July 2015

Revision 15A

MAGNASTOR®

(Modular Advanced Generation Nuclear All-purpose STORage)

FINAL SAFETY ANALYSIS REPORT Amendment 6 Initial Submittal

NON-PROPRIETARY VERSION

Docket No. 72-1031

NAC INTERNATIONAL

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Enclosure 1 – List of SAR Changes

<u>Enclosure 1</u>

List of Changes

for

MAGNASTOR® FSAR, Amendment 6

(Docket No 72-1031)

NAC International

July 2015

List of Changes for the MAGNASTOR® FSAR, Amendment 6

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 1.1-5, added text to the terminology for "Transfer Cask."
- Page 1.1-6, text flow changes.
- Page 1.2-1, modified the last line of the first paragraph of Section 1.2.
- Pages 1.3-6 thru 1.3-9, modified Section 1.3.1.4, "Transfer Cask," to include PMTC information; made an editorial change to Section 1.3.1.5, "Damaged Fuel Can;" and modified Section 1.3.2, "Operational Features," in the third line of the first paragraph and the fifth bullet, and added new last bullet on page 1.3-8.
- Pages 1.3-9 thru 1.3-14, text flow changes.
- Page 1.3-15, added PMTC text to the end of the "Transfer Cask" section of Table 1.3-1, "Design Characteristics."
- Pages 1.3-16 thru 1.3-19, text flow changes.
- Page 1.5-1, modified the embedded table at the bottom of the page.
- Page 1.6-1, modified the third sentence of the first paragraph of Section 1.6.
- Page 1.8-1, added new Drawings 71160-656 and 71160-657 to Section 1.8, "License Drawings."

Chapter 2

- Page 2.2-2, added the third paragraph from the bottom of the page.
- Page 2.2-3, text flow changes.
- Page 2.2-7, added the new last bullet below Table 2.2-1.
- Page 2.4-7, modified the third row ("Transfer Cask Assembly") and added a new fourth row ("Passive Transfer Cask Assembly") to Table 2.4-1.

Chapter 3

- Page 3.1-1, modified the "Transfer Cask" column of the embedded table.
- Page 3.1-5, modified text throughout the paragraph under subheading, "Transfer Cask," in Section 3.1.2
- Page 3.2-1, modified the last paragraph on the page in Section 3.2.1 to include PMTC.
- Page 3.2-2 thru 3.2-3, replaced Table 3.2.1-1 to include PMTC.
- Page 3.4-15, modified the second paragraph of Section 3.4.3.3, "Transfer Cask Lift," to include PMTC.
- Pages 3.4-43 thru 3.4-57, added new Section 3.4.3.3.3, "Transfer Cask Lift: PMTC," and Figures 3.4.3-3 and 3.4.3-4 to the chapter.
- Pages 3.4-58 thru 3.4-63, text flow changes.

- Page 3.9-3, added new reference number 32.
- Pages 3.10.5-3 thru 3.10.5-4, added new Sections 3.10.5.4, 3.10.5.5 and 3.10.5.6.
- Pages 3.10.5-5 thru 3.10.5-6, text flow changes.
- Pages 3.10.5.5-7 thru 3.10.5-9, added new Figures 3.10.5-3, 3.10.5-4 and 3.10.5-5.

Chapter 4

- Pages 4.1-1 thru 4.1-2, added a new paragraph at the bottom of page 4.1-1 that continues at the top of page 4.1-2.
- Page 4.1-3, modified text in the second and third full paragraphs on the page.
- Page 4.4-21, added text to the first line of the second paragraph on the page.
- Page 4.4-22, text flow changes.
- Page 4.4-30, modified text in the middle of the page by adding a sentence.
- Page 4.5-3, modified title of Section 4.5.2.
- Page 4.5-4, text flow changes.
- Page 4.7-2, added Reference number 28.
- Page 4.9-1, modified title of Section 4.9.
- Pages 4.10-1 thru 4.10.2-5, added new Section 4.10 and Figures 4.10-1 thru 4.10-4 to the end of the chapter.

Chapter 5

- Page 5-1, modified the last paragraph on the page of Section 5, "Shielding Evaluation."
- Page 5.7-3, added Reference number 37.
- Pages 5.9.1-1 thru 5.9.11-41, added new Section 5.9.

Chapter 6

- Page 6.1-1, added a sentence to the end of the second paragraph of Section 6.1.1.
- Pages 6.1-2 thru 6.1-5, text flow changes.

