are provided in Table 1.3-1.

Fuel tubes support an enclosed neutron absorber sheet on up to four interior sides of the fuel tube. The neutron absorber panels, in conjunction with minimum TSC cavity water boron levels, provide criticality control in the basket. Each neutron absorber panel is covered by a sheet of stainless steel to protect the material during fuel loading and to keep it in position. The neutron

absorber and stainless steel cover are secured to the fuel tube using weld posts located across the width and along the length of the fuel tube.

Each PWR fuel basket has a capacity of up to 37 undamaged fuel assemblies. Square tubes are assembled in an array where the tubes function as independent fuel positions and as sidewalls for the adjacent fuel positions in what is called a developed cell array. Consequently, the 37 fuel positions are developed using only 21 tubes. The array is surrounded by weldments that serve both as sidewalls for some perimeter fuel positions and as the structural load path from the array to the TSC shell wall. Each PWR basket fuel tube has a nominal 8.86-in square opening. Each developed cell fuel position has a nominal 8.76-in square opening.

The system is also designed to store up to four damaged fuel cans (DFCs) in the DF Basket Assembly. The DF Basket Assembly has a capacity of up to 37 undamaged PWR fuel assemblies, including four DFC locations. DFCs may be placed in up to four of the DFC locations. The arrangement of tubes and fuel positions is the same as in the standard fuel basket, but the design of each of the four corner support weldments is modified with additional structural support to provide an enlarged position for a damaged fuel can at the outermost corners of the fuel basket. Each damaged fuel can location has a nominal 9.80-in square opening. A damaged fuel can or an undamaged fuel assembly may be loaded in a damaged fuel can corner location.

### **BWR Fuel Basket**

The BWR fuel basket design is an arrangement of square fuel tubes held in a right-circular cylinder configuration using support weldments that are bolted to the outer fuel tubes. The design parameters for the two lengths of BWR fuel baskets are provided in Table 1.3-1.

Each fuel tube supports an enclosed neutron absorber sheet on up to four interior sides of the fuel tube, which provides criticality control in the basket. The neutron absorber is covered by a sheet of stainless steel to protect the material during fuel loading and to keep it in position. The neutron absorber and stainless steel cover are secured to the fuel tube using weld posts located across the width and along the length of the fuel tube.

Each BWR fuel basket has a capacity of 87 fuel assemblies in an aligned configuration. Square tubes are assembled in an array where the tubes function as independent fuel positions and as sidewalls for the adjacent fuel positions in what is called a developed cell array. Consequently, the 87 fuel positions are developed using only 45 tubes. The array is surrounded by weldments that serve both as sidewalls for some perimeter fuel positions and as the structural load path from the array to the TSC shell wall. Each BWR basket fuel tube has a nominal 5.86-in square opening. Each developed cell fuel position has a nominal 5.77-in square opening.

## **2.4            Safety Protection Systems**

MAGNASTOR relies upon passive systems to ensure the protection of public health and safety, except in the case of fire or explosion. As discussed in Sections 2.4.8 and 2.4.9, fire and explosion events are effectively precluded by site administrative controls that prevent the introduction of flammable and explosive materials. The use of passive systems provides protection from mechanical or equipment failure.

### **2.4.1            General**

MAGNASTOR is designed for safe, long-term storage of spent fuel and FBM. The system will withstand all of the evaluated normal conditions and off-normal and postulated accident events without release of radioactive material or excessive radiation exposure to workers or the general public. The major design considerations to assure safe, long-term fuel storage and retrievability for ultimate disposal by the Department of Energy in accordance with the requirements of 10 CFR 72 and ISG-2 [24] are as follows.

- Continued radioactive material confinement in postulated accidents.
- Thick steel and concrete biological shield.
- Passive systems that ensure reliability.
- For TSCs containing Spent Fuel, pressurized inert helium atmosphere to provide corrosion protection for fuel cladding and enhanced heat transfer for the stored fuel. Heat transfer media within the FBM TSC is provided by helium backfill (1 atm). Helium backfill will assure removal of oxygen. FBM does not require cladding protection as cladding has already failed.

Retrievability is defined as: “maintaining spent fuel or FBM in substantially the same physical condition as it was when originally loaded into the storage cask, which enables any future transportation, unloading and ultimate disposal activities to be performed using the same general type of equipment and procedures as were used for the initial loading.”

Each major component of the system is classified with respect to its function and corresponding potential effect on public safety. In accordance with Regulatory Guide 7.10 [19], each major system component is assigned a safety classification (see Table 2.4-1). The safety classification is based on review of the component’s function and the assessment of the consequences of its failure following the guidelines of NUREG/CR-6407 [20]. The safety classification categories are defined in the following list.

Category A - Components critical to safe operations whose failure or malfunction could directly result in conditions adverse to safe operations, integrity of spent fuel, or public health and safety.

Category B - Components with major impact on safe operations whose failure or malfunction could indirectly result in conditions adverse to safe operations, integrity of spent fuel, or public health and safety.

Category C - Components whose failure would not significantly reduce the packaging effectiveness and would not likely result in conditions adverse to safe operations, integrity of spent fuel, or public health and safety.

As discussed in the following sections, the MAGNASTOR design incorporates features addressing the design considerations described previously to assure safe operation during loading, handling, and storage of spent nuclear fuel and FBM.

#### **2.4.2 Confinement Barriers and Systems**

The radioactive materials that MAGNASTOR must confine during storage originate from the stored fuel assemblies, FBM and residual contamination inside the TSC. The system is designed to safely confine this radioactive material under all storage conditions.

The stainless steel TSC is assembled and closed by welding. All of the field-installed welds are liquid penetrant examined as detailed in Chapter 10 and on the License Drawings. The longitudinal and girth shop welds of the TSC shell are full penetration welds that are radiographically and liquid penetrant examined during fabrication. The TSC bottom-plate-to-shell shop weld joint is ultrasonically and liquid penetrant examined during fabrication.

The TSC vessel provides a leaktight boundary precluding the release of solid, volatile, and gaseous radioactive material. There are no evaluated normal conditions or off-normal or accident events that result in damage to the TSC producing a breach in the confinement boundary. Neither normal conditions of operation or off-normal events preclude retrieval of the TSC for transport and ultimate disposal. The TSC is designed to withstand accident conditions, including a 24-inch end drop in the concrete cask and a tip-over of the concrete cask, without precluding the subsequent removal of the fuel (i.e., the fuel tubes do not deform such that they bind the fuel assemblies).

Operator radiation exposure during handling and closure of the TSC is minimized by the following.

- Minimizing the number of operations required to complete the TSC loading and sealing process.
- Placing the closure lid on the TSC while the transfer cask and TSC are under water in the fuel pool.
- Using temporary shielding, including a weld shield plate as the mounting component of the weld machine.
- Using the retaining blocks or bolted retaining ring on the transfer cask to ensure that the TSC is not raised out of the transfer cask.

reactor fuel in a cask. To achieve accurate results, three-dimensional models, as close to the actual experiment as possible, are used to evaluate the experiments.

#### **2.4.7 Radiological Protection**

MAGNASTOR is designed to minimize operator radiological exposure in keeping with the As Low As Reasonably Achievable (ALARA) philosophy.

##### **2.4.7.1 Access Control**

Access to MAGNASTOR at an ISFSI site will be controlled by a fence with lockable truck and personnel access gates to meet the requirements of 10 CFR 72, 10 CFR 73, and 10 CFR 20 [21]. Access to the storage area, and its designation as to the level of radiation protection required, will be established by site procedures by the licensee.

##### **2.4.7.2 Shielding**

MAGNASTOR is designed to limit the dose rates in accordance with 10 CFR 72.104 and 72.106, which set whole body dose limits for an individual located beyond the controlled area at  $\leq 25$  mrem per year (whole body) during normal operations and  $\leq 5$  rem (5,000 mrem) from any design basis accident. Burnup profile shape should be considered during ALARA and site boundary planning by the system licensee, as it may affect system dose rate profiles.

##### **2.4.7.3 Ventilation Off-Gas**

MAGNASTOR is passively cooled by radiation and natural convection heat transfer at the outer surface of the concrete cask and in the TSC-concrete cask annulus. In the TSC-concrete cask annulus, air enters the air inlets, flows up between the TSC and concrete cask liner in the annulus, and exits the air outlets. If the exterior surface of the TSC is excessively contaminated, the possibility exists that contamination could be carried aloft by the airflow. Therefore, during fuel loading, the spent fuel pool water is minimized in the transfer cask/TSC annulus by supplying the annulus with clean or demineralized spent fuel pool water. Water is supplied into the annulus while the transfer cask is submerged. The use of the annulus system minimizes the potential for contamination of the exterior surfaces of the TSC.

After the transfer cask is removed from the pool, removable contamination levels on the TSC exterior are determined. If TSC decontamination is required, clean water can be used to flush the annulus. To facilitate decontamination, the TSC exterior surfaces are smooth.

MAGNASTOR has no radioactive releases during normal conditions or off-normal or accident events of storage. Hence, there are no off-gas system requirements for MAGNASTOR.

#### **2.4.7.4      Radiological Alarm Systems**

No radiological alarms are required on MAGNASTOR. Typically, total radiation exposure due to the ISFSI installation is monitored by the use of the licensee's boundary dose monitoring program.

#### **2.4.8      Fire Protection**

A major ISFSI fire is not considered credible, since there is very little material near the concrete casks that could contribute to a fire. The concrete cask is largely impervious to incidental thermal events. Administrative controls will be established by the licensee to ensure that the presence of combustibles at the ISFSI is minimized. A hypothetical 1,475°F fire occurring at the base of the cask for eight minutes is evaluated as an accident condition.

#### **2.4.9      Explosion Protection**

MAGNASTOR is analyzed to ensure its proper function under an over-pressure event. The TSC is protected from direct over-pressure conditions by the concrete cask. For the same reasons as for the fire condition, a severe explosion on an ISFSI site is not considered credible. The evaluated 20 psig over-pressure condition is considered to bound any explosive over-pressure resulting from an industrial explosion at the boundary of the owner-controlled area.

#### **2.4.10      Auxiliary Structures**

The loading, welding, vacuum drying, cooling, helium backfill, transfer, and transport of MAGNASTOR require the use of auxiliary equipment as described in Chapter 9. External transfer of a TSC may require the use of a structure, referred to as a "TSC Handling and Transfer Facility." The TSC Handling and Transfer Facility is a specially designed and engineered structure independent of the 10 CFR 50 facilities at the site.

The design of the TSC Handling and Transfer Facility would meet the requirements for MAGNASTOR described in the Design Features presented in Appendix A of the Technical Specifications, in addition to those requirements established by the licensee.

The design, analysis, fabrication, operation, and maintenance of the TSC Handling and Transfer Facility would be performed in accordance with the quality assurance program requirements of the licensee. The components of the TSC Handling and Transfer Facility would be classified as Important-to-Safety or Not-Important-to-Safety in accordance with the guidelines of NUREG-6407.

**Table 2.4-1 Safety Classification of MAGNASTOR Components**

<b>Component Description</b>	<b>Reference Drawings</b>	<b>Safety Function</b>	<b>Safety Classification</b>
TSC Assembly Shell and Base Plate Closure Lid Closure Ring Port Covers	71160-581 71160-584 71160-585	Structural and Confinement	A
FBM TSC Assembly Shell and Base Plate Closure Lid Closure Ring Port Covers	71160-L281 71160-L278 71160-L285	Structural and Confinement	A
Fuel Basket Assembly Basket Support Weldments Fuel Tube Assemblies Neutron Absorbers Damaged Fuel Cans	71160-551    71160-571 71160-572    71160-574 71160-575    71160-591 71160-598    71160-599 71160-600    71160-601 71160-602    71160-671 71160-673    71160-674 71160-675    71160-681 71160-684    71160-685	Criticality, Structural and Thermal	A
Transfer Cask Assembly Trunnions Inner and Outer Shells Shield Doors and Rails Lead Gamma Shield Solid Neutron Shield	71160-560 71160-556 71160-656 71160-657	Structural, Shielding and Operations	B
Passive Transfer Cask Assembly Trunnions Inner and Outer Shells Shield Doors and Rails Lead Gamma Shield Water Neutron Shield	71160-656 71160-657	Structural, Shielding, Thermal and Operations	B
Adapter Plate Assembly Base Plate Door Rails Hydraulic Operating System Side Shields	None	Operations and Shielding	NQ

**Table 2.4-1 Safety Classification of MAGNASTOR Components (continued)**

<b>Component Description</b>	<b>Reference Drawings</b>	<b>Safety Function</b>	<b>Safety Classification</b>
Concrete Cask Assembly Structural Weldments and Base Plate Lid Weldment Lifting Lugs Reinforcing Bars Concrete	71160-561 71160-562 71160-590	Structural, Shielding, Operations and Thermal	B
Debris Material Container Assembly	71160-L201	Note <sup>(1)</sup>	NQ
Segmented Tube Assembly	71160-L205	Note <sup>(1)</sup>	NQ
FBM Waste Basket Liner	71160-L211	Shielding <sup>(2)</sup>	B

Note 1: These items have non-structural functions and are not credited in the safety analysis.

Note 2: Lifting of the FBM Waste Basket Liner (WBL) is a non-safety related lift performed underwater. It is not structurally credited in the safety analysis; however, the WBL lift lugs are conservatively evaluated to the requirements of ANSI N-14.6 and NUREG-0612 for critical lift criteria. The thermal modeling does include the WBL in a conservative manner to report the WBL maximum temperature.

#### **4.12            Thermal Evaluation for MAGNASTOR System for Loading of Fuel Bearing Material**

This section presents the thermal analysis of the MAGNASTOR system for loading of Fuel Bearing Material (FBM) for normal, off-normal and accident conditions of storage. As described in Chapter 1, the FBM is stored in the FBM TSC with a design basis heat load of 139 Watts. Also identified in Chapter 1, FBM is permitted to be loaded loose into the WBL or within other internal structures (dunnage) loaded into the WBL. While the WBL is considered in the thermal modelling, the WBL internal structures such as the segmented tube assembly (STA) or the debris material container (DMC) are handling/placement devices and are considered to be dunnage and are not credited within the safety evaluations. These components neither generate any heat nor have temperature allowables. The FBM TSC will be helium backfilled at a nominal pressure of 1 atmosphere. However, the backfill gas in the FBM TSC thermal models is conservatively considered to be nitrogen as discussed in the following sections. The FBM TSC is placed in the CC6 concrete cask for long term storage. For the transfer operation, the stainless steel transfer cask, MTC2, is used. The thermal evaluations for all the conditions show that this MAGNASTOR system meets the thermal performance requirements of 10 CFR 72 and NUREG-2215.



#### **4.12.1 Thermal Models for the MAGNASTOR System for Loading of FBM**

The thermal evaluation for the MAGNASTOR system for loading of Fuel Bearing Material (FBM) uses two-dimensional axisymmetric models. Section 4.12.1.1 describes a two-dimensional axisymmetric model for the concrete cask and the loaded FBM TSC. The model is used to perform steady state ANSYS analyses for the normal, off-normal and accident conditions of storage. Section 4.12.1.2 presents the two-dimensional axisymmetric models for the FBM TSC transfer operation using a transfer cask.

##### **4.12.1.1 Two-Dimensional Axisymmetric Concrete Cask and TSC Model**

This section describes the two-dimensional axisymmetric finite element model used to evaluate the thermal performance of the concrete cask and the loaded FBM TSC. The model includes the following:

- Concrete cask, liner and pedestal top
- Air in the annulus
- FBM TSC shell, lid and bottom plate
- Equivalent region for the FBM (and dunnage) inside the TSC
- WBL is modeled as a part of the medium inside the TSC (nitrogen)
- Nitrogen between the FBM region and the TSC Shell

The model is shown in Figures 4.12-1. The modeling of the major components is discussed below.

##### **Modeling of Concrete Cask**

The concrete cask portion in the two-dimensional axisymmetric concrete cask and TSC model includes the concrete region, steel liner and the top plate of the pedestal. The annulus between the TSC and the cask liner is conservatively modeled as air without flow. The stand-offs are not modeled since they have an insignificant effect on the thermal performance of the system due to the low system heat load.