Chapter 7

- No changes

Chapter 8

- No changes

Chapter 9

- Pages 9.1-1 thru 9.1-20, extensive changes including text flow throughout Section 9.1.
- Pages 9.2-1 thru 9.2-3, extensive changes including text flow throughout Section 9.2.
- Pages 9.3-1 thru 9.3-2, extensive changes including text flow throughout Section 9.3.

- Pages 9.4-1 thru 9.4-14, new Section 9.4, "Loading MAGNASTOR Using Passive MAGNASTOR Transfer Cask (PMTC)".
- Pages 9.5-1 thru 9.5-2, new Section 9.5, "Removing the Loaded TSC from a Concrete Cask Using a PMTC".
- Pages 9.6-1 thru 9.6-3, new Section 9.6, "Wet Unloading a TSC Using a PMTC".

Chapter 10

- Pages 10.1-5 thru 10.1-6, added new Section 10.1.2.5, "Pressure Testing of the Passive MAGNASTOR Transfer Cask (PMTC)."
- Pages 10.1-7 thru 10.1-22, text flow changes.
- Pages 10.2-1 thru 10.2-2, added three paragraphs to the end of Section 10.2.1.
- Page 10.2-3, modified the last line of the fourth and fifth rows of Table 10.2-1 by adding "or PMTC", and added a new sixth row to the table.

Chapter 11

- No changes

Chapter 12

- Page 12.1-5, modified Section 12.1.4 by adding a sentence to the end of the paragraph.

Chapter 13

- Page13C-11, modified the first sentence of the second paragraph on the page for "BACKGROUND (cont.)".
- Page 13C-12, modified "LCO (cont.)" throughout.
- Pages 13C-13 thru 13C-14, text flow changes.
- Page 13C-17, modified Surveillance Requirements SR 3.1.2.1 by adding a sentence near the middle of the paragraph.

Chapter 14

- No changes

Chapter 15

- No changes

Enclosure 2 – List of Drawing Changes

<u>Enclosure 2</u>

List of Drawing Changes

for

MAGNASTOR® FSAR, Amendment 6

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<u>Drawing 71160-656, Cask Body Weldment, Passive Transfer Cask, MAGNASTOR, Revision 0P and 0NP</u>

Initial Issue

<u>Drawing 71160-657, Passive Transfer Cask, Assembly, MAGNASTOR, Revisions 0P and 0NP</u>

Initial Issue

Enclosure 3 – Proposed Changes for Technical Specifications

<u>Enclosure 3</u>

Proposed Changes

for

MAGNASTOR® Technical Specifications, Amendment 6

(Docket No 72-1031)

NAC International

July 2015

APPENDIX A

TECHNICAL SPECIFICATIONS AND DESIGN FEATURES
FOR THE MAGNASTOR SYSTEM

AMENDMENT 6

Appendix A
Table of Contents

PROPOSED

List of Figures

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1.0 USE AND APPLICATION

1.1 Definitions

NOTE

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

Term	Definition
ACTIONS	ACTIONS shall be that part of a Specification that prescribes Required Actions to be taken under designated Conditions within specified Completion Times.
ASSEMBLY AVERAGE FUEL ENRICHMENT	Value calculated by averaging the ^{235}U wt % enrichment over the entire fuel region (UO_2) 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	a) Assembly Average Burnup: Value calculated by averaging the burnup over the entire fuel region (UO_2) 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. b) Nonfuel Hardware Burnup: Equivalent accumulated irradiation exposure for activation evaluation.
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.
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.

(continued)

DAMAGED FUEL

SPENT NUCLEAR FUEL (SNF) assembly that cannot fulfill its fuel-specific or system-related function. SNF is classified as damaged under the following conditions.

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.

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.

3. The SNF assembly has missing, displaced or damaged structural components such that:

   3.1. Radiological and/or criticality safety is adversely affected (e.g., significantly changed rod pitch); or

   3.2. The SNF assembly cannot be handled by normal means (i.e., crane and grapple); or

   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.

   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.

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 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.

(continued)

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.
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.
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 CONCRETE CASK and a TSC. A MAGNASTOR TRANSFER CASK (MTC) or Passive MAGNASTOR TRANSFER CASK (PMTC) is provided and utilized to load and place a TSC in a CONCRETE CASK or to remove a TSC from a CONCRETE CASK.

(continued)

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.

OPERABLE

A system, component, or device is OPERABLE when it is capable of performing its specified safety functions.

(continued)

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 OPERATIONS	STORAGE OPERATIONS include all licensed activities that are performed at the ISFSI following placement of a CONCRETE 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 a MAGNASTOR TRANSFER CASK (MTC) or Passive MAGNASTOR TRANSFER CASK (PMTC) may be used.
TRANSFER OPERATIONS	TRANSFER OPERATIONS include all licensed activities involved in using a MAGNASTOR TRANSFER CASK (MTC) or Passive MAGNASTOR TRANSFER CASK (PMTC) to move a loaded and sealed TSC from a CONCRETE CASK to another CONCRETE CASK.
TRANSPORT OPERATIONS	TRANSPORT OPERATIONS include all licensed activities performed on a loaded MAGNASTOR CONCRETE CASK when it is being moved to and from its designated location on the ISFSI. TRANSPORT OPERATIONS begin when the loaded CONCRETE CASK is placed on or lifted by a transporter and end when the CONCRETE 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.

(continued)

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; 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: 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.
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 into a TRANSFER CASK in an unloading facility and end when the last fuel assembly has been removed from the TSC.

1.0 USE AND APPLICATION

1.2 Logical Connectors

PURPOSE

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

Logical connectors are used in Technical Specifications (TS) to discriminate between, and yet connect, discrete Conditions, Required Actions, Completion Times, Surveillances, and Frequencies. The only logical connectors that appear in 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 . . . AND 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 . . . OR A.2.1 Verify . . . AND A.2.2 A.2.2.1 Reduce . . . OR A.2.2.2 Perform . . . OR A.3 Remove . . .	

This example represents a more complicated use of logical connectors. Required Action 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)*.

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.

(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
	AND		
	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 AND B.2 Complete action B.2	12 hours 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 AND B.2 Complete action B.2	6 hours 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.
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".

(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 AND 24 hours thereafter

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

LCO 3.0.1	LCOs shall be met during specified conditions in the Applicability, except as provided in LCO 3.0.2.
LCO 3.0.2	Upon failure to meet an LCO, the Required Actions of the associated Conditions shall be met, except as provided in LCO 3.0.5. If the LCO is met or is no longer applicable prior to expiration of the specified Completion Time(s), completion of the Required Action(s) is not required, unless otherwise stated.
LCO 3.0.3	Not applicable to MAGNASTOR.
LCO 3.0.4	When an LCO is not met, entry into a specified condition in the Applicability shall not be made except when the associated ACTIONS to be entered permit continued operation in the specified condition in the Applicability for an unlimited period of time. This Specification shall not prevent changes in specified condition in the Applicability that are required to comply with ACTIONS or that are related to the unloading of MAGNASTOR. 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.
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.

3.0 SURVEILLANCE REQUIREMENT (SR) APPLICABILITY

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.

SR 3.0.2

The specified Frequency for each SR is met if the Surveillance is performed within 1.25 times the interval specified in the Frequency, as measured from the previous performance or as measured from the time a specified condition of the Frequency is met.

For Frequencies specified as "once," the above interval extension does not apply. If a Completion Time requires periodic performance on a "once per..." basis, the above Frequency extension applies to each performance after the initial performance.

Exceptions to this Specification are stated in the individual Specifications.

SR 3.0.3

If it is discovered that a Surveillance was not performed within its specified Frequency, then compliance with the requirement to declare the LCO not met may be delayed from the time of discovery up to 24 hours or up to the limit of the specified Frequency, whichever is less. This delay period is permitted to allow performance of the Surveillance.

If the Surveillance is not performed within the delay period, the LCO must immediately be declared not met, and the applicable Condition(s) must be entered. When the Surveillance is performed within the delay period and the Surveillance is not met, the LCO must immediately be declared not met, and the applicable Condition(s) must be entered.

SR 3.0.4

Entry into a specified Condition in the Applicability of an LCO shall not be made, unless the LCO's Surveillances have been met within their specified Frequency. This provision shall not prevent entry into specified conditions in the Applicability that are required to comply with Actions or that are related to the unloading of MAGNASTOR.

3.1 MAGNASTOR SYSTEM Integrity

3.1.1 Transportable Storage Canister (TSC)

LCO 3.1.1

The TSC shall be dry and helium filled. 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 with 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 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 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 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[1]

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

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

Note: The helium backfill times and TSC transfer times provided in Tables 1.B and 1.D shall be used for operations following the second or subsequent vacuum drying cycles using the MTC.