The top and the bottom of the model are conservatively modeled as adiabatic. The following boundary conditions are applied to the outer surface of the concrete cask side surface:

- Solar insolation on the outer side surface of the concrete cask
- Natural convection heat transfer at the outer side surface of the concrete cask
- Radiation heat transfer at the outer side surface of the concrete cask

## **Modeling of TSC**

As shown in Figure 4.12-1, the content of the FBM TSC includes an equivalent region for the FBM (and dunnage), WBL (conservatively modeled as nitrogen), and a nitrogen region between the FBM and TSC shell. The diameter of the equivalent region is determined using the maximum weight of FBM. The FBM region is modeled as stainless steel. No radiation or convection are considered inside the TSC. Radiation is considered between the TSC shell outer surface and the cask steel liner.

ANSYS PLANE55 and SURF151 elements are used in the model. While the design basis heat load is 139 Watts, a heat load of 500 Watts is conservatively used and is applied to the FBM region of the model by a uniform heat generation. A film coefficient corresponding to vertical plates is used for the outside of the cask side surface. The emissivity and view factor for concrete surface as described in Section 4.4.1.1 are used in the model.

The two-dimensional axisymmetric model described in this Section is used to perform steady state analyses for the normal, off-normal (severe heat and severe cold) and accident (extreme heat) conditions as described in Table 4.1-1. The half inlet blocked condition is bounded by the normal condition since no flow is considered in the annulus air in the model. The ambient temperatures and solar insolation conditions listed in Table 4.1-1 are applied accordingly.

### **4.12.1.2 Two-Dimensional Axisymmetric Transfer Cask and TSC Model**

This section describes the two-dimensional axisymmetric finite element models used to evaluate the thermal performance of the transfer cask containing the loaded FBM TSC. The model includes the following:

- Transfer cask
- Air or water in the annulus between TSC and transfer cask
- FBM TSC shell, lid and bottom plate
- Equivalent region for the FBM (and dunnage) inside the TSC
- WBL is modeled as a part of the medium inside the TSC (nitrogen or water)
- Nitrogen or water between the FBM region and the TSC Shell

The model is shown in Figures 4.12-2. The modeling of the major components is discussed below.

## **Modeling of Transfer Cask**

The transfer cask portion in the two-dimensional axisymmetric transfer cask and TSC model includes the transfer cask inner shell, lead, neutron shield, outer shell, bottom forging, top

forging, and the door. Two cases are considered for the annulus between the TSC and the transfer cask: one with air and the other with water. No flow is considered for the air or water in the annulus.

The top and the bottom of the model are conservatively modeled as adiabatic. The following boundary conditions are applied to the outer side surface of the transfer cask:

- Natural convection heat transfer at the outer surface of the TFR side
- Radiation heat transfer at the TFR side outer surface.

### **Modeling of TSC**

The modeling of the loaded TSC for the transfer cask model is identical to the TSC in the model described in Section 4.12.1.1.

ANSYS PLANE55 elements are used in the model. No radiation and convection are considered inside the TSC. A heat load of 500 Watts is conservatively applied to the FBM region of the model. The same film coefficient as used in the two-dimensional axisymmetric model in Section 4.12.1.1 is applied to the transfer cask side surface.

The two-dimensional axisymmetric models described in this Section are used to perform steady state analyses for the transfer conditions. The ambient temperature is 100°F for the model for both water and air cases.



#### **4.12.2 Normal Condition of Storage**

This section evaluates thermal performance of the MAGNASTOR system for loading of FBM for normal condition of storage and the transfer conditions. The two-dimensional axisymmetric ANSYS model for concrete cask and TSC is described in Section 4.12.1.1 and is used to perform steady state analyses for storage conditions. The analysis results for normal condition are discussed in Section 4.12.2.1. The two-dimensional axisymmetric ANSYS model for transfer cask and TSC presented in Section 4.12.1.2 is used for the evaluation for transfer conditions. The results for transfer conditions are presented in Section 4.12.2.2.

##### **4.12.2.1 Maximum temperatures for Normal Conditions**

Table 4.12-1 shows maximum temperatures of TSC and concrete for normal conditions of storage. Note that, these temperature results are conservative since the analysis was performed using a conservative heat load of 500 W, while the design basis heat load is 139 W. The average nitrogen temperature is 242°F for normal condition.

##### **4.12.2.2 Maximum Temperatures for Transfer Condition**

The maximum component temperatures during the transfer operations are reported in this Section. The transfer operation is comprised of three phases: water phase, vacuum drying phase, and transfer phase. No cooling/helium phase is needed due to the low temperatures. For the water phase and vacuum phase, a steady state analysis is performed considering water in the annulus, with water and nitrogen inside the TSC, respectively. For the transfer phase, steady state analysis is performed considering air in the annulus with nitrogen inside the TSC. The maximum component temperatures for water/vacuum phases (water in annulus) and the transfer phase (air in annulus) presented in Table 4.12-2. The acceptable temperature results from these steady state analyses indicate that no time limit is required for any phase (water, vacuum and transfer) of the transfer operation.

##### **4.12.2.3 Maximum Internal Pressure**

The FBM TSC will be helium backfilled at a nominal 1 atmosphere. As previously stated, the backfill gas is conservatively modeled as nitrogen in the thermal models. As average gas temperatures in the system are below 300°F under all operating conditions the maximum operating pressure (assuming a conservative room temperature gas backfill) will be under 2 atmosphere per ideal gas law. No significant quantities of releasable fission gases are remaining within the fuel material as a result of the high temperature reactor accident conditions. There is therefore no increase in system pressure associated with the release of fission gases. Limited

gas generation may occur as a result of foreign material and/or filter material loading. As gas generating media is limited to assuring a maximum 4% hydrogen within the TSC cavity (flammability/explosive limit), no significant additional pressure is expected from such materials. Therefore, the internal pressure in the FBM TSC for all storage conditions is significantly lower than the internal pressure for the normal condition of the MAGNASTOR system loaded with fuel assemblies (104 psig as shown in Section 4.4.4).

**4.12.3 Off-Normal Events**

**4.12.3.1 Off-Normal Storage Events**

This section evaluates postulated off-normal storage conditions. The off-normal storage events include severe ambient temperature (106°F and -40°F) and half inlets blocked conditions. The evaluation of the off-normal events for variations in the ambient temperature only evaluation requires a change to the boundary condition temperature. The analysis results for half inlet block condition are bounded by the analysis results for normal condition (Section 4.12.2.1) since the evaluation for normal condition considers air with no flow in the annulus, which essentially represents the All Inlets Blocked condition. The temperatures of different components for off-normal storage conditions are shown below.

<b>Component</b>	<b>106°F Ambient, Maximum Temperatures (°F)</b>	<b>-40°F Ambient, Maximum Temperatures (°F)</b>	<b>76°F Ambient/Half Blocked Air Inlets Temperatures (°F)*</b>	<b>Allowable Temperature (°F)</b>
TSC Shell	244	101	220	800
WBL**	267	115	242	800
Concrete	184	-4	155	350

\* The Normal conditions evaluated assumed a 100% vent blocked condition which bounds the half vent blocked condition.

\*\* The temperature shown is the average nitrogen temperature which bounds the maximum WBL temperature.

The maximum average nitrogen temperature is 267°F for all off-normal conditions. As discussed in Section 4.12.2.3, the maximum TSC internal pressure for off-normal events for the FBM TSC is significantly bounded by the internal pressure for the normal condition of the MAGNASTOR system loaded with fuel assemblies (104 psig as shown in Section 4.4.4).



#### 4.12.4 Accident Events

This section presents the evaluations of the thermal accident design events, which address very low probability events that might occur once during the lifetime of the ISFSI or hypothetical events that are postulated because their consequences may result in the maximum potential impact on the surrounding environment. Three thermal accident events are evaluated in this section: maximum anticipated heat load, fire accident and full blockage of the air inlets.

##### 4.12.4.1 Maximum Anticipated Temperatures

This section evaluates the concrete cask and the TSC for the postulated event of an ambient temperature of 133°F. A steady state condition is considered in the thermal evaluation of the system for this accident event. The two-dimensional concrete cask and TSC model described in Section 4.12.1.1 is used for this evaluation. The analysis is performed using a bounding heat load of 500 W. The maximum temperatures of the different components of the system are shown in the following table. The average nitrogen temperature in the FBM TSC is 289°F.

Component	Maximum Temperatures (°F)	Allowable Temperature (°F)
TSC Shell	265	800
WBL*	289	800
Concrete	210	350

\* The temperature shown is the average nitrogen temperature which bounds the maximum WBL temperature

##### 4.12.4.2 Fire Accident

The evaluation of the hypothetical fire accident for MAGNASTOR system is described in Section 4.6.2. The transient analysis presented in Section 4.6.2 for the concrete cask for the PWR system is for the design basis heat load of 35.5 kW, which significantly bounds the design basis heat of 139 W for the MAGNASTOR system containing FBM TSC. Therefore, the analysis results in Section 4.6.2 are applicable to the MAGNASTOR system with FBM.

##### 4.12.4.3 Full Blockage of Concrete Cask Air Inlets

This section evaluates the concrete cask for the transient condition of full blockage of all the air inlets at the normal storage condition temperature (76°F). Since the evaluation of normal condition of storage (Section 4.12.2) uses the two-dimensional concrete cask and TSC model

(Section 4.12.1.1) with no air flow in the annulus, the steady state analysis results for normal condition are applicable for the all inlets blocked condition. The maximum concrete temperature and average nitrogen temperature in TSC are 155°F and 242°F, respectively. Since the component temperatures for a steady state analysis are well below temperature limits, there is no time limit for cleaning the air inlets for this full blockage event.

#### **4.12.4.4      Maximum TSC Internal Pressure for Accident Events**

The maximum average nitrogen temperature is 289°F for the accident events based on the evaluations in Sections 4.12.4.1 through 4.12.4.3. As discussed in Section 4.12.2.3, the maximum TSC internal pressure for the accident events for the FBM TSC is significantly bounded by the internal pressure for the normal condition of the MAGNASTOR system loaded with fuel assemblies (104 psig as shown in Section 4.4.4).

Figure 4.12-1 Two-Dimensional Axisymmetric Concrete Cask and TSC Model

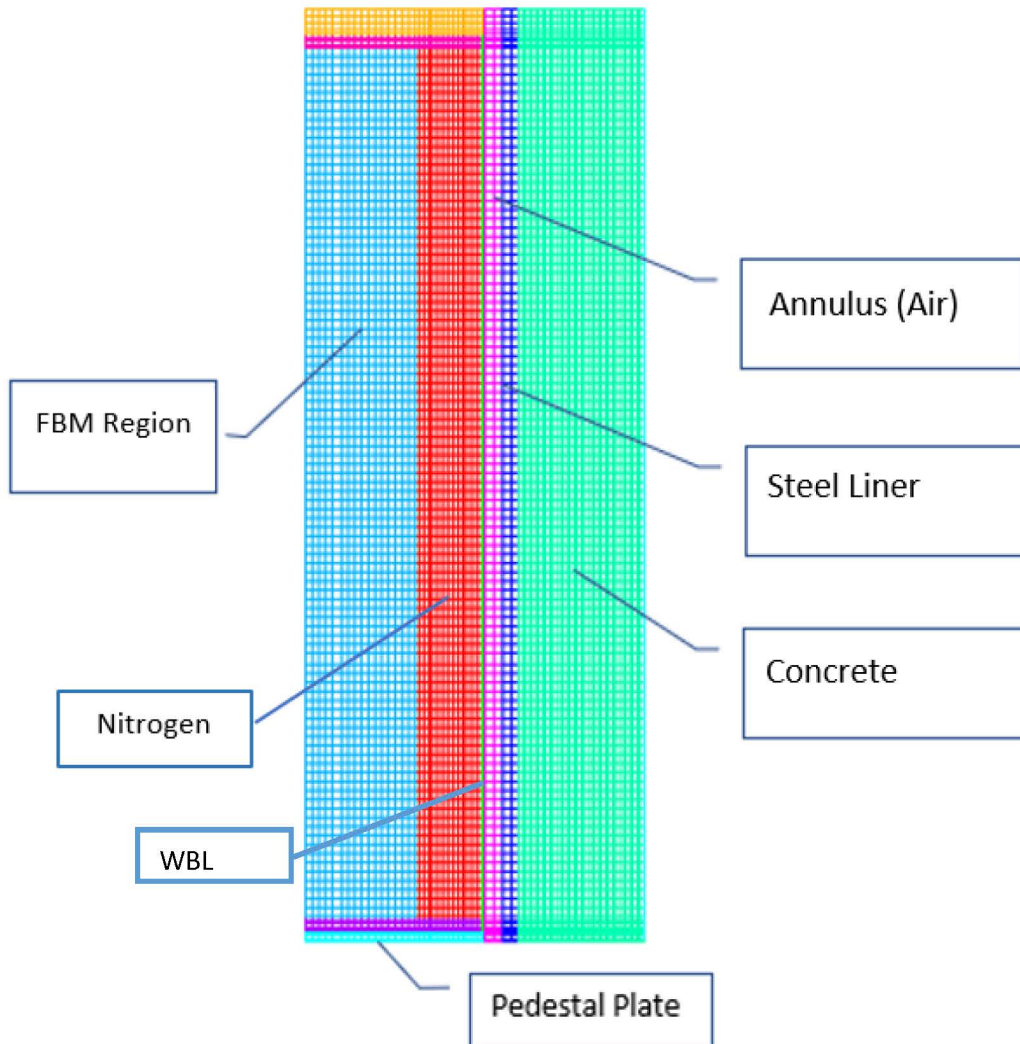
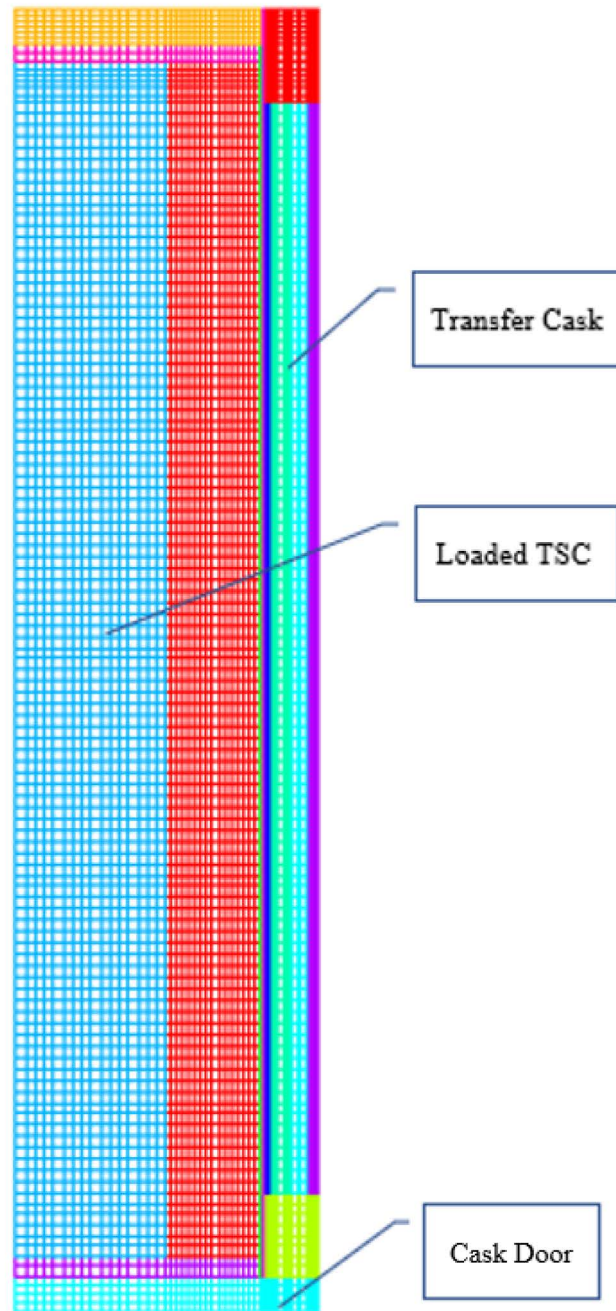


Figure 4.12-2 Two-Dimensional Axisymmetric Transfer Cask and TSC Model



**Table 4.12-1 Maximum Component Temperatures for Normal Condition of Storage**

		Maximum Temperatures (°F)	Allowable Temperature (°F)
TSC Shell		220	800
WBL*		242	800
Concrete	local	155	300
	bulk	137	200

\* The temperature shown is the average nitrogen temperature which bounds the maximum WBL temperature

**Table 4.12-2 Maximum Temperatures for Transfer Conditions**

	Water Phases	Vacuum Phases	Transfer Phase
Maximum Temperature of TSC Shell (°F)	114	131	133
Maximum Temperature of Neutron Shield (°F)	112	120	120
Average Media (Water or Nitrogen) Temperature inside TSC (°F)*	122	176	179

\* The temperature shown bounds the maximum WBL temperature



The minimum as-manufactured loading of the neutron absorber sheets depends on the effectiveness of the absorber and the minimum effective absorber areal density. Effectiveness of the absorber is influenced by the uniformity and quantity of the  $^{10}\text{B}$  nuclide within the absorber base material. Table 6.1.1-5 translates the effective absorber content to absorber materials at 75% and 90% credit.

MCNP, a three-dimensional Monte Carlo code, is used in the system criticality analysis. Evaluations are primarily based on the ENDF/B-VI continuous energy neutron cross-section library [4] available in the MCNP distribution. Nuclides for which no ENDF/B-VI data is available are set to the latest cross-section sets available in the code distribution. The code and cross-section libraries are benchmarked by comparison to a range of critical experiments relevant to light water reactor fuel in storage and transport casks. An upper subcritical limit (USL) for the system is determined based on guidance given in NUREG/CR-6361 [10].

Key assembly physical characteristics, maximum initial enrichment, and soluble boron requirements (PWR only) for each PWR and BWR fuel assembly type are shown in Table 6.1.1-1, Table 6.1.1-2 and Table 6.1.1-6 for the PWR system and Table 6.1.1-3 and Table 6.1.1-4 for the BWR system. PWR results represent the bounding values for fuel assemblies with and without nonfuel inserts in the guide tubes. Maximum enrichment is defined as peak rod enrichment for PWR assemblies and the maximum peak planar-average enrichment for BWR assemblies. The maximum initial peak planar-average enrichment is the maximum planar-average enrichment at any height along the axis of the fuel assembly.

Assemblies are evaluated with a full, nominal set of fuel rods. Fuel rod (lattice) locations may contain filler rods. A filler rod must occupy, at a minimum, a volume equivalent to the fuel rod it displaces. Filler rods may be placed into the lattice after assembly in-core use or be designed to replace fuel rods prior to use, such as integral burnable absorber rods.

The assembly must contain its nominal set of guide and instrument tubes (PWR), and water rods (BWR). Analysis demonstrated that variations in the guide/instrument tube and water rod thickness and diameter have no significant effect on system reactivity.

#### FBM TSC System

The TSC is comprised of a stainless steel canister and a Waste Basket Liner (WBL) within which FBM is loaded. A transfer cask is used for handling the TSC during loading of FBM. Once loaded, the TSC closure lid is welded and the TSC is drained, dried, and backfilled with helium. The transfer cask is then used to move the TSC into or out of the concrete cask. The transfer cask provides shielding during the TSC loading and transfer operations.

Under normal conditions, such as loading in a moderated (water) environment, water is present in the TSC during the initial stages of FBM transfer. During draining and drying operations, moderator with varying density is present. Thus, the criticality evaluation of the transfer cask includes a variation in moderator density and a determination of optimum moderator density.

Structural analyses demonstrate that the TSC confinement boundary remains intact through all storage operating conditions. Therefore, moderator is not present in the TSC while it is in the concrete cask. However, access to the concrete cask interior environment is possible via the air inlets and outlets and the heat transfer annulus between the TSC and the cask steel liner. This access provides paths for moderator intrusion during a flood. Under off-normal and accident conditions, moderator intrusion into the convective heat transfer annulus is evaluated.

FBM TSC criticality control is achieved through a combination of absorbers present within the FBM and limitations of the mass of fissile material within a TSC. No geometry controls are credited.

MCNP, a three-dimensional Monte Carlo code, is used in the system criticality analysis. Evaluations are primarily based on the ENDF/B-VI continuous energy neutron cross-section library [4] available in the MCNP distribution. Nuclides for which no ENDF/B-VI data is available are set to the latest cross-section sets available in the code distribution. The code and cross-section libraries are benchmarked by comparison to a range of critical experiments relevant to light water reactor fuel in storage and transport casks. An upper subcritical limit (USL) for the system is determined based on guidance given in NUREG/CR-6361 [10].

Analysis model details, including material descriptions applied to the FBM, and results of the FBM evaluations are presented in Section 6.8.

#### **6.1.1.1 Spent Fuel System - Undamaged Fuel Criticality Results**

The maximum multiplication factors ( $k_{\text{eff}} + 2\sigma$ ) are calculated, using conservative assumptions, for the transfer and concrete cask. The USL applied to the analysis results is 0.9376 per Section 6.5.2. The results of the analyses are presented in detail in Sections 6.4.3 and 6.7, and are summarized as follows.

## **7**            **CONFINEMENT**

The MAGNASTOR<sup>®</sup> TSC provides confinement for its radioactive contents in long-term storage. The confinement boundary provided by the TSC is closed by welding, creating a solid barrier to the release of contents in the design basis normal conditions and off-normal or accident events. The welds are visually inspected and nondestructively examined to verify integrity.

The sealed TSC contains a pressurized inert gas, helium when storing spent fuel and when storing FBM. The confinement boundary retains the helium and also prevents the entry of outside air into the TSC in long-term storage. The exclusion of air precludes fuel rod cladding oxidation failures during storage.

The TSC confinement system meets the requirements of 10 CFR 72.24 [1] for protection of the public from release of radioactive material. The design of the TSC allows the recovery of stored spent fuel, including FBM, should it become necessary per the requirements of 10 CFR 72.122. The TSC meets the requirements of 10 CFR 72.122 (h) for protection of the spent fuel contents in long-term storage such that future handling of the contents would not pose an operational safety concern.

The MAGNASTOR TSC provides an austenitic stainless steel closure design sealed by welding, precluding the need for continuous monitoring. The analysis for normal conditions and off-normal or accident events shows that the integrity of the confinement boundary is maintained in all of the evaluated conditions. Consequently, there is no release of radionuclides from the TSC resulting in site boundary doses in excess of regulatory requirements. Therefore, the confinement design of MAGNASTOR meets the regulatory requirements of 10 CFR 72 and the acceptance criteria defined in NUREG-1536 [2].



## **7.1 Confinement Boundary**

The welded TSC is the confinement vessel for the PWR or BWR spent fuel assembly or FBM contents.

The confinement boundary of the TSC consists of the TSC shell, bottom plate, closure lid, inner vent and drain port covers, and the welds that join these components. The redundant closure of the TSC confinement boundary consists of the closure ring, the outer vent and drain port covers, and the welds that join these components to the TSC shell and closure lid. The confinement boundary is shown in Figure 7.1-1. The confinement boundary does not incorporate bolted closures or mechanical seals. The confinement boundary welds are described in Table 7.1-1.

### **7.1.1 Confinement Vessel**

The TSC consists of three principal components: the TSC shell, bottom plate, and closure lid assembly. The TSC shell is a right circular cylinder constructed of rolled Type 304/304L (dual certified) stainless steel plate with the edges of the plate joined by full penetration welds. It is closed at the bottom end by a circular plate joined to the shell by a full penetration weld. The TSC has two lengths to accommodate different fuel lengths. The TSC shell, the composite closure lid, and FBM TSC lid stainless steel plate are helium leak tested to leak tight criteria per ANSI N14.5-1997 following fabrication, as described in the Acceptance Test Program of Chapter 10.

After loading, the TSC is closed at the top by a closure lid assembly fabricated from 9-inch thick Type 304 stainless steel (for TSC1 and TSC2), or a composite lid assembly consisting of a 4-inch thick stainless steel plate and a bolted 5-inch thick carbon steel shield plate, or a 5-inch thick stainless steel plate for the FBM TSC. The closure lid assembly is joined to the TSC shell using a field-installed groove weld. The closure lid-to-TSC shell weld is analyzed, installed, and examined in accordance with ISG-15 [6] guidance. This closure lid-to-TSC shell weld is a partial penetration weld progressively examined at the root, midplane, and final surface by liquid penetrant (PT) examination.

For spent fuel assembly containing TSCs following NDE of the closure lid-to-TSC shell weld, the TSC cavity is reflooded and the TSC vessel and closure lid assembly are hydrostatically pressure tested as described in the Operating Procedures of Chapter 9 and the Acceptance Test Program of Chapter 10. The acceptance criteria for the test is no leakage from the closure lid to shell weld during the minimum 10-minute test duration.

The Type 304 stainless steel closure ring is installed in the TSC-to-closure lid weld groove, and welded to both the closure lid and the TSC shell. The closure ring welds are inspected by PT

examination of the final weld surfaces. The closure ring provides the double weld redundant sealing of the confinement boundary, as required by 10 CFR 72.236(e). At the option of the user, the closure ring installation and welding can be completed later in the TSC preparation process following final helium (spent fuel assemblies or FBM) back fill operations.

The closure lid assembly incorporates drain and vent penetrations, which provide access to the TSC cavity for canister draining, drying and helium backfilling operations during TSC closure and preparation for placement into storage. The design of the penetrations incorporates features to provide adequate shielding for the operators during these operations and closure welding.

Following final helium backfill and pressurization, the vent and drain port penetrations are closed with Type 304 stainless steel inner port covers that are partial-penetration welded in place. Each inner port cover weld is tested for helium leakage past the port cover to closure lid weld. Each inner port cover weld final surface is then PT examined. A second (outer) port cover is then installed and welded to the closure lid at each of the ports to provide the double weld redundant sealing of the confinement boundary. The outer port cover weld final surfaces are inspected by PT examination.

Prior to sealing, for TSCs containing spent fuel assemblies, the TSC cavity is backfilled and pressurized with helium. The minimum helium purity level of 99.995% (minimum) specified in the Operating Procedures maintains the quantity of oxidizing contaminants to less than one mole per canister for all loading conditions. Based on the maximum empty canister free volume of 10,400 liters and the design basis helium density (Section 4.4.4), an empty canister would contain approximately 2,000 moles of gases. Conservatively, assuming that all of the impurities in the helium are oxidants, a maximum of 0.1 moles of oxidants could exist in the largest canister during storage. By limiting the amount of oxidants to less than one mole, the recommended limits for preventing cladding degradation found in the PNL-6365 [4] are satisfied. A TSC containing FBM does not require clad protection as fuel failure already occurred prior to storage. Helium backfill is used for the 1 atmosphere (absolute) backfill of the FBM TSC.

For loading of spent fuel assemblies, the thermal analysis of the loaded TSC is based, in part, on heat transfer from the fuel to the TSC shell by convection within the TSC. The provision of a specific density of high-purity helium, which ensures the establishment of internal convection in the TSC, also ensures that a positive pressure exists within the TSC during the design life of the system. The maintenance of a positive helium pressure eliminates any potential for in-leakage of air into the TSC cavity during storage operations. For the FBM TSC, only conduction through the helium backfill gas is credited (no convection).

The closure lid assembly to TSC shell weld completed in the field is not helium leakage tested. Interim Staff Guidance (ISG)-18 [5] provides that an adequate confinement boundary is established for stainless steel spent fuel storage canisters that are closed using a closure weld that meets the guidance of ISG-15 [6]. The TSC closure weld meets the ISG-15 guidance in that the analysis of the weld considers a stress reduction factor of 0.8. The weld is qualified and performed in accordance with the ASME Code, Section IX requirements [7]; and the weld is dye penetrant examined after the root, midplane, and final surface passes. The final surfaces of the welds joining the closure ring to the closure lid and shell, and joining the redundant port covers to the closure lid are PT examined. The inner port cover welds are helium leakage tested as defined in Chapter 10.

During fabrication, the TSC shell and bottom plate welds are volumetrically inspected and the shell assembly is shop helium leakage tested to the leaktight criteria of  $2 \times 10^{-7}$  cm<sup>3</sup>/sec (helium) in accordance with the requirements and approved methods of ASME Code, Section V, Article 10, and ANSI N14.5 [8]. A minimum test sensitivity of  $1 \times 10^{-7}$  cm<sup>3</sup>/sec (helium) is required. In addition, the 9-inch stainless steel closure lid assembly (TSC1 and TSC2) are volumetrically inspected in accordance with ASME Code, Section III, Subsection NB-2500 requirements. The 4-inch stainless steel closure lid that is part of the composite closure lid assembly (TSC3 and TSC4) and the FBM 5-inch stainless steel closure lid assembly are shop helium leakage tested due to its reduced thickness and shield plate bolt holes (TSC3 and TSC4 only). The closure lid is tested in accordance with the requirements and approved methods of ASME Code, Section V, Article 10, and ANSI N14.5 [8] to the leak tight criteria of  $2 \times 10^{-7}$  cm<sup>3</sup>/sec (helium). A minimum test sensitivity of  $1 \times 10^{-7}$  cm<sup>3</sup>/sec (helium) is required.

Based on the shop helium leakage testing of the 4-inch thick closure lid (spent fuel containing TSC with composite lid or 5-inch thick FBM TSC closure lid), the TSC shell, bottom plate and the joining welds; the design analyses and qualifications of the closure lid and inner port cover welds; the performance of a TSC field hydrostatic pressure test, as applicable, of the closure lid assembly-to-TSC shell weld; the helium leakage test performed on the inner vent and drain port covers; and the multiple NDE performed on all of the confinement boundary welds, the loaded TSC is considered and analyzed as having no credible leakage.

The confinement boundary details at the top of the TSC are shown in Figure 7.1-1. The closure is welded by qualified welders using weld procedures qualified in accordance with ASME Code, Section IX. Over its 50-year design life, the TSC precludes the release of radioactive contents to the environment and the entry of air or water that could potentially damage the cladding of the stored spent fuel.

### 7.1.2 Confinement Penetrations

Two penetrations fitted with quick-disconnect fittings are provided in the TSC closure lid for operational functions during system loading and sealing operations. The drain port accesses a drain tube that extends into a sump located in the bottom plate. The vent port extends to the underside of the closure lid and accesses the top of the TSC cavity.

After the completion of the closure lid-to-TSC shell weld, TSC pressure test and cavity draining, the vent and drain penetrations are utilized for drying the TSC internals and contents, and for helium backfilling and pressurizing the TSC. After backfilling to a specific helium density for spent fuel TSC or to a specific pressure for the FBM TSC, both penetrations are closed with redundant port covers welded to the closure lid. As presented for storage, the TSC has no exposed or accessible penetrations, has no mechanical closures, and does not employ seals to maintain confinement.

### 7.1.3 Seals and Welds

The confinement boundary welds consist of the field-installed welds that close and seal the TSC, and the shop welds that join the bottom plate to the TSC and that join the rolled plates that form the TSC shell. The TSC shell may incorporate both longitudinal and circumferential weld seams in joining the rolled plates. No elastomer or metallic seals are used in the confinement boundary of the TSC. All cutting, machining, welding, and forming of the TSC vessel are performed in accordance with Section III, Article NB-4000 of the ASME Code, unless otherwise specified in the approved fabrication drawings and specifications. Code alternatives are listed in Table 2.1-2.

Weld procedures, welders, and welding machine operators shall be qualified in accordance with ASME Code, Section IX. Refer to Chapter 10 for the acceptance criteria for the TSC weld visual inspections and nondestructive examinations (NDE).