(continued)

[1] CE 16 × 16 fuel only, with a maximum storage cell location heat load of 811 watts.

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:

	Heat Load	Time Limit (hours)
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

(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
	AND	
	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.	B.1 Perform an engineering evaluation to determine the effect of helium density differential.	72 hours
	AND	
	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.	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	Following vacuum drying and evacuation to < 3 torr, backfill the cavity with high purity helium until a mass M_{helium} corresponding to the free volume of the TSC measured during draining (V_{TSC}), multiplied by the helium density (L_{helium}) required for the design basis heat load and specified in Table A3-1, is reached.	Once, prior to TRANSPORT OPERATIONS.

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

Fuel Type	Helium Density (g/liter)
PWR	0.694 – 0.802
BWR	0.704 – 0.814

3.1 MAGNASTOR SYSTEM Integrity

3.1.2 CONCRETE CASK Heat Removal System

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

APPLICABILITY: During STORAGE OPERATIONS

ACTIONS

NOTE
Separate Condition entry is allowed for each MAGNASTOR SYSTEM.

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

SURVEILLANCE REQUIREMENTS

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

PROPOSED

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 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.

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

(continued)

PROPOSED

SURVEILLANCE REQUIREMENTS

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 OPERATIONS or UNLOADING OPERATIONS. <u>AND</u> Every 24 hours thereafter while the TSC is in the spent fuel pool or while water is in the TSC.

3.3 MAGNASTOR SYSTEM Radiation Protection

3.3.1 CONCRETE CASK Maximum Surface Dose Rate

LCO 3.3.1 The maximum surface dose rates for the CONCRETE CASK, Reference Figure A3-1, shall not exceed the following limits:

a. PWR and BWR – 120 mrem/hour gamma and 5 mrem/hour neutron on the vertical concrete surfaces; and

b. PWR and BWR – 450 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.

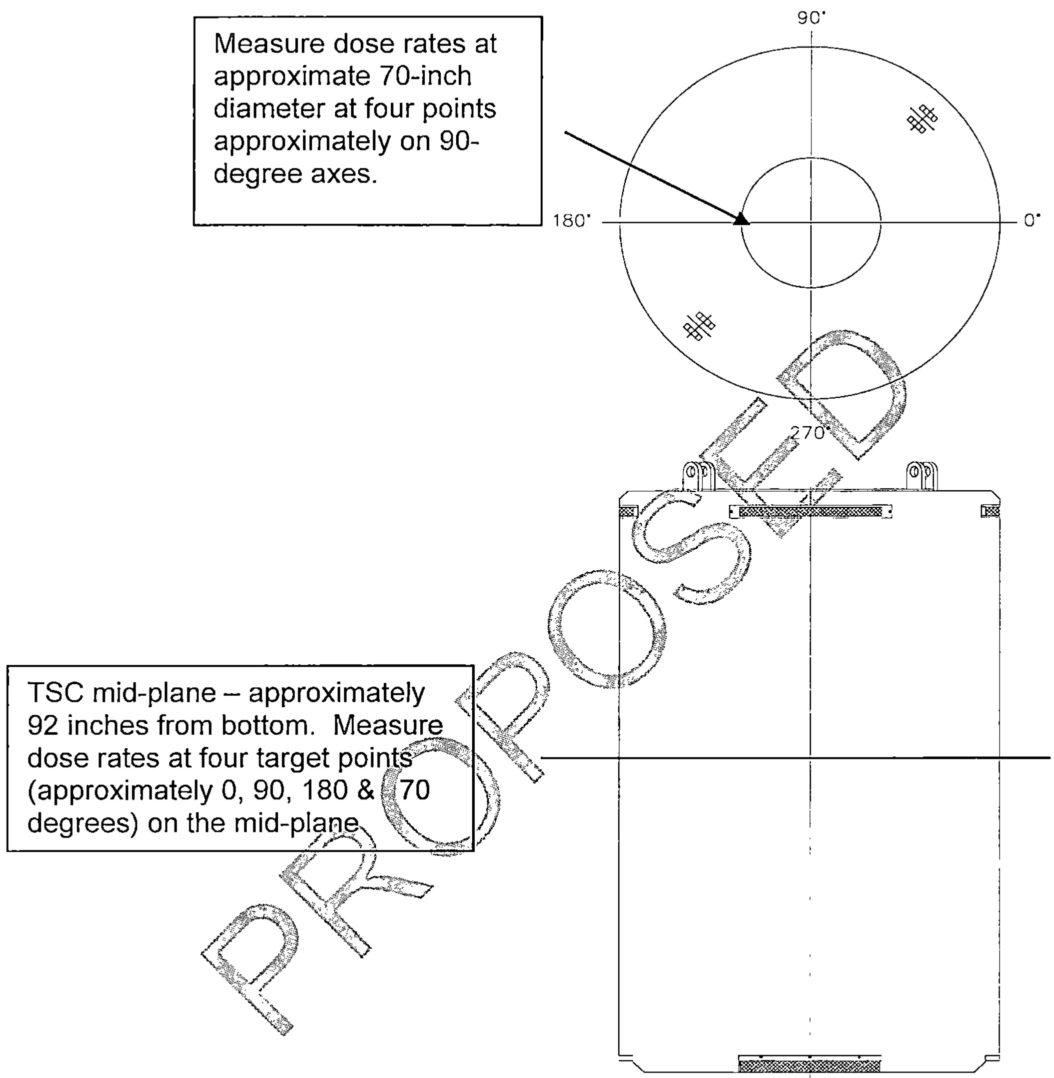
CONDITION	REQUIRED ACTION	COMPLETION TIME
A. CONCRETE CASK maximum surface dose rate limits not met	A.1 Administratively verify correct fuel loading	24 hours
	AND	
	A.2 Perform analysis to verify compliance with the ISFSI radiation protection requirements of 10 CFR 20 and 10 CFR 72	7 days
B. Required 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