The loaded TSC is closed using field-installed welds. The closure lid to TSC shell weld is liquid penetrant examined at the root, at the midplane level and the final surface. After the completion of TSC hydrostatic pressure, as applicable, testing or helium backfilling, the closure ring is installed and welded to the TSC shell and closure lid. The final surface of each of the closure ring welds is liquid penetrant examined. Following draining, drying, and helium backfilling operations, the vent and drain ports are closed with redundant port covers that are welded in place. The inner port cover welds are helium leakage tested. The final surface of each port cover to closure lid weld is liquid penetrant examined.

## **7.2 Requirements for Normal Conditions of Storage**

The TSC is transferred to a concrete cask using a transfer cask. Once the TSC is placed inside of the concrete cask, it is effectively protected from direct structural loading due to natural phenomena, such as wind, snow, and ice loading. The principal direct loading for normal operating conditions results from increased internal pressure caused by decay heat, solar insolation, and ambient temperature. Loading due to transient handling may occur during the transfer of the loaded TSC to the concrete cask.

### **7.2.1 Release of Radioactive Material**

The structural analysis of the TSC for normal conditions of storage presented in Chapter 3 demonstrates that the confinement boundary is not breached in any of the normal operating events. Therefore, there is no release of radioactive material during normal storage conditions.

### **7.2.2 Pressurization of the Confinement Vessel**

The TSC cavity is dried and pressurized with helium prior to installing and welding the vent and drain port covers. Under normal conditions, the internal pressure increases due to an increase in temperature of the backfill gas and the postulated normal storage cladding failure of 1% of the stored fuel rods, which is assumed to release 30% of the available fission gases in the rods.

No significant gas release is expected from the FBM TSC as the high temperatures encountered during the in-core accident that generated the material released available fission gas inventories. Limited amounts of non-metallic materials may be included within the FBM contents. Non-metallics may generate gases as a result of radiolytic decomposition over the storage period (temperature in the FBM TSC is not expected to rise to a level that would result in significant thermal degradation). To avoid the potential of generating a flammable gas mixture, the amount of hydrogen generating media within the TSC, accounting for energy absorption by radiation, must be limited to 4% by volume (the lower flammability limit of hydrogen). Due to the low backfill pressure of helium in the FBM system, i.e., 1 atm (absolute) versus the approximately 8 atm (absolute) backfill in the spent fuel system, the minor amounts of gases generated through radiolysis will have no significant impact on the structural ability of the TSC to maintain confinement.

The TSC, closure lid, fittings, and the basket assembly are fabricated from materials that either do not react with ordinary or borated spent fuel pool water to generate gases, or which have an electroless nickel plating to significantly reduce, or eliminate, the potential for interaction with water. Refer to Chapter 8 for a description of the electroless nickel plating and process. The

neutron absorber sheets in the fuel baskets, as described in Chapter 8, and the stainless steel covers are held in place by weld posts attached to the fuel tubes. The neutron absorber is a borated aluminum composite, which is protected by an oxide film that forms shortly after fabrication of the plates. This oxide layer effectively precludes further oxidation that could result in the generation of gases in the TSC.

As the spent fuel containing TSC is dried and helium backfilled prior to sealing, no significant moisture or other gases, such as air, remain in the TSC. Consequently, for spent fuel containing systems, there is no potential that radiolytic decomposition could cause an increase in TSC internal pressure or result in a buildup of explosive gases in the TSC. Foreign materials will be excluded from the cavity to the extent required to ensure that explosive levels of gases due to radiological decomposition will not be generated.

Similarly, the FBM TSC is dried, vacuumed, and helium backfilled prior to sealing. This process will remove the bulk of the system moisture or other gases. Limited quantity of moisture may remain trapped within the FBM, or within filter media, post vacuum drying. In combination with any non-metallic content potential gas generation, the total gas generating media must not produce hydrogen levels in excess of the 4% (by volume) lower flammability limit. As noted in the discussion of non-metallic FBM contents, the minor quantity of gases that may be generated within the TSC, subject to flammability limits, will not significantly impact the TSC structural evaluation as spent fuel systems are evaluated for significantly higher pressure.

The calculated TSC pressure for normal conditions of storage is presented in Chapter 4 and is less than the pressure evaluated in Chapter 3 for the maximum normal operating pressure. Consequently, there is no adverse consequence due to the internal pressure resulting from normal storage conditions.

As the confinement boundary is closed by welding and does not contain seals or O-rings, and the boundary is not ruptured or otherwise compromised under any normal handling event, the release of contents during normal conditions of storage is precluded.

## **8.10            Chemical and Galvanic Reactions**

The materials used in the fabrication and operation of MAGNASTOR are evaluated to determine whether chemical, galvanic or other reactions among the materials, contents, and environments can occur. All phases of operation — loading, unloading, handling, and storage — are considered for the environments that may be encountered under normal conditions and off-normal or accident events. Based on the evaluation, no potential reactions that could adversely affect the overall integrity of the concrete cask, the fuel basket, the TSC, or the structural integrity and retrievability of the fuel from the TSC have been identified. The evaluation conforms to the guidelines of ISG-15 [10].

No potential chemical, galvanic, or other reactions have been identified for MAGNASTOR. Therefore, the overall integrity of the TSC and the structural integrity and retrievability of the spent fuel are not adversely affected for any operations throughout the design basis life of the TSC. Based on the evaluation, no change in the TSC or fuel cladding thermal properties is expected, and no corrosion of mechanical surfaces is anticipated. No change in basket clearances or degradation of any safety components, either directly or indirectly, is likely to occur since no potential reactions have been identified.

### **8.10.1            Component Operating Environment**

Most of the component materials of MAGNASTOR are exposed to two typical operating environments: 1) an open TSC containing fuel pool water or borated water with a pH of 4.5 and spent fuel or other radioactive material; or 2) a sealed TSC containing helium (including an FBM TSC), but with external environments that include air, rain water/snow/ice and marine (salty) water/air. Each category of TSC component materials is evaluated for potential reactions in each of the operating environments to which those materials are exposed. These environments may occur during fuel loading or unloading, handling or storage, and include normal conditions or off-normal and accident events.

The long-term environment to which the TSC's internal components are exposed is dry helium (including an FBM TSC). Both moisture and oxygen are removed prior to sealing the TSC. The backfill gas (helium) displaces the oxygen in the TSC, effectively precluding chemical corrosion. The dry environment inside the sealed TSC also inhibits galvanic corrosion between dissimilar metals in electrical contact.

In addition to the spent fuel, the fuel assemblies in the basket may hold control element assemblies, thimble plugs or other nonfuel components that are nonreactive with the fuel

assembly. By design, the control components and nonfuel components are inserted in the guide tubes of a fuel assembly. During reactor operation, the control and nonfuel components are immersed in acidic water having a high flow rate and are exposed to significantly higher neutron flux, radiation and pressure than will exist in dry storage. The control and nonfuel components are physically placed in storage in a dry, inert atmosphere in the same configuration as when used in the reactor. Therefore, there are no adverse reactions, such as gas generation, galvanic or chemical reactions or corrosion, since these components are nonreactive with the zirconium-alloy guide tubes and fuel rods. Fuel assemblies typically do not contain aluminum or carbon steel parts exposed to coolant/moderator or are in contact with non-fuel hardware, and therefore are not subject to significant gas generation or corrosion during prolonged water immersion (20-40 years). Carbon steel plenum springs, which are not normally exposed to water, may be used in some fuel designs. Clad failure could expose the springs. Small quantities of uncoated exposed carbon steel are permitted in the system as discussed in Section 8.6.1. Thus, no adverse reactions occur with the control and nonfuel components over prolonged periods of dry storage.

The FBM is loaded into the WBL for storage inside the FBM TSC. The WBL and TSC are both Type 304 stainless steel. No adverse reaction between TSC and WBL will occur. As discussed in Section 1.4.2, FBM is comprised of material from components associated with the reactor primary system contaminated by used nuclear fuel and associated byproducts. These components are primarily metallic in nature and are not expected to yield adverse reactions with the WBL or TSC when in the dry helium backfilled storage configuration. The FBM contents can be loaded bare into the WBL or within metallic dunnage (e.g. STA & DMC). Metallic dunnage similarly does not present the potential for adverse material reactions due to the dry helium environment inside the sealed FBM TSC.

### **8.10.2 Component Material Categories**

The component materials are categorized in this section for their chemical and galvanic corrosion potential on the basis of similarity of physical and chemical properties and component functions. The categories are stainless steels, nonferrous metals, carbon steel, coatings, concrete, and criticality control materials. The evaluation is based on the environment to which these categories could be exposed during operation or use.

The TSC component materials are not reactive among themselves with the TSC's contents, or with the TSC's operating environments during any phase of normal conditions, off-normal or accident events, loading, unloading, handling or storage operations. Since no reactions will occur, no gases or other corrosion by-products will be generated.

The control component and nonfuel component materials are those that are typically used in the fabrication of fuel assemblies, i.e., stainless steels, Inconel 625, and zirconium-based alloy, so no adverse reactions occur in the inert atmosphere that exists in storage. The control element assembly, thimble plugs and nonfuel components—including start-up sources or instrument segments to be inserted into a fuel assembly—are nonreactive among themselves with the fuel assembly or with the TSC’s operating environment for any storage condition.

#### **8.10.2.1      Stainless Steels**

No reaction of the TSC and MTC2 component stainless steels is expected in any environment, except for the marine environment where chloride-containing salt spray could potentially initiate pitting of the TSC stainless steel if the chlorides are allowed to concentrate and stay wet for extended periods of time (weeks). Only the external TSC surface could be so exposed. The corrosion rate will, however, be so low that no detectable corrosion products or gases will be generated. MAGNASTOR has smooth external surfaces to minimize the collection of such materials as salts.

The TSC confinement boundary uses Type 304/304L dual-certified stainless steel for all components except the closure lid. The MTC2 transfer cask structural components are fabricated primarily from ASTM A240/A182 Type 304 stainless steel. No coatings are applied to the stainless steels. Type 304/304L stainless steel resists chromium-carbide precipitation at the grain boundaries during welding and assures that degradation from intergranular stress corrosion will not be a concern over the life of the TSC. Fabrication specifications control the maximum interpass temperature for austenitic steel welds to less than 350°F. The material will not be heated to a temperature above 800°F, other than by welding or thermal cutting. Minor sensitization of Type 304/304L stainless steel that may occur during welding will not affect the material performance over the design life.

#### **8.10.2.2      Carbon Steel**

Carbon steel is used to fabricate all of the structural components of the PWR and BWR baskets, and the shield plate of the TSC composite closure lid assembly. There is a small electrochemical potential difference between carbon steel and the stainless steel of the TSC shell and the stainless steel sheet used to protect the neutron absorber in the fuel tubes. However, the carbon steel basket components and the shield plate of the TSC composite closure lid assembly are coated with electroless nickel using an immersion process. The immersion process ensures that the carbon steel is appropriately coated, reducing the possibility of corrosion due to exposure to air or pool water. When in contact with stainless steel in water, the carbon steel exhibits a limited electrochemically driven corrosion. Typically, BWR pool water is demineralized, and is not

sufficiently conductive to promote detectable corrosion for these metal couples. Once the TSC is loaded, the water is drained from the cavity, the air is removed, and the TSC is backfilled with helium (fuel contents or FBM contents) and sealed. Removal of the water and the moisture eliminates the catalyst for galvanic corrosion between the carbon and stainless steels. In addition, the displacement of oxygen by helium effectively inhibits oxidation.

The MTC1 transfer cask structural components are fabricated primarily from ASTM A588 and A36 carbon steel. The exposed carbon steel components are coated with an epoxy enamel coating system tested and certified for use in Nuclear Service Level 1 conditions to protect the components during in-pool use and to provide a smooth surface to facilitate decontamination.

The concrete shell of the concrete cask contains an ASTM A36 carbon steel liner, as well as other carbon steel components. The exposed surfaces of the carbon steel liner and air inlets and outlets are coated to provide protection from weather-related moisture. The coating is formulated for use in continuous high- temperature environments.

No potential reactions associated with the shield plate of the TSC composite closure lid assembly, basket supports and fuel tubes, the transfer cask components or concrete cask components are expected to occur.

### **8.10.2.3      Nonferrous Metals**

Aluminum is used in the neutron absorber material. The aluminum material in electrical contact with the stainless steel cover and carbon steel fuel tube could experience corrosion driven by an electrochemically induced electromotive force when immersed in water, where the conductivity of the water is the dominant factor. Typically, BWR fuel pool water is demineralized and is not sufficiently conductive to promote detectable corrosion for these metal couples. PWR pool water, however, does provide a conductive medium.

Shortly after fabrication, aluminum produces a thin surface film of oxidation that effectively inhibits further oxidation of the surface. This oxide layer adheres tightly to the base metal and does not react readily with the materials or environments to which the fuel basket will be exposed. The volume of the aluminum oxide does not increase significantly over time. Thus, binding due to corrosion product build-up during future removal of spent fuel assemblies is not a concern. The borated water in a PWR fuel pool is an oxidizing-type acid with a pH on the order of 4.5. However, aluminum is generally passive in pH ranges down to about 4 [11]. Data provided by the Aluminum Association [12] shows that aluminum alloys are resistant to aqueous solutions (1-15%) of boric acid (at 140°F). Based on these considerations and the very short exposure of the aluminum in the fuel basket to the borated water, oxidation of the aluminum is not likely to occur beyond the formation of a thin surface film. No observable degradation of

To ensure safe loading of the TSC, the loading procedure described in Chapter 9 provides for the monitoring of hydrogen gas before and during the root pass welding operations that join the closure lid to the TSC shell. The monitoring system is capable of detecting hydrogen at 60% of the Lower Flammability Limit (LFL) for hydrogen (i.e., 2.4% H<sub>2</sub>). The hydrogen detector is connected to the cavity volume so as to detect hydrogen prior to initiation of welding. The hydrogen concentration is monitored during the root pass welding operation. The welding operation is stopped upon the detection of hydrogen in a concentration exceeding 2.4%. Hydrogen gas concentrations exceeding 2.4% are removed by flushing air, nitrogen, argon or helium into the region below the closure lid or by evacuating the hydrogen using a vacuum pump.

The vacuum pump exhausts to a system or area where hydrogen flammability is not an issue. Once the root pass weld is completed, there is no further likelihood of a combustible gas burn because the ignition source is isolated from the potential source of combustible gases, and hydrogen gas monitoring is stopped.

Hydrogen is not expected to be detected prior to, or during, the welding operations. During the completion of the closure lid to TSC shell root pass, the hydrogen gas detector accesses the vent port and is used to monitor the hydrogen gas levels. Following closure lid welding and TSC hydrostatic testing, as applicable, the TSC is drained. Once the TSC is dry, no combustible gases form within the TSC.

### **8.10.3.2      Evaluation of Unloading Operations**

The TSC is dried and backfilled with helium (fuel contents or FBM contents) immediately prior to final closure welding operations, thereby eliminating all oxidizing gases and water. Therefore, it is not expected that the TSC will contain any combustible gases during the time period of storage. To ensure the safe, wet unloading of the TSC, the unloading procedure described in Chapter 9 provides for monitoring for hydrogen gas during closure lid weld cutting/removal operations.

The principal steps in opening the TSC are the removal of the vent and drain port cover welds, and the removal of the closure lid weld. The welds are expected to be removed by cutting or grinding. Following removal of the vent and drain port covers, the TSC is sampled for radioactive gases, vented, flushed with nitrogen or helium gas, and cooled down with water using the vent and drain ports. Prior to cutting the closure lid weld, the cavity water level is lowered to permit removal of the closure lid weld in a dry environment, and the cavity gas volume is sampled for hydrogen gas levels  $\geq 2.4\%$  using a hydrogen gas detector connected to the vent port. If unacceptable hydrogen levels are detected during closure lid weld removal

operations, weld removal operations are terminated and the cavity is flushed with air, nitrogen, argon or helium, or the cavity is evacuated with a vacuum pump.

### **8.10.3.3      Conclusions**

The steps taken to monitor for the presence of hydrogen will ensure that combustion of any hydrogen gas does not occur due to either closure lid welding or lid removal operations. Based on this evaluation, which results in no identified reactions, it is concluded that MAGNASTOR operating controls and procedures for loading and unloading the TSC presented in Chapter 9 are adequate to minimize the occurrence of hazardous conditions.

## Chapter 9 Operating Procedures

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**9.7            Loading Fuel Bearing Material (FBM) into MAGNASTOR Using Standard MAGNASTOR Transfer Cask (MTC)**

MAGNASTOR may be used to load, transfer, and store fuel bearing material (FBM). The three principal components of the system are: the fuel bearing material transportable storage canister (FBM TSC), the MAGNASTOR transfer cask (MTC), and the concrete cask. The MTC contains and supports the FBM TSC during loading of Waste Basket Liners (WBLs) into which FBM has been loaded into, lid welding and closure operations. The MTC, with the transfer adapter, is also used to move the FBM TSC into position for placement in the concrete cask.

These loading procedures are based on three initial conditions.

- the MTC is located in a facility's designated workstation for cask preparation
- an empty FBM TSC (properly receipt inspected and accepted) is located in the MTC cavity
- an accepted concrete cask is available to receive the FBM TSC when loading and preparation activities are complete

Fuel Bearing Material (FBM) may be loaded into the FBM TSC in either a submerged (i.e., wet) or non-submerged (i.e., dry) environment, as approved by the Users ALARA program.

For FBM materials harvested and accumulated in filter media contained within intermediate pressure vessels, the vessel containing FBM shall be qualified for storage prior to sealing the FBM TSC. Loading of vessel(s) containing FBM will be conducted in a non-submerged (dry) environment.

Submerged (Wet) loading and processing of FBM TSCs

For wet loading conditions, the FBM TSC is filled with clean or designated loading area water and the transfer cask containing the FBM TSC is lowered into the designated loading area within the facility for loading of the WBL containing FBM. The user must ensure that all FBM is loaded into a WBL prior to loading into an FBM TSC.

Following WBL loading into the FBM TSC, the closure lid is installed and the transfer cask containing the loaded FBM TSC is lifted from the designated loading area. The FBM TSC is partially drained and the closure lid is welded to the FBM TSC shell. The closure lid-to-shell weld is visual and progressive dye penetrant examined. The closure ring, which provides the redundant confinement closure barrier, is installed, welded and inspected. The FBM TSC cavity water is then drained. At the option of the user, the closure ring welding sequence can be completed later in the cask loading operational sequence following completion of vacuum drying and inerting of the FBM TSC.

The residual moisture in the FBM TSC is then removed by vacuum drying techniques and the FBM TSC dryness is verified before being backfilled with helium to provide an inert atmosphere for the safe long-term storage of the fuel bearing material contents. System connections to the vent and drain openings are removed and the inner port covers are installed, welded, dye penetrant examined and helium leakage rate tested. The outer port covers, which provide the redundant sealing of the confinement boundary, are installed, welded and dye penetrant examined. Installation and welding of the FBM TSC closure lid, shell, closure ring and port covers complete the assembly of the confinement boundary and redundant closure.

#### Non-submerged (dry) loading and processing of FBM TSCs

For non-submerged (dry) loading conditions, the transfer cask containing the FBM TSC is positioned in the designated loading area within the facility for loading of the FBM. For loading of vessels containing FBM, the user must ensure that the WBL is loaded into the TSC prior to loading the PV.

Following loading of the PV(s) into the TSC, the closure lid is installed and then welded to the FBM TSC shell. The closure lid-to-shell weld is visual and progressive dye penetrant examined. The closure ring, which provides the redundant confinement closure barrier, is installed, welded and inspected. The FBM TSC cavity is then evacuated of air and non-condensable gasses using removed by vacuum drying techniques and the FBM TSC dryness is verified before being backfilled with helium to provide an inert atmosphere for the safe long-term storage of the fuel bearing material contents. At the option of the user, the closure ring welding sequence can be completed later in the cask loading operational sequence following completion of vacuum drying and inerting of the FBM TSC.

System connections to the vent and drain openings are removed and the inner port covers are installed, welded, dye penetrant examined and helium leakage rate tested. The outer port covers, which provide the redundant sealing of the confinement boundary, are installed, welded and dye penetrant examined. Installation and welding of the FBM TSC closure lid, shell, closure ring and port covers complete the assembly of the confinement boundary and redundant closure.

#### FBM TSC Transfer

The concrete cask is positioned for the transfer of the FBM TSC and the transfer adapter is installed. The transfer cask containing the loaded FBM TSC is positioned on the transfer adapter on the top of the concrete cask. The FBM TSC is lowered into the concrete cask and the transfer cask and transfer adapter are removed. The concrete cask upper segment is installed and secured to complete the loading process.

The loaded concrete cask is moved to the ISFSI storage pad using the site-specific transporter and placed in its long-term storage location. Final radiation surveys are completed and the temperature monitoring system is installed, if used, which completes the MAGNASTOR loading and transfer sequence.

### **9.7.1 Submerged (Wet) Loading and Closing the FBM TSC Using Standard MTC**

This section describes the sequence of operations to perform loading and submerged underwater (wet) and closure of the FBM TSC in preparation for transferring the FBM TSC to the concrete cask. The empty FBM TSC is assumed to be positioned inside the transfer cask located at the designated workstation.

1. Visually inspect the FBM TSC internals for foreign materials or debris.
2. Visually inspect the top of the FBM TSC shell and closure lid weld preps.
3. Inflate the upper MTC annulus seal with air or nitrogen gas. Disconnect the gas supply.  
Note: Gas supply lines may be left connected to ensure against unintended deflation. Note:  
The sequence and use of upper and lower annulus seals are at the discretion of the Licensee/User based on selected in-plant operational procedures.  
Note: Optional FBM TSC annulus shims may be utilized at the discretion of the user to assist in centering the FBM TSC in the MTC annulus.
4. Verify the three FBM TSC retaining blocks (MTC1/MTC2) are pinned in the retracted position or the retaining ring (MTC2) is removed.
5. Verify that at least one lock pin is installed on each MTC shield door.
6. Fill the FBM TSC with clean or designated loading area water. Note that alternatively, FBM TSC may be filled while lowering it into the Fuel Transfer Canal are at the discretion of the user's choice of operation.
7. Attach the lift yoke to a crane suitable for handling the loaded FBM TSC, MTC and yoke. Position the lift yoke over the transfer cask and engage it with the two transfer cask trunnions.  
Note: The temperature of the transfer cask (surrounding ambient air temperature) must be verified to be at or above the minimum operating temperature of 0°F, per Section 4.3.1.f. of the Technical Specifications (not applicable to the stainless steel MTC2 design).
8. Lift the MTC containing the empty FBM TSC and move it to the designated loading area following the prescribed load path.  
Note: An optional protective cover, attached to the bottom of the MTC, may be used to prevent imbedding contaminated particles in the shield doors and door rails.
9. Connect the clean water lines to the lower annulus fill ports of the MTC. Ensure that the unused ports are closed or capped to prevent designated loading area water in-leakage.

10. Lower the MTC to the surface of the designated loading area and turn on the clean water supply lines to the lower annulus fill ports to fill the MTC/FBM TSC annulus.  
Note: Sequence on connection and filling/draining MTC/FBM TSC annulus is at the discretion of the user based on approved site-specific procedures.
11. Spray the transfer cask and lift yoke with clean water to wet the exposed surfaces.  
Note: Wetting the components that enter the designated loading area and spraying the components leaving the designated loading area will reduce the effort required to decontaminate the components.
12. Lower the MTC as the annulus fills with clean water until the upper annulus fill ports are accessible. Hold this position and connect the clean water annulus fill lines to the upper fill ports. Ensure the unused ports are closed or capped to prevent designated loading area water in-leakage.
13. Lower the transfer cask to the bottom of the designated loading area in the cask loading area.
14. Disengage the lift yoke and visually verify that the lift yoke is fully disengaged. Remove the lift yoke from the designated loading area while spraying the yoke and crane cables with clean water.
15. Using the slings attached to the WBL, load the WBL containing FBM into the FBM TSC basket.
16. Install three swivel hoist rings hand tight in the three closure lid lifting holes or in three of the six FBM TSC lift holes, and torque to the value specified in Table 9.1-2. Install a three-legged sling set to the hoist rings and connect the sling set to the crane hook or the attachment point on the lift yoke.  
Note: At the discretion of the user, the closure lid can be attached to the lift yoke and the lid installed during the lowering of the lift yoke.
17. Raise the closure lid. Adjust closure lid rigging to level the closure lid.
18. Move the closure lid over the designated loading area and align the lift yoke (if used) to the MTC trunnions and align the closure lid to the match marks of the FBM TSC.
19. Lower the closure lid until it enters the FBM TSC and seats in the top of the FBM TSC. Visually verify closure lid alignment using the match marks ( $\pm \frac{1}{2}$  inch).
20. Allow sling cables to go slack and move the lift yoke into position to engage the MTC trunnions. Engage the lift yoke to the trunnions, apply a slight tension, and visually verify engagement.
21. Raise the MTC until its top clears the designated loading area surface. Visually verify that the closure lid is properly seated. If necessary, lower the transfer cask and reinstall the closure lid. Rinse the lift yoke and MTC with clean water as the equipment is removed from the designated loading area.

22. Rinse and flush the top of the MTC and FBM TSC with clean water as necessary to remove any radioactive particles. Survey the top of the FBM TSC closure lid and the top of the MTC to check for radioactive particles.
23. As the MTC is removed from the designated loading area, terminate the annulus fill water supply, remove the annulus fill system hoses, and allow annulus water to drain into the designated loading area.
24. Following the prescribed load path, move the MTC to the designated workstation for FBM TSC closure operations.

Note: At the option of the user, the FBM TSC closure operations may be performed with the MTC partially submerged in the designated loading area, cask loading pit, or an equivalent structure. This operational alternative provides additional shielding for the cask operators.

25. Disengage the three-legged sling set from the closure lid and the lift yoke from the MTC trunnions. Place lift yoke and sling set in storage/lay-down area.
26. Inflate the MTC lower annulus seal with air or nitrogen. Disconnect the gas supply from the transfer cask.

Note: The installation, use, and operational sequence of the lower annulus seal is at the discretion of the user based on approved site-specific procedures. At the option of the user, the gas supply can be maintained continuously to the annulus seals. Use of the ACWS, or similar system, is optional for the FBM TSC as safe operating temperatures are maintained with air or stagnant water in the TSC to MTC annulus. Annulus may be water filled for contamination control only. Steps 27, 28 and 68 may be skipped or modified depending on site requirements at this stage (i.e., air filled annulus., annulus water filled with or without flow).

27. Install the ACWS, R-ACWS or alternative annulus flush/circulating water system, to the lower and upper annulus fill lines. Unused fill lines are to be closed or capped.

Note: For FBM TSCs prepared with the MTC partially submerged on an in-designated loading area shelf, partially drained cask loading pit or equivalent partial submerged condition, or in an ACWS catch basin, alternative ACWS operations (e.g., reverse flow ACWS [R-ACWS]) may be utilized.

Note: ACWS or R-ACWS operation may be used to enhance vacuum drying times of the FBM TSC via application of heated water (maximum water temperature 200°F).

28. Initiate clean water flow into the MTC lower fill lines with annulus water discharging through the upper fill lines.
29. Detorque and remove the lifting hoist rings from the closure lid.
30. Using a portable suction pump, remove any standing water from the closure lid weld groove, and the vent and drain ports.

31. Decontaminate the top of the MTC and FBM TSC closure lid to allow installation of the welding equipment. Decontaminate external surfaces of the MTC and remove the bottom protective cover, if installed.
32. Insert the drain line with a quick-connector attached through the drain port opening and into the basket drain port sleeve. Remove the quick-disconnect and any contaminated water displaced from the cavity.
33. Torque the drain tube connector to the drain opening to the value specified in Table 9.1-2. Verify quick-disconnect is installed and properly torqued in the vent port opening.
34. Install a venting device to the vent port quick-disconnect to prevent combustible gas or pressure buildup below the closure lid.
35. Verify that the top of the closure lid is level (flush) with, or slightly above, the top of the FBM TSC shell.
36. At the discretion of the user, establish foreign material exclusion controls to prevent objects from being dropped into the annulus or FBM TSC.
37. Install the welding system, including supplemental shielding, to the top of the closure lid.  
Note: At the discretion of the user, supplemental shielding may be installed around the transfer cask to reduce operator dose. Use of supplemental shielding shall be evaluated to ensure its use does not adversely affect the safety performance of MAGNASTOR.
38. Connect a suction pump to the drain port quick-disconnect and verify venting through the vent port quick-disconnect.
39. Operate the suction pump to remove approximately 70 gallons of water from the FBM TSC. Disconnect the suction pump.  
Note: The radiation level will increase as water is removed from the FBM TSC cavity, as shielding material is being removed.
40. Attach a hydrogen detector to the vent line. Ensure that the vent line does not interfere with the operation of the weld machine.
41. Sample the gas volume below the closure lid and observe hydrogen detector for H<sub>2</sub> concentration prior to commencing closure lid welding operations. Monitor H<sub>2</sub> concentration in the FBM TSC until the mid-plane layer of the closure lid-to-shell weld is completed.  
Note: If H<sub>2</sub> concentration exceeds 2.4%, immediately stop welding operations. Evacuate the FBM TSC gas volume or purge the gas volume with nitrogen. Verify H<sub>2</sub> levels are <2.4% prior to restarting welding operations.  
Note: In place of continuous H<sub>2</sub> monitoring, continuous gas purging of the volume below the lid may be used in concert with initial (prior to start of welding) and intermittent H<sub>2</sub> monitoring (upon termination of gas purging and prior to re-starting welding operations).

42. Install shims into the closure lid-to-FBM TSC shell gap, as necessary, to establish a uniform gap for welding. Tack weld the closure lid and shims, as required.
43. Operate the welding equipment to complete the closure lid-to-FBM TSC shell root pass weld in accordance with the approved weld procedure.
44. Perform visual and liquid penetrant (PT) examinations of the root pass and record the results.
45. Operate the welding equipment to perform the closure lid-to-shell weld to the midplane between the root and final weld surfaces. Perform visual and PT examinations for the midplane weld pass, and record the results.
46. Remove the H2 detector from the vent line while ensuring the FBM TSC cavity vent line remains installed and allows venting of gases from the cavity.
47. Complete welding through the completion of the final pass of the closure lid weld, perform final visual and PT examinations, and record the results.
48. Install and tack the closure ring in position in the closure lid-to-FBM TSC shell weld groove.  
Note: At the option of the user, the installation and tacking of the closure ring may be performed immediately after helium backfill (Step 58) or after completion of the welding, testing, and NDE of the vent and drain inner or outer port covers (Step 63 or 66).
49. Weld the closure ring to the FBM TSC shell and to the closure lid. Perform visual and PT examinations of the final surfaces of the welds and record the results.  
Note: At the option of the user, the installation, welding, and NDE of the closure ring may be performed immediately after helium backfill (Step 58) or after completion of the welding, testing, and NDE of the vent and drain inner or outer port covers (Step 63 or 66).
50. Remove the water from the FBM TSC using one of the following methods: drain down using a suction pump with a pressurized nitrogen cover gas; or blow down using pressurized nitrogen gas.
51. Connect a drain line with or without suction pump to the drain port connector.
52. Connect a regulated nitrogen gas supply to the vent port connector.
53. Open gas supply valve and start suction pump, if used, and drain water from the FBM TSC until water ceases to flow out of the drain line. Close gas supply valve and stop suction pump.
54. At the option of the user, disconnect suction pump, close discharge line isolation valve, and open nitrogen gas supply line. Pressurize FBM TSC to approximately 20 psig and open discharge line isolation valve to blow down the FBM TSC. Repeat blow down operations until no significant water flows out of the drain line.
55. Disconnect the drain line and gas supply line from the drain and vent port quick-disconnects.
56. Dry the FBM TSC cavity using vacuum drying methods as follows.
  - a. Connect the vacuum drying system to the vent and drain port openings.