(continued)

SURVEILLANCE REQUIREMENTS

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

Figure A3-1 CONCRETE CASK 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. 10,000 dpm/100 cm^2 from beta and gamma sources; and

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

APPLICABILITY: During LOADING OPERATIONS

ACTIONS

---NOTE---
Separate Condition entry is allowed for each MAGNASTOR SYSTEM.

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

(continued)

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.3.2	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

4.0 DESIGN FEATURES

4.1 Design Features Significant to Safety

4.1.1 Criticality Control

a) Minimum ^{10}B loading in the neutron absorber material:

Neutron Absorber Type	Required Minimum Effective Areal Density (^{10}B g/cm^2)		% Credit Used in Criticality Analyses	Required Minimum Actual Areal Density (^{10}B g/cm^2)	
	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

The nominal configuration transfer cask radial bulk shielding (i.e., shielding integral to the transfer cask; excludes supplemental shielding) must provide a

(continued)

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 % B_4C 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).

4.1.4 TSC Confinement Integrity

The TSC shell, bottom plate, all confinement welds, and the COMPOSITE CLOSURE 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).

4.2 Codes and Standards

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

4.2.1 Alternatives to Codes, Standards, and Criteria

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.

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

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:

(continued)

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.

4.3 Site-Specific Parameters and Analyses

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

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 ≤106°F.

b. The allowed temperature extremes, averaged over a three-day period, shall be ≥–40°F and ≤133°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 CONCRETE 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°F. This limit is NOT applicable to the stainless steel MTC or PMTC.

g. The CONCRETE CASK shall not be lifted by the lifting lugs with surrounding air temperatures < 0°F.

h. Loaded CONCRETE CASK lifting height limit ≤24 inches.

(continued)

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.

4.4 TSC Handling and Transfer Facility

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.

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.

(continued)

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 ≤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 CONCRETE CASK in a horizontal orientation is not permitted.

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 ≥ 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[1]
W' = Tornado wind load for the facility site[1]
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

The following programs shall be established, implemented and maintained.

5.1 Radioactive Effluent Control Program

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

A program shall be established and maintained to implement the FSAR, Chapter 9 requirements for loading fuel and components into the TSC, unloading fuel and components from the TSC, and preparing the TSC and CONCRETE 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 shall provide for evaluation and control of the following FSAR requirements during the applicable operation:

a. Verify that no TRANSFER CASK handling or CONCRETE CASK handling using the lifting lugs occurs when the ambient temperature is < 0°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.

c. Verify that the drying time, cavity vacuum pressure, and component and gas temperatures ensure that the fuel cladding temperature limit of 400°C is not exceeded during TSC preparation activities, including TRANSFER OPERATIONS, and that the TSC is adequately dry. For fuel with burnup > 45 GWd/MTU, limit cooling cycles to ≤ 10 for temperature changes greater than 65°C.

d. Verify that the helium backfill purity and mass assure adequate heat transfer and preclude fuel cladding corrosion.