- b. Operate the vacuum pump until a vapor pressure of  $< 3$  torr is achieved in the FBM TSC.
- c. Isolate the vacuum pump from the FBM TSC and turn off the vacuum pump. Observe the vacuum gauge connected to the FBM TSC for an increase in pressure for a minimum period of 30 minutes.

Note: If the FBM TSC pressure is  $< 3$  torr at the end of 30 minutes, the FBM TSC is dry of free water.

Note: Moisture removal during vacuum drying may be improved by injection of nitrogen (heated or non-heated) during the vacuum drying process (i.e., while the FBM TSC internal pressure is under a vacuum condition). This process may be repeated as needed.

57. Upon satisfactory completion of the dryness verification, backfill and pressurize the FBM TSC cavity with helium as follows:

- a. Set the helium bottle regulator to 20 (+5,-0) psig.
- b. Connect the helium backfill system to the vent port.
- c. Slowly open the helium supply valve and backfill the FBM TSC with helium until the FBM TSC is at a pressure of 0 (+2/-0) psig.

58. Disconnect the vacuum drying helium backfill system from the vent and drain openings.

Note: At the option of the user, Steps 48 and 49 can alternatively be performed at this point or immediately following Steps 63 or 66. The user to establish appropriate radiological controls to maintain operator dose ALARA.

59. Install and tack weld the inner port cover to the FBM TSC closure lid vent port opening.

60. Purge the vent port cavity with high-purity helium.

61. Weld the inner port cover to the FBM TSC closure lid.

62. Perform visual and PT examinations of the final surface of the vent port inner cover weld and record the results.

63. Perform helium leak test on the vent port inner cover weld to verify the absence of helium leakage past the vent port inner cover weld.

64. Repeat steps 59 thru 63 for the FBM TSC inner port cover on the drain port opening.

65. Install and weld the outer port cover on the drain port opening. Perform visual and PT examinations of the final weld surface and record the results.

66. Install and weld the outer port cover on the vent port opening. Perform visual and PT examinations of the final weld surface and record the results.

67. Using an appropriate crane, remove the weld machine and supplemental shield.

68. Drain the FBM TSC/MTC annulus by stopping ACWS flow to the annulus and connecting one or more drain lines to the lower annulus fill ports. Once the annulus is drained, deflate the top and bottom annulus seals.
69. If using MTC1 or MTC2 with retaining blocks, remove the lock pins and move the MTC retaining blocks inward into their functional position, and reinstall the lock pins. If using MTC2 with retaining ring, install the transfer cask retaining ring and torque the retaining ring bolts to the value specified in Table 9.1-2.
70. Install the TSC Adapter Assembly and secure using the six threaded holes in the closure lid. Torque the bolts to the designated value listed in Table 9.1-2.  
Note: Complete final decontamination of the MTC exterior surfaces. Final FBM TSC contamination surveys may be performed after FBM TSC transfer following Step 21 in Section 9.7.3 when FBM TSC surfaces are more accessible.
71. Proceed to Section 9.7.3.

### **9.7.2            Non-submerged (Dry) Loading and Closing the FBM TSC Using Standard MTC**

This section describes the sequence of operations to perform the loading of FBM in a non-submerged (dry) configuration and subsequent closure of the FBM TSC in preparation for transferring the FBM TSC to the concrete cask. The empty FBM TSC is assumed to be positioned inside the transfer cask located at the designated workstation.

1. Visually inspect the FBM TSC internals for foreign materials or debris.
2. Visually inspect the top of the FBM TSC shell and closure lid weld preps.
3. Inflate the upper MTC annulus seal with air or nitrogen gas. Disconnect the gas supply.  
Note: Gas supply lines may be left connected to ensure against unintended deflation.  
Note: The sequence and use of upper and lower annulus seals are at the discretion of the Licensee/User based on selected in-plant operational procedures.  
Note: Optional FBM TSC annulus shims may be utilized at the discretion of the user to assist in centering the FBM TSC in the MTC annulus.
4. Verify the three FBM TSC retaining blocks (MTC1/MTC2) are pinned in the retracted position or the retaining ring (MTC2) is removed.
5. Verify that at least one lock pin is installed on each MTC shield door.
6. Connect the clean water lines to the lower annulus fill ports of the MTC.
7. Using the slings attached to the WBL, load the WBL into the FBM TSC basket.
8. Install the appropriate WBL internal(s) for loading of vessel(s) containing FBM.
9. Verify the closure seals of the vessel(s) containing FBM are intact.
10. Select and install the vessel(s) containing FBM into the WBL.

11. Install three swivel hoist rings hand tight in the three closure lid lifting holes or in three of the six FBM TSC lift holes, and torque to the value specified in Table 9.1-2. Install a three-legged sling set to the hoist rings and connect the sling set to the crane hook.
12. Raise the closure lid. Adjust closure lid rigging to level the closure lid.
13. Move the closure lid over the designated loading area and align the closure lid to the match marks of the FBM TSC.
14. Lower the closure lid until it enters the FBM TSC and seats in the top of the FBM TSC. Visually verify closure lid alignment using the match marks ( $\pm \frac{1}{2}$  inch).
15. Disconnect the three-legged sling set from the closure lid. Place the sling set in storage/lay-down area.
16. Inflate the MTC lower annulus seal with air or nitrogen. Disconnect the gas supply from the transfer cask.

Note: The installation, use, and operational sequence of the lower annulus seal is at the discretion of the user based on approved site-specific procedures. At the option of the user, the gas supply can be maintained continuously to the annulus seals. Use of the ACWS, or similar system, is optional for the FBM TSC as safe operating temperatures are maintained with air or stagnant water in the TSC to MTC annulus. Annulus may be water filled for contamination control only. Steps 17, 18 and 51 may be skipped or modified depending on site requirements at this stage (i.e., air filled annulus., annulus water filled with or without flow).

17. Install the ACWS, R-ACWS or alternative annulus flush/circulating water system, to the lower and upper annulus fill lines. Unused fill lines are to be closed or capped.  
Note: For FBM TSCs prepared with the MTC in an ACWS catch basin, alternative ACWS operations (e.g., reverse flow ACWS [R-ACWS]) may be utilized.  
Note: ACWS or R-ACWS operation may be used to enhance vacuum drying times of the FBM TSC via application of heated water (maximum water temperature 200°F).
18. Initiate clean water flow into the MTC lower fill lines with annulus water discharging through the upper fill lines.
19. Detorque and remove the lifting hoist rings from the closure lid.
20. Insert the drain line with a quick-connector attached through the drain port opening and into the basket drain port sleeve.
21. Torque the drain tube connector to the drain opening to the value specified in Table 9.1-2. Verify quick-disconnect is installed and properly torqued in the vent port opening.
22. Install a venting device to the vent port quick-disconnect to prevent combustible gas or pressure buildup below the closure lid.
23. Verify that the top of the closure lid is level (flush) with, or slightly above, the top of the FBM TSC shell.

24. At the discretion of the user, establish foreign material exclusion controls to prevent objects from being dropped into the annulus or FBM TSC.
25. Install the welding system, including supplemental shielding, to the top of the closure lid.  
Note: At the discretion of the user, supplemental shielding may be installed around the transfer cask to reduce operator dose. Use of supplemental shielding shall be evaluated to ensure its use does not adversely affect the safety performance of MAGNASTOR.
26. Verify venting through the vent port quick-disconnect.
27. Attach a hydrogen detector to the vent line. Ensure that the vent line does not interfere with the operation of the weld machine.
28. Sample the gas volume below the closure lid and observe hydrogen detector for H<sub>2</sub> concentration prior to commencing closure lid welding operations. Monitor H<sub>2</sub> concentration in the FBM TSC until the mid-plane layer of the closure lid-to-shell weld is completed.  
Note: If H<sub>2</sub> concentration exceeds 2.4%, immediately stop welding operations. Evacuate the FBM TSC gas volume or purge the gas volume with nitrogen. Verify H<sub>2</sub> levels are <2.4% prior to restarting welding operations.  
Note: In place of continuous H<sub>2</sub> monitoring, continuous gas purging of the volume below the lid may be used in concert with initial (prior to start of welding) and intermittent H<sub>2</sub> monitoring (upon termination of gas purging and prior to re-starting welding operations).
29. Install shims into the closure lid-to-FBM TSC shell gap, as necessary, to establish a uniform gap for welding. Tack weld the closure lid and shims, as required.
30. Operate the welding equipment to complete the closure lid-to-FBM TSC shell root pass weld in accordance with the approved weld procedure.
31. Perform visual and liquid penetrant (PT) examinations of the root pass and record the results.
32. Operate the welding equipment to perform the closure lid-to-shell weld to the midplane between the root and final weld surfaces. Perform visual and PT examinations for the midplane weld pass, and record the results.
33. Remove the H<sub>2</sub> detector from the vent line while ensuring the FBM TSC cavity vent line remains installed and allows venting of gases from the cavity.
34. Complete welding through the completion of the final pass of the closure lid weld, perform final visual and PT examinations, and record the results.
35. Install and tack the closure ring in position in the closure lid-to-FBM TSC shell weld groove.  
Note: At the option of the user, the installation and tacking of the closure ring may be performed immediately after helium backfill (Step 41) or after completion of the welding, testing, and NDE of the vent and drain inner or outer port covers (Step 46 or 49).

36. Weld the closure ring to the FBM TSC shell and to the closure lid. Perform visual and PT examinations of the final surfaces of the welds and record the results.

Note: At the option of the user, the installation, welding, and NDE of the closure ring may be performed immediately after helium backfill (Step 41) or after completion of the welding, testing, and NDE of the vent and drain inner or outer port covers (Step 46 or 49).

37. Disconnect the vent line from the vent port quick-disconnect.

38. Evacuate the FBM TSC cavity using vacuum drying methods as follows.

- a. Connect the vacuum drying system to the vent and drain port openings.
- b. Operate the vacuum pump until a vapor pressure of  $< 3$  torr is achieved in the FBM TSC.
- c. Isolate the vacuum pump from the FBM TSC and turn off the vacuum pump. Observe the vacuum gauge connected to the FBM TSC for an increase in pressure for a minimum period of 30 minutes.

Note: If the FBM TSC pressure is  $< 3$  torr at the end of 30 minutes, the FBM TSC has been evacuated.

Note: Moisture removal during vacuum drying may be improved by injection of nitrogen (heated or non-heated) during the vacuum drying process (i.e., while the FBM TSC internal pressure is under a vacuum condition). This process may be repeated as needed.

39. Upon satisfactory completion of the dryness verification, backfill and pressurize the FBM TSC cavity with helium as follows:

- a. Set the helium bottle regulator to 20 (+5,-0) psig.
- b. Connect the helium backfill system to the vent port.
- c. Slowly open the helium supply valve and backfill the FBM TSC with helium until the FBM TSC is at a pressure of 0 (+2/-0) psig.

40. Disconnect the vacuum drying helium backfill system from the vent and drain openings.

Note: At the option of the user, Steps 35 and 36 can alternatively be performed at this point or immediately following Steps 46 or 49. The user to establish appropriate radiological controls to maintain operator dose ALARA.

41. Install and tack weld the inner port cover to the FBM TSC closure lid vent port opening.

42. Purge the vent port cavity with high-purity helium.

43. Weld the inner port cover to the FBM TSC closure lid.

44. Perform visual and PT examinations of the final surface of the vent port inner cover weld and record the results.

45. Perform helium leak test on the vent port inner cover weld to verify the absence of helium leakage past the vent port inner cover weld.

46. Repeat steps 41 thru 45 for the FBM TSC inner port cover on the drain port opening.

47. Install and weld the outer port cover on the drain port opening. Perform visual and PT examinations of the final weld surface and record the results.
48. Install and weld the outer port cover on the vent port opening. Perform visual and PT examinations of the final weld surface and record the results.
49. Using an appropriate crane, remove the weld machine and supplemental shield.
50. Drain the FBM TSC/MTC annulus by stopping ACWS flow to the annulus and connecting one or more drain lines to the lower annulus fill ports. Once the annulus is drained, deflate the top and bottom annulus seals.
51. If using MTC1 or MTC2 with retaining blocks, remove the lock pins and move the MTC retaining blocks inward into their functional position, and reinstall the lock pins. If using MTC2 with retaining ring, install the transfer cask retaining ring and torque the retaining ring bolts to the value specified in Table 9.1-2.
52. Install the TSC Adapter Assembly and secure using the six threaded holes in the closure lid. Torque the bolts to the designated value listed in Table 9.1-2.  
Note: Complete final decontamination of the MTC exterior surfaces. Final FBM TSC contamination surveys may be performed after FBM TSC transfer following Step 21 in Section 9.7.3 when FBM TSC surfaces are more accessible.
53. Proceed to Section 9.7.3.

### **9.7.3        Transferring the FBM TSC to the Concrete Cask Using a Standard MTC**

This section describes the sequence of operations required to complete the transfer of a loaded FBM TSC from the MTC into a concrete cask, and preparation of the concrete cask for movement to the ISFSI pad.

1. Position an empty concrete cask with the upper segment removed in the designated FBM TSC transfer location.

Note: The concrete cask can be positioned on the ground, or on a deenergized air pad set, roller skid, heavy-haul trailer, rail car, or transfer cart. The transfer location can be inside the loading facility or an external area accessed by the facility cask handling crane.

Note: The minimum ambient air temperature (either in the facility or external air temperature, as applicable for the handling sequence) must be > 0°F for lifting the concrete cask with lifting plugs, per Section 4.3.1.g. of the Technical Specifications.

2. Inspect all concrete cask openings for foreign objects and remove if present.
3. Install a four-legged sling set to the lifting points on the transfer adapter.

4. Using the crane, lift the transfer adapter and place it on top of the concrete cask ensuring that the guide ring sits inside the concrete cask lid flange. Remove the sling set from the crane and move the slings out of the operational area.
5. Connect a hydraulic supply system to the hydraulic cylinders of the transfer adapter.
6. Verify the movement of the connectors and move the connector tees to the fully extended position.
7. Connect the Secure Lift Handling System to the crane and engage the lift yoke to the MTC trunnions. Ensure all lines, temporary shielding and work platforms are removed to allow for the vertical lift of the transfer cask.

Note: The minimum ambient air temperature (either in the facility or external air temperature, as applicable for the handling sequence) must be  $> 0^{\circ}\text{F}$  for the use of the carbon steel MTC, per Section 4.3.1.f. of the Technical Specifications (not applicable to stainless steel MTC2).

8. Lower the SLHS equalizer beam to permit engagement of the TSC Locking Pin with the TSC Adapter Assembly.
9. Actuate the TSC locking pin to securely couple the equalizer beam to the TSC Adapter Assembly.
10. Raise the MTC and move it into position over the empty concrete cask.
11. Slowly lower the MTC into the engagement position on top of the transfer adapter to align with the door rails and engage the connector tees.
12. Following set down, remove the lock pins from the shield door lock tabs.
13. Using the SLHS redundant hoists, lift the FBM TSC slightly (approximately  $\frac{1}{2}$ -1 inch) to remove the FBM TSC weight from the shield doors.

Note: The lifting system operator must take care to ensure that the FBM TSC is not lifted such that the retaining blocks (MTC1/MTC2) or the retaining ring (MTC2) is engaged by the top of the FBM TSC.

14. Open the MTC shield doors with the hydraulic system to provide access to the concrete cask cavity.
15. Perform FBM TSC contamination surveys on the MTC shield doors to confirm contamination levels are acceptable.
16. Slowly lower the FBM TSC into the concrete cask cavity until the FBM TSC is seated on the pedestal.

Note: The transfer adapter and the standoffs in the concrete cask will ensure the FBM TSC is appropriately centered on the pedestal within the concrete cask.

17. When the FBM TSC is seated, retract the TSC locking pin from the TSC adapter assembly and raise the equalizer beam up into the MTC until the equalize beam has reached full up position.

18. Close the shield doors using the hydraulic system and reinstall the lock pins into the shield door lock tabs.
19. Lift the MTC from the top of the concrete cask and return it to the cask preparation area for next loading sequence or to its designated storage location.
20. Disconnect hydraulic supply system from the transfer adapter hydraulic cylinders.
21. Loosen and remove the six bolts securing the TSC adapter assembly to the FBM TSC closure lid. Using the designated sling sets, remove from the top of the FBM TSC and store properly.
22. Verify all equipment and tools have been removed from the top of the FBM TSC and transfer adapter.
23. Connect the transfer adapter four-legged sling set to the crane hook and lift the transfer adapter off the concrete cask. Place the transfer adapter in its designated storage location and remove the slings from the crane hook.
24. Using the on-site heavy haul vehicle, remove the concrete cask using the designated conveyance from the FBM TSC transfer station location to permit installation of the concrete cask upper segment.
25. Attach the concrete cask upper segment lift rig. Connect the slings to the overhead crane.
26. Perform visual inspection of the top of the concrete cask and verify all equipment and tools have been removed.  
Note: Take care to minimize personnel access to the top of the unshielded loaded concrete cask due to radiation streaming from the FBM TSC.
27. Lift the concrete cask upper segment and move it into position over the concrete cask, ensuring proper alignment.
28. Lower the concrete cask upper segment into position and remove the rig set from the concrete cask upper segment
29. Install four of the concrete cask upper segment bolts and tighten to the torque specified in Table 9.1-2.
30. Perform radiation surveys of the top and sides of the concrete cask. Confirm dose rates are within allowable values.
31. Using the vertical cask transporter lift fixture or device, position the two concrete cask lifting lugs on the concrete cask.
32. Install the lift lug bolts (2 per lift lug) and into the threaded holes in the embedment base.  
Torque each of the lug bolts to the value specified in Table 9.1-2.
33. Proceed to Section 9.7.3.

#### **9.7.4 Transporting and Placing the Loaded Concrete Cask**

The section describes the general procedures for moving a loaded concrete cask to the ISFSI pad using the vertical cask transporter.

##### **Vertical Cask Transporter**

1. Using the cask transporter, lift the loaded concrete cask and move it to the ISFSI pad following the approved onsite transport route.  
Note: Ensure vertical cask transporter lifts the concrete cask evenly using the two lifting lugs.  
Note: Do not exceed the maximum lift height for a loaded concrete cask of 24 inches, per Section 4.3.1.h. of the Technical Specifications.
2. Move the concrete cask into position over its intended ISFSI pad storage location. Ensure the surface under the concrete cask is free of foreign objects and debris.
3. Using the vertical transporter, slowly lower the concrete cask into position.
4. Loosen and remove the two lift lug bolts from each lifting lug, raise the lift lugs from the top of the concrete cask and move the cask transporter from the area.
5. Install the remaining four concrete cask upper segment bolts into the threaded holes. Torque each bolt to the value specified in Table 9.1-2.
6. For the casks with extensions containing anchor cavities, install the weather seal and cover plates. Install the bolts and washers and torque to the value specified in Table 9.1-2.
7. Install inlet screens to prevent access by debris and small animals.  
Note: Screens may be installed on the concrete cask prior to FBM TSC loading to minimize operations personnel exposure.
8. Scribe and/or stamp the concrete cask nameplate, if not already done, with the required information at a minimum.
9. Perform a radiological survey of the concrete cask within the ISFSI array to confirm dose rates comply with ISFSI administrative boundary and site boundary dose limits.

#### **9.7.5 Removing the Loaded FBM TSC from a Concrete Cask Using a Standard MTC**

This procedure assumes the loaded concrete cask is returned to the reactor loading facility for unloading. However, transfer of the FBM TSC to another concrete cask can be performed at the ISFSI without the need to return to the loading facility, provided a cask transfer facility that meets the requirements specified in the Technical Specifications is available.

As the steps to move a loaded concrete cask are essentially the reverse of the procedures in Section 9.7.2 and Section 9.7.3, the procedural steps are only summarized here.

1. Remove concrete cask inlet screens.

Note: The minimum ambient air temperature (either in the facility or external air temperature, as applicable for the handling sequence) must be  $> 0^{\circ}\text{F}$  for the use of the concrete cask, per Section 4.3.1.g. of the Technical Specifications.

Remove four of the concrete cask upper segment bolts, and install the lift lugs. Torque the lift lug bolts for each lift lug to the value specified in Table 9.1-2. Attach the concrete cask to the vertical cask transporter.

2. Move the loaded concrete cask to the facility.
3. Remove the concrete cask upper segment.
4. Install the TSC adapter assembly using the six bolts inserted into the canister closure lid threaded holes. Torque the bolts to the prescribed value,
5. Install transfer adapter on top of the concrete cask.
6. Place MTC onto the transfer adapter and engage the shield door connectors.
7. Note: The minimum ambient air temperature (either in the facility or external air temperature, as applicable for the handling sequence) must be  $> 0^{\circ}\text{F}$  for the use of the carbon steel MTC, per Section 4.3.1.f. of the Technical Specifications (not applicable to stainless steel MTCs).
8. Open the shield doors, retrieve the lifting slings, and install the slings on the lifting system.
9. Slowly withdraw the FBM TSC from the concrete cask. The chamfer on the underside of the transfer adapter assists in the alignment into the MTC.
10. Bring the FBM TSC up to just below the retaining blocks (MTC1/MTC2) or the retaining ring (MTC2). Close the MTC shield doors and install the shield door lock pins.
11. Lift MTC off the concrete cask and move to the designated workstation.
12. After the MTC with the loaded FBM TSC is in, or adjacent to, the facility, the operational sequence to load the FBM TSC into another concrete cask is performed in accordance with the procedures in Section 9.7.2.

### **9.7.6 Wet Unloading a FBM TSC Using a Standard MTC**

This section provides the basic operational sequence to prepare, open, and unload a FBM TSC in a designated loading area. Due to the rugged design and fabrication of the FBM TSC, users are not expected to perform this operational sequence. However, in accordance with the Technical Specifications, each user shall have the procedures and required equipment available, and perform a dry run of the unloading process.

The procedure that follows assumes that the FBM TSC is in a MTC in the appropriate workstation.

1. If using MTC1 or MTC2 with retaining blocks, pull the lock pins and retract the retaining blocks in the transfer cask, and reinstall the lock pins. If using MTC2 with retaining ring, detach and remove the retaining ring.
2. Survey the FBM TSC and MTC to establish radiation areas.
3. Install and secure by welding the Port Cover Drill Fixture to the outer vent port cover.
4. Install the Gas Sampling and Pressure Measurement System to the Port Cover Drill Fixture access port.
5. Operate the Port Cover Drill Fixture to remotely drill through the outer and inner vent port covers.
6. Measure cavity gas pressure utilizing the Gas Sampling and Pressure Measurement System.
7. Obtain a cavity gas sample from the Port Cover Drill Fixture connection.
8. Determine total gaseous inventory and connect a venting system to the Gas Sampling and Pressure Measurement System and route to the HEPA filters or to the off-gas system.
9. Vent the FBM TSC cavity gas and reduce FBM TSC pressure to atmospheric.
10. Remove the Port Cover Drill Fixture from the outer vent port cover.
11. Install the weld removal system on the closure lid and bolt the system to the closure lid threaded holes.
12. Establish appropriate airborne radiation controls.  
Note: Initial TSC cooling can be provided by an external TSC cooling system prior to port cover removal.
13. Using the weld removal system, remove the outer and inner port covers from the vent and drain ports.
14. Remove the weld removal system.
15. Using appropriate radiological controls, remove the vent and drain quick-disconnects and seals.
16. Replace the vent port quick-connect, drain tube with quick-disconnect, and seals with approved spares, and torque them to the value specified in Table 9.1-2.
17. Attach the cooldown system to the vent and drain connections.  
Note: Initial TSC cooling can be provided by an external TSC cooling system prior to port cover removal.
18. Initiate purge gas flow (nitrogen) through the FBM TSC to flush out residual radioactive gases. Continue nitrogen flow for a minimum of 10 minutes.
19. Initiate the controlled filling (5 +3/-0 gpm) of the FBM TSC with clean water through the drain connector under controlled temperature (minimum 70°F) and pressure conditions (20 +5/-0 psig).
20. Monitor steam/water temperature of the discharge from the vent connection.

21. Continue cooldown operations until the discharge water temperature is below 180°F.
22. Terminate cooling water flow and disconnect the cooldown system from the drain and vent ports. Install a vent line to the vent port.
23. Connect a suction pump to the drain connector. Operate the pump and remove approximately 70 gallons of water from the cavity. Disconnect and remove the pump.
24. Remove the drain line from the closure lid.
25. Install the hydrogen detector to the vent line and verify hydrogen gas concentration in the gas volume in the cavity. If the concentration reaches 2.4%, stop all cutting activities and purge the hydrogen from the FBM TSC using nitrogen.
26. Install the weld removal system on the closure lid. Operate the weld removal system to remove the closure ring-to-FBM TSC shell and closure ring-to-closure lid welds. Remove the closure ring from the lid area.
27. Operate the weld removal system to remove the closure lid-to-shell weld.
28. Remove shims, if installed, to provide a suitable gap to be able to extract the closure lid under water.
29. Remove the weld removal system. Terminate ACWS or R-ACWS, if used.
30. Install three swivel hoist rings into the closure lid threaded holes and torque to value in Table 9.1-2. Attach three-legged sling set to the hoist rings and the lifting system (or, alternately, the MTC lifting yoke).
31. Engage the lift yoke to the MTC trunnions and bring the transfer cask over the designated loading area.
32. Install lower annulus fill lines and fill the annulus with clean water while lowering the MTC.
33. When the trunnions are near the designated loading area surface, install upper annulus fill lines and start clean water flow.
34. Lower the MTC to the bottom of the designated loading area. Disengage the lift yoke.
35. Slowly remove the closure lid and move the lid to an appropriate storage area. Note: The closure lid may be contaminated and slightly activated.
36. Attach slings between the WBL and the crane hook. Remove from the FBM TSC and place in designated location.
37. Following WBL unloading, reengage the lift yoke to the MTC trunnions and remove the MTC from the designated loading area.
38. While the MTC is over the designated loading area, stop the flow of water to the annulus, disconnect the upper and lower fill lines, and allow the water in the annulus to drain back into the designated loading area.
39. Place MTC and empty FBM TSC in the cask decontamination area or other workstation.

40. Using a suction pump, remove the water from the FBM TSC and pump to radwaste drains or return the water to the designated loading area.
41. Remove and store the contaminated FBM TSC until a determination is made regarding reuse or disposition of the closure lid and FBM TSC.
42. As appropriate, the user may proceed with the loading of the removed WBL into a new FBM TSC in accordance with the procedures in Section 9.7.

reduced thickness of the stainless steel closure lid (4-inch thick base material) of the composite closure lid assembly, and the presence of extended bolt holes for attachment of the shield plate assembly, a shop helium leakage test of the composite closure lid stainless steel plate shall be performed following fabrication. Also reduced in thickness is the FBM TSC closure lid (5-inch thick base material). Due to the reduced thickness, a shop helium leakage test of the FBM TSC closure lid shall be performed following fabrication. The leakage test shall be performed in accordance with the requirements and approved methods of ASME Code, Section V, Article 10, and ANSI N14.5-1997 to confirm the total leakage rate is less than, or equal to,  $2 \times 10^{-7}$  cm<sup>3</sup>/s (helium). The sensitivity of the test shall be one-half of the acceptance test criteria as specified in ANSI N14.5-1997.

If leakage is detected, the area of leakage shall be identified, repaired and re-examined in accordance with ASME Code, Section III, Subsection NB, NB-4130. Following repair and completion of required NDE, the helium leak test shall be re-performed to the original test acceptance criteria.

Leakage testing of the composite closure lid and the FBM TSC closure lid shall be performed in accordance with written and approved procedures, and the test results documented.

In order to ensure the integrity of the vent and drain inner port cover welds, a helium leakage test of each weld is performed following welding of the inner port covers to the closure lid assembly using the evacuated envelope method, as described in ASME Code, Section V, Article 10, and ANSI N14.5. The leakage test is to confirm that the leakage rate for each port cover is  $\leq 2 \times 10^{-7}$  cm<sup>3</sup>/s helium. Following inner port cover welding, a test bell is installed over the top of the port cover and the test bell volume is evacuated to a low pressure by a helium MSLD system. The minimum sensitivity of the helium MSLD shall be  $\leq 1 \times 10^{-7}$  ref. cm<sup>3</sup>/s, helium, which is one-half of the allowable leakage criteria for leaktight.

If leakage is detected, the area of leakage shall be identified, repaired and re-examined in accordance with ASME Code, Section III, Subsection NB, NB-4450. Following repair, the helium leak test shall be re-performed to the original test acceptance criteria.

#### **10.1.4      Component Tests**

##### **10.1.4.1    Valves, Rupture Discs, and Fluid Transport Devices**

The MAGNASTOR system design does not include any rupture discs or fluid transport devices. The closure lid vent and drain openings are each closed by valved quick-disconnect nipples. These nipples are recessed into the closure lid and are used during TSC preparation activities to drain, dry, and helium fill the TSC cavity. No credit is taken for the ability of the valved nipples to confine radioactive material. After completion of final helium backfill pressure adjustment, the port covers are welded

in the vent and drain openings enclosing the valved nipples. The port covers provide the confinement boundary for the vent and drain openings.

#### **10.1.4.2 Gaskets**

The confinement boundary provided by the welded TSC has no mechanical seals or gaskets. The concrete cask includes optional weather seals at the concrete cask lid to cask interface. These gaskets do not provide a safety function and loss of the gaskets during operation would have no effect on the safe operation of the concrete cask. The gaskets are provided to facilitate concrete cask maintenance by minimizing water intrusion into the gasketed area.

#### **10.1.5 Shielding Tests**

The MAGNASTOR system design is analyzed based on the materials of fabrication and their thickness, using conservative shielding codes to evaluate system dose rates at the system's surface and at selected distances from the surface. The system shield design does not require performance of a shield test.

Following the loading of each MAGNASTOR and its movement to the ISFSI pad, radiological surveys are performed by the system user to establish area access requirements and to confirm that evaluated offsite doses will meet the applicable regulations. These tests are sufficient to identify any significant defect in the shielding effectiveness of the concrete cask.

#### **10.1.6 Neutron Absorber Tests**

NOTE

Sections 10.1.6.4.5, 10.1.6.4.6, 10.1.6.4.7 and 10.1.6.4.8 are incorporated into the MAGNASTOR CoC Technical Specification by reference, Paragraph 4.1.1, and may not be deleted or altered in any way without a CoC amendment approval from the NRC. The text in these four sections is shown in bold to distinguish it from other sections.

Neutron absorber materials are included in the design and fabrication of the MAGNASTOR fuel basket assemblies to assist in the control of reactivity, as described in Chapter 6. Criticality safety is dependent upon the neutron absorber material remaining fixed in position on the fuel tubes and containing the required amount of uniformly distributed boron. A neutron absorber material can be a composite of fine particles in a metal matrix or an alloy of boron compounds with aluminum. Fine particles of boron or boron-carbide that are uniformly distributed are required to obtain the best neutron absorption. Three types of neutron absorber materials are commonly used in spent fuel storage and transport cask fuel baskets: Boral (registered trademark), borated metal matrix composites (MMC), and borated aluminum alloy. The

BASES (continued)

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SR 3.0.4 (continued) The provisions of this Specification should not be interpreted as endorsing the failure to exercise the good practice of restoring systems or components before entering an associated specified condition in the Applicability.

However, in certain circumstances, failing to meet an SR will not result in SR 3.0.4 restricting a change in specified condition. When a system, subsystem, division, component, device, or variable is outside the specified limits, the associated SR(s) are not required to be performed per SR 3.0.1, which states that Surveillances do not have to be performed on equipment that has been determined to not meet the LCO. When equipment does not meet the LCO, SR 3.0.4 does not apply to the associated SR(s) since the requirement for the SR(s) to be performed is removed. Therefore, failing to perform the Surveillance(s) within the specified conditions of the Applicability. However, since the LCO is not met in this instance, LCO 3.0.4 will govern any restrictions that may (or may not) apply to specified condition changes.