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.

(continued)

f. Verify that the time to complete the transfer of the TSC from the TRANSFER CASK to the CONCRETE CASK and from a CONCRETE CASK to another CONCRETE CASK assures that the fuel cladding temperature limit of 400°C is not exceeded.

g. The surface dose rates of the CONCRETE CASK are adequate to allow proper storage and to assure consistency with the offsite dose analysis.

h. The equipment used to move the loaded CONCRETE 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.

PROPOSED

5.3 Transport Evaluation Program

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 or CONCRETE 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.

5.4 ISFSI Operations Program

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 CONCRETE 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 CONCRETE CASK lift heights ensure that the g-load limits analyzed in the FSAR are not exceeded.

(continued)

5.5 Radiation Protection Program

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 CONCRETE CASK outside of facilities governed by 10 CFR 50. 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 CONCRETE 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.

5.6 Special Requirements for the First System Placed in Service

The heat transfer characteristics and thermal performance of the MAGNASTOR SYSTEM will be validated by recorded mass flow measurements in the air flow cooling passages of the first system placed in service with a heat load equal to or greater than 30 kW. A letter report summarizing the results of the measurements with respect to analyses of the actual canister content will be submitted to the NRC in accordance with 10 CFR 72.4 within 60 days of placing the loaded cask on the ISFSI pad. The report will include a comparison of the calculated mass flow of the MAGNASTOR SYSTEM at the loaded heat load to the measured mass flow. A report is not required to be submitted for the MAGNASTOR SYSTEMs that are subsequently loaded, provided that the performance of the first system placed in service with a heat load of ≥ 30 kW is demonstrated by the comparison of the calculated and measured mass flow rates.

(continued)

5.7 Training Program

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).

5.8 Preoperational Testing and Training Exercises

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 into its designated loading area
b. Moving the TRANSFER CASK containing the empty TSC into the spent fuel pool
c. Loading one or more dummy fuel assemblies into the TSC, including independent verification
d. Selection and verification of fuel assemblies to ensure conformance with appropriate loading configuration requirements
e. Installing the closure lid
f. Removal of the TRANSFER CASK from the spent fuel pool
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
j. Transfer of the TSC to the CONCRETE CASK
k. CONCRETE CASK lid assembly installation
l. Transport of the CONCRETE CASK to the ISFSI
m. TSC removal from the CONCRETE 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.

APPENDIX B

APPROVED CONTENTS
FOR THE MAGNASTOR SYSTEM

AMENDMENT 6

Appendix B
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1.0 FUEL SPECIFICATIONS AND LOADING CONDITIONS

The MAGNASTOR SYSTEM is designed to safely store up to 37 undamaged PWR fuel assemblies in the 37 PWR Basket Assembly or up to 87 undamaged BWR fuel assemblies in the 87 BWR Basket Assembly. The system is also designed to store up to 4 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 4 DFC locations. DFCs may be placed in up to 4 of the DFC locations. Each DFC may contain an undamaged PWR fuel assembly, a damaged PWR fuel assembly, or PWR FUEL DEBRIS equivalent to one PWR fuel assembly. FUEL DEBRIS is included in the definition of DAMAGED FUEL (Appendix A, Section 1.1). PWR UNDAMAGED FUEL assemblies may be placed directly in the DFC locations of a DF Basket Assembly without the use of a DFC.

The system requires few operating controls. The principal controls and limits for MAGNASTOR are satisfied by the selection of fuel for storage that meets the Approved Contents presented in this section and in the tables for MAGNASTOR design basis spent fuels.

If any Fuel Specification or Loading Condition of this section is violated, the following actions shall be completed:

- The affected fuel assemblies shall be placed in a safe condition.
- Within 24 hours, notify the NRC Operations Center.
- Within 60 days, submit a special report that describes the cause of the violation and actions taken to restore or demonstrate compliance and prevent reoccurrence.

2.0 FUEL TO BE STORED IN THE MAGNASTOR SYSTEM

UNDAMAGED PWR FUEL ASSEMBLIES, DAMAGED PWR FUEL ASSEMBLIES, PWR FUEL DEBRIS (DAMAGED FUEL), UNDAMAGED BWR FUEL ASSEMBLIES and NONFUEL HARDWARE meeting the limits specified in Tables B2-1 through B2-41 may be stored in the MAGNASTOR SYSTEM.

Table B2-1 TSC with PWR Fuel Limits

I. TSC with PWR Fuel Basket

A. Allowable Contents

1. Uranium PWR UNDAMAGED FUEL ASSEMBLIES listed in Tables B2-2 and B2-3 and meeting the following specifications:

a. Cladding Type:	Zirconium-based alloy.
b. Enrichment, Post-irradiation Cooling Time and Average Assembly Burnup:	Generic maximum enrichment limits are shown in Table B2-2. The physical characteristics of the different PWR SNF ASSEMBLIES are defined in Table B2-3. The fuel type specific maximum enrichments as a function of neutron absorber sheet areal density at various minimum soluble boron levels are defined in Table B2-4. For variable enrichment SNF assemblies, maximum enrichments represent peak rod enrichments. Combined minimum enrichment, maximum SNF assembly average burnup and minimum cool time limits are shown generically in Tables B2-15 through B2-22 and specifically for WE 14x14 in Tables B2-25 through B2-33 and CE 16x16 in Tables B2-34 through B2-41. For SNF assembly average burnup levels below those shown in Tables B2-15 through B2-22, an SNF assembly minimum cool time is specified generically in Table B2-13, provided that the minimum initial SNF assembly average enrichment limits are applied. The minimum cool times for fuel in TSCs transferred via the PMTC are specified in Tables B2-42 and B2-43.
c. Decay Heat Per SNF Assembly	
1) Preferential Loading:	≤ 1,200 watts[a]
2) Uniform Loading:	≤ 959 watts[b]
d. Nominal Fresh Fuel Assembly Length (in.):	≤ 178.3
e. Nominal Fresh Fuel Assembly Width (in.):	≤ 8.54
f. Weight Per Storage Location (lbs.):	≤ 1,765, including SNF Assembly, NONFUEL HARDWARE and fuel spacers
g. Total Canister Contents Weight (lbs.):	≤ 62,160, including SNF Assemblies, NONFUEL HARDWARE and fuel spacers

B. Quantity per TSC: Up to 37 PWR UNDAMAGED SNF ASSEMBLIES as shown in Figure B2-1.

(continued)

[a] 1,800 Watts for the four-zone preferential loading with WE 14x14 and CE 16x16 fuel

[b] 811 Watts for the PMTC with CE 16x16 fuel only

Table B2-1 TSC with PWR Fuel Limits (continued)

C. PWR UNDAMAGED SNF ASSEMBLIES may contain NONFUEL HARDWARE. SNF assembly lattices possessing less than the nominal number of undamaged fuel rods specified in Table B2-3 must contain solid filler rods that displace a volume equal to, or greater than, that of the fuel rod that the filler rod replaces. SNF assemblies may have stainless steel rods inserted to displace guide tube "dashpot" water. NONFUEL HARDWARE cool times shall be in accordance with Tables B2-5, B2-6, and B2-7. Alternatively, the ^{60}Co curie limits in Tables B2-6 and B2-7 may be used to establish site-specific NONFUEL HARDWARE constraints.

D. Spacers may be used in a TSC to axially position SNF assemblies to facilitate handling and operations.

E. Unenriched fuel assemblies and unirradiated (i.e., not inserted in-core) fuel assemblies are not authorized for loading. Low enriched, unenriched, and/or annular fuel pellet axial end blankets are permitted, provided that the nominal length of the blanket is not greater than six (6) inches.

F. SNF may be loaded uniformly at a maximum heat load of 959 watts/assembly (Figure B2-1). Alternatively, a preferential loading pattern may be applied as described in Table B2-8 and Figure B2-2. TSCs to be transferred via the PMTC may be loaded at a maximum heat load of 811 watts/assembly.