The provisions of SR 3.0.4 shall not prevent changes in specified conditions in the Applicability that is required to comply with ACTIONS.

In addition, the provisions of LCO 3.0.4 shall not prevent changes in specified conditions in the Applicability that is related to the unloading of the MAGNASTOR SYSTEM.

The precise requirements of performance of SRs are specified such that exceptions to SR 3.0.4 are not necessary. The specific time frames and conditions necessary for meeting the SRs are specified in the Frequency, in the Surveillance, or both. This allows performance of Surveillances when the prerequisite condition(s) specified in a Surveillance procedure require entry into the specified condition in the Applicability of the associated LCO prior to the performance or completion of Surveillance. A Surveillance that could not be performed until after entering the LCO Applicability would have its Frequency specified such that it is not "due" until the specific conditions needed are met.

Alternately, the Surveillance may be stated in the form of a Note as not required (to be met or performed) until a particular event, condition, or time has been reached. Further, discussion of the specific formats of SRs annotation is found in Technical Specification Section 1.4, Frequency.

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3.1 MAGNASTOR SYSTEM Integrity

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3.1.1 Transportable Storage Canister (TSC)

BASES

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**BACKGROUND** A TRANSFER CASK with an empty TSC is placed into the spent fuel pool and loaded with SNF assemblies and other approved contents meeting the requirements of Appendix B, Approved Contents. An empty FBM TSC may be loaded with FBM meeting the requirements of Appendix B, Approved contents (FBM TSCs may be loaded at a location not within the spent fuel). A closure lid is then placed on the TSC, and the TRANSFER CASK containing the TSC is removed from the pool, as applicable and placed in the cask preparation area or prepared in a partially submerged condition. As applicable, cooling water flow to the TRANSFER CASK annulus shall be provided to assist in limiting the MAGNASTOR SYSTEM component temperatures during TSC preparation and closure activities. The closure lid is welded to the TSC shell and the weld is examined by dye penetrant examination methods (i.e., root, mid-plane and final surface). As applicable, a hydrostatic pressure test of the weld is performed at a minimum of 125% of the TSC maximum normal operating pressure. The TSC cavity water is removed by pumping and/or blow down while backfilling the cavity with helium, and the free volume of the TSC is determined by measuring the volume of water removed.

TSC cavity moisture removal is performed using vacuum drying methods following draining of the bulk cavity water. TSC cavity dryness is confirmed by ensuring that any pressure rise in the isolated TSC cavity with the vacuum pump turned off and isolated is less than the acceptance criteria.

Upon verification of the dryness of the TSC cavity following vacuum drying operations, the TSC is further evacuated using the vacuum pumping system to a vacuum pressure that excludes significant quantity of oxidizing gases (i.e., < 1 mole).

For TSCs containing spent fuel assemblies the TSC cavity is then backfilled with high purity helium ( $\geq 99.995\%$  purity) until the required helium mass density is established. Drying and backfilling the TSC cavity with helium provides the capability to remove the contents decay heat by convective and conductive heat transfer and minimizes any oxidizing gases to below a significant value. Establishment of the inert helium atmosphere protects the fuel cladding from degradation. The backfilling and resulting pressurization of the cavity with helium to an established helium mass density will provide the required helium mass and pressure to ensure the operation of the heat transfer design of the

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BASES (continued)

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BACKGROUND  
(continued)

MAGNASTOR SYSTEM, and will eliminate the possibility of air in-leakage over the storage period.

For FBM containing TSCs, the TSC cavity is then backfilled with helium to 1 atm absolute (see Chapter 9 for tolerance on backfill). Drying and backfilling the TSC cavity with helium provides the capability to remove the contents decay heat by conductive heat transfer and minimizes any oxidizing gases to below a significant value. Establishment of the helium atmosphere ensures the operation of the heat transfer design of the MAGNASTOR SYSTEM and will eliminate the possibility of air in-leakage over the storage period.

The closure ring is installed in the closure lid-to-TSC shell weld groove, welded to the shell and to the closure lid, and the final weld surface examined by dye penetrant methods. The inner port covers of the vent and drain openings are installed, welded and the final weld surface examined by final surface dye penetrant methods. The vent and drain inner port covers are then helium leak tested to verify the absence of helium leakage to a minimum sensitivity of  $1.0 \times 10^{-7} \text{ cm}^3 / \text{sec}$  (helium). The outer port covers are then installed, welded and the final weld surface examined by dye penetrant methods.

The TSC weldment and closure lids with a thickness of < 9 inches are designed, analyzed, and tested to meet the leaktight criteria of ANSI N14.5. In addition, the closure lid-to-TSC shell weld is hydrostatically pressure tested (as applicable) and examined by multi-pass dye penetrant examination following fuel loading. The closure lid, closure ring and inner and outer port covers provide redundant closures to ensure confinement boundary integrity. Therefore, leakage of radioactive materials from the TSC and loss of helium and possible in-leakage of air are not considered credible.

APPLICABLE  
SAFETY ANALYSIS

The confinement of the radioactive materials contents in the TSC is ensured by the multiple confinement boundaries, including the fuel pellet matrix, the fuel rod cladding, and the pressure boundary provided by the TSC. FBM materials are not credited with clad or matrix confinement function with only the TSC carrying that designation. Long-term integrity of the spent fuel assembly contents is ensured by the inert helium atmosphere of the TSC, which is accomplished by the removal of free water, elimination of residual oxidizing gases, and backfilling with a measured mass of high purity helium. The pressurized helium atmosphere in the TSC ensures that the MAGNASTOR SYSTEM convective heat transfer thermal design will perform as analyzed. The measurement of the helium backfill mass ensures that the TSC internal pressure does not exceed the TSC's design pressure under design storage operating conditions. For FBM containing TSCs, the helium backfill at atmospheric pressure assures the heat transfer design will perform as analyzed

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BASES (continued)

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LCO

For spent fuel assembly containing TSCs a dry pressurized, helium filled and sealed TSC establishes the inert environment that will ensure the integrity of the fuel cladding and proper performance of the MAGNASTOR SYSTEM thermal design, while precluding air in-leakage and out-leakage of radioactive materials.

The Section 1 Tables of the LCO specify the limits for both PWR and BWR SNF contents (based on the decay heat load of the TSC contents) for Maximum Vacuum Drying Times; Minimum Helium Backfill Time (i.e., minimum time period the TSC is allowed to soak with annulus cooling system in operation following completion of the helium mass backfill prior to the initiation of the TSC transfer to the CONCRETE CASK or Metal Storage Overpack (MSO) in the TRANSFER CASK); and the Maximum TSC Transfer Time available to complete the transfer of the TSC to the CONCRETE CASK or MSO.

The Section 2 Table in the LCO provides the Maximum Drying Time Limit for the second and subsequent vacuum drying cycles following a minimum cooling period dependent on the Transfer Cask and TSC heat load of either in-pool cooling or annulus circulating water system (ACWS) cooling with the TSC backfilled to the prescribed pressure which is dependent on the type of Transfer Cask and the TSC heat load with high purity helium, if the TSC dryness criteria were not met on the first vacuum drying cycle (this Table is not applicable to PWR contents with decay heat loads of  $\leq 20$  kW, which has unlimited vacuum drying time, no minimum helium backfill time and 600-hour TSC transfer time).

The Section 2 and 3 Tables in the LCO provides the Maximum Drying Time Limit for the second and subsequent vacuum drying cycles following a minimum cooling period dependent on the Transfer Cask and TSC heat load of either in-pool cooling or annulus circulating water system (ACWS) or reverse ACWS (R-ACWS) cooling with the TSC backfilled to the prescribed pressure which is dependent on the type of Transfer Cask and the TSC heat load with high purity helium, if the TSC dryness criteria were not met on the first vacuum drying cycle.

The table in Section 2 is applicable to TSCs prepared in the standard MAGNASTOR Transfer Cask (MTC) and Lightweight MAGNASTOR Transfer Cask (LMTC) and are dependent on the TSC heat load. A Note in Section 2 refers the Licensee to use the applicable Tables (dependent on the Transfer Cask and TSC Heat Load combination) following the additional drying cycle(s) to determine the Minimum Helium Backfill Time and Maximum TSC Transfer Time applicable for the second TSC transfer cycle. Note that the Minimum Helium Backfill Time and Maximum TSC Transfer Times in Tables 1.B and 1.D are applicable for a second cycle of TSC transfer from the MTC to the CONCRETE CASK or MSO if the first transfer cycle was not completed in the allowed

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BASES (continued)

LCO  
(continued)

time. The minimum 24-hour helium soak would lower and reset the TSC and SNF content temperatures to a value corresponding to the temperatures used in the determination of the Table 1.B and 1.D values for Maximum TSC Transfer Time limits for TSCs being transferred using the MTC. Tables F, G and H are applicable to TSCs being loaded and transferred using the LMTC.

The table in Section 3 is applicable to PWR TSCs prepared in a Passive MAGNASTOR Transfer Cask (PMTTC). A Note in Section 3 refers the Licensee to use Table 1.E following additional drying cycle(s) to determine the Minimum Helium Backfill Time and Maximum TSC Transfer Time applicable for the second TSC transfer cycle. As the PMTTC is designed to provide efficient convective air cooling of the loaded TSC and its' contents, no additional Minimum Helium Backfill Time is required prior to commencing TSC transfer operations following final helium mass backfill. In addition, the PMTTC Maximum TSC Transfer Time is 600-hours for all PWR decay heat loads.

Each temperature transient, either resulting from additional water cooling and vacuum drying cycles, or from additional helium soak, cooling and TSC transfer cycles, would need to be accounted for in the 10 allowable thermal transients for SNF assemblies with burnups exceeding 45,000 MWd/MTU.

For FBM containing TSCs, no time limits are specified during any operational steps, including loading, vacuum drying, or transfer to the CONCRETE CASKS. With helium gas cover, at low pressure conditions during vacuum drying or at the 1 atmosphere backfill pressure, the system remains at allowable temperature at steady state conditions. ACWS may be used to facilitate drying by circulating heated water thru the TSC to MTC annulus. Operation of an annulus cooling system, or water conditions in the TSC to MTC annulus without water circulation, is permitted for the FBM TSCs but is not required for safe operation (i.e., air condition is acceptable in the TSC to MTC annulus).

APPLICABILITY

The sealed TSC with a dry measured helium mass cavity atmosphere for spent fuel assembly system, or for the FBM system, is required to be established prior to TRANSPORT OPERATIONS to ensure integrity of the fuel contents and the effectiveness of the heat dissipation capability during LOADING OPERATIONS and STORAGE OPERATIONS.

ACTIONS

A note has been added to the ACTIONS, which states that, for this LCO, separate Condition entry is allowed for each TSC. This is acceptable as the Required Actions for each Condition provide appropriate compensatory measures for each TSC not meeting the LCO. Subsequent TSCs that do not meet the LCO are governed by

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BASES (continued)

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ACTIONS  
(continued)

subsequent Condition entry and application of associated Required Actions.

A.1

If the cavity vacuum drying pressure with the vacuum pump isolated and turned off is not met prior to TRANSPORT OPERATIONS, an engineering evaluation is necessary to determine the potential quantity of moisture left in the TSC. Since moisture remaining in the cavity during TRANSPORT and STORAGE OPERATIONS may represent a long-term degradation issue, immediate action is not required. The Completion Time is sufficient to complete an engineering evaluation of the safety significance of the Condition.

AND

A.2

Upon determination of the mass of water potentially contained in the TSC, a corrective action plan shall be developed and actions initiated, as required, in a timely manner to return the TSC to an analyzed condition.

B.1

If a determination is made that, as applicable, the helium backfill mass or backfill pressure or backfill gas purity requirements are not met prior to TRANSPORT OPERATIONS, an engineering evaluation shall be performed to determine backfill gas quantity in the TSC. As high or low helium mass values could result in TSC over-pressurization or reduced effectiveness of the TSC heat rejection capability, respectively, the engineering evaluation shall be performed in a timely manner. High or low helium pressure will have limited impact on system safe operation of the FBM TSC, but an engineering evaluation of the condition shall be performed in a timely manner. The Completion Time is sufficient to complete an engineering evaluation of the safety significance of the Condition.

AND

B.2

When, as applicable, the mass of helium or pressure of helium (FBM contents) in the TSC is determined, a corrective action plan shall be developed and actions implemented, as required, in a timely manner to return the TSC to an analyzed condition.

C.1

If the TSC cannot be returned to an analyzed safe condition, the TSC contents are required to be placed in a safe condition in the spent fuel pool. The Completion Time is reasonable based on the time required to plan, train and perform UNLOADING OPERATIONS in an orderly manner.

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BASES (continued)

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SURVEILLANCE  
REQUIREMENTS

SR 3.1.1.1, and SR 3.1.1.2

The long-term integrity of the TSC and stored contents is dependent on a dry and pressurized helium or atmospheric pressure helium (FBM contents) cavity environment. The dryness of the TSC cavity is demonstrated by evacuation by a vacuum pump to a low vacuum and monitoring the rise in pressure over a specified period with the vacuum pump isolated and turned off.

The establishment of the required helium backfill mass or helium pressure, as applicable, and corresponding operating pressure at operating temperature will ensure the effectiveness of the TSC capability to reject the contents decay heat to the fuel basket and TSC structure. The decay heat will subsequently be rejected by the cooling air flows provided by the CONCRETE CASK or MSO during STORAGE OPERATIONS (note that FBM contents do not require cooling air flow to demonstrate safe operating conditions).

These two surveillances shall be performed once prior to TRANSPORT OPERATIONS. Successful completion will ensure that the appropriate conditions have been established for long-term storage in compliance with the analyzed design bases.

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REFERENCES

1. FSAR Sections 4.4 and 9.1.

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- 3.1 MAGNASTOR SYSTEM Integrity
- 3.1.2 STORAGE CASK Heat Removal System

BASES

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**BACKGROUND** The heat removal system for the STORAGE CASK containing a loaded TSC is a passive, convective air-cooled heat transfer system that ensures that the decay heat emitted from the TSC is transferred to the environment by the upward flow of air through the STORAGE CASK annulus. During STORAGE OPERATIONS, ambient air is drawn into the STORAGE CASK annulus through the four air inlets located at the base of the STORAGE CASK. The heat from the TSC surfaces is transferred to the air flow via natural circulation. The buoyancy of the heated air creates a chimney effect forcing the heated air upward and drawing additional ambient air into the annulus through the air inlets. The heated air flows back to the ambient environment through the four air outlets located at the top of the STORAGE CASK.

**APPLICABLE SAFETY ANALYSIS** The thermal analyses of the MAGNASTOR SYSTEM take credit for the decay heat from the TSC contents being transferred to the ambient environment surrounding the STORAGE CASK. Transfer of heat from the TSC contents ensures that the fuel cladding and TSC component temperatures do not exceed established limits. During normal STORAGE OPERATIONS, the four air inlets and four air outlets are unobstructed and full natural convection heat transfer occurs (i.e., maximum heat transfer for a given ambient temperature and decay heat load). Vent obstruction can be any type of accumulation within the vent that restricts airflow. FBM TSCs do not require air convection through the vents for safe system operations.

For spent fuel assembly systems, analyses have been performed for two scenarios corresponding to the complete obstruction of what is equivalent to two and four air inlets. Blockage of the equivalent area of two air inlets reduces the convective air flow through the STORAGE CASK/TSC annulus and decreases the heat transfer from the TSC surfaces to the ambient environment. Under this off-normal event, no STORAGE CASK or TSC components or fuel cladding exceed established short-term temperature limits, and the TSC internal pressure does not exceed the analyzed maximum pressure.

The complete blockage of all four air inlets effectively stops the transfer of the decay heat from the TSC due to the elimination of the convective air flow. The TSC will continue to radiate heat to the liner of the STORAGE CASK. Upon loss of air cooling, the MAGNASTOR SYSTEM component temperatures will increase toward their respective

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