G. RCCs are restricted to fuel storage locations No. 11, 12, 13, 18, 19, 20, 25, 26 and 27 (Figure B2-1). Minimum RCC cool times are:

Minimum Cool Time (years)	Maximum Exposure (GWd/MTU)
10[a]	180
14	270
20	360

H. One Neutron Source or Neutron Source Assembly (NSA) is permitted to be loaded in a TSC in fuel storage locations No. 11, 12, 13, 18, 19, 20, 25, 26, or 27 (Figure B2-1). Neutron source assemblies may contain source rods attached to hardware similar in configuration to guide tube plug devices (thimble plugs) and burnable absorbers, in addition to containing burnable poison rodlets and/or thimble plug rodlets. For NSAs containing absorber rodlets, the BPAA cool time and burnup/exposure or hardware ^{60}Co curie limit listed in Table B2-6 are applied to the neutron sources. NSAs having only thimble plug rodlets require the thimble plug restriction in Table B2-7 to be applied. Combination NSAs, containing both thimble plug and burnable absorber rodlets must apply the more limiting of the two minimum cool time/curie limit.

I. Fuel assemblies may contain any number of unirradiated (i.e., not inserted in-core) nonfuel solid filler fuel replacement rods. Activated stainless steel rods are limited to 5 per assembly at a maximum burnup/exposure of 32.5 GWd/MTU.

J. Fuel assemblies may contain an HFRA at a maximum burnup/exposure of 4.0 GWd/MTU and a minimum cool time of 16 years.

(continued)

[a] 2.5 years for the WE 14x14 RCC in uniform and four-zone preferential loading and 5.0 years for the CE 16x16 RCC in uniform and four-zone preferential loading (footnote not applicable for PMTC payloads)

Table B2-1 TSC with PWR Fuel Limits (continued)

II. TSC with DF Basket Assembly

A. Allowable Contents

1. Uranium PWR UNDAMAGED SNF ASSEMBLIES and DAMAGED FUEL (PWR DAMAGED SNF ASSEMBLIES or PWR FUEL DEBRIS) listed in Tables B2-2 and B2-3 and meeting the following specifications:

a. Cladding Type:	Zirconium-based alloy.
b. Enrichment, Post-irradiation Cooling Time and Average Assembly Burnup:	Generic maximum enrichment limits are shown in Table B2-2. The physical characteristics of the different PWR SNF ASSEMBLIES are defined in Table B2-3. The fuel type specific *maximum enrichments as a function of neutron absorber sheet* areal density at various minimum soluble boron levels are defined in Table B2-4. For variable enrichment SNF assemblies, maximum SNF enrichments represent peak rod enrichments. Combined minimum enrichment, maximum SNF assembly average burnup and minimum cool time limits are shown generically in Tables B2-15 through B2-22 and specifically for WE 14x14 in Tables B2-25 through B2-33 and CE 16x16 in Tables B2-34 through B2-41. For SNF assembly average burnup levels below those shown in Tables B2-15 through B2-22, an SNF assembly minimum cool time is specified generically in Table B2-13, provided that the minimum initial SNF assembly average enrichment limits are applied. The minimum cool times for fuel in TSCs transferred via the PMTC are specified in Tables B2-42 and B2-43.
c. Decay Heat Per SNF Assembly	
1). Preferential Loading:	≤ 1,200 watts[a]
2). Uniform Loading:	≤ 959 watts[b]
d. Nominal Fresh SNF Assy:	≤ 178.3
e. Nominal Fresh SNF Assembly Width (in.):	≤ 8.54
f. Weight Per Storage location (lbs.)	≤ 1,765, including SNF Assembly, NONFUEL HARDWARE, DFC and fuel spacer
g. Total Canister Contents Weight (lbs.)	≤ 61,184, including SNF Assemblies, NONFUEL HARDWARE, DFCs and fuel spacers

(continued)

[a] 1,800 Watts for the four-zone preferential loading with WE 14x14 and CE 16x16 fuel
[b] 811 Watts for the PMTC with CE 16x16 fuel only

Table B2-1 TSC with PWR Fuel Limits (continued)

B. Quantity per TSC: Up to a total of 37 PWR UNDAMAGED SNF ASSEMBLIES including up to four (4) DFCs containing PWR UNDAMAGED SNF ASSEMBLIES, PWR DAMAGED SNF ASSEMBLIES, and/or PWR FUEL DEBRIS loaded in the DFC locations No. 4, 8, 30 and 34, as shown on Figure B2-3, for the DF Basket Assembly.

C. The contents of a DFC must be less than, or equivalent to, one PWR UNDAMAGED SNF ASSEMBLY. PWR SNF ASSEMBLIES loaded in a DFC shall not contain NONFUEL HARDWARE with the exception of instrument tube tie components, guide tube anchors or similar devices, and steel inserts.

D. PWR UNDAMAGED SNF ASSEMBLIES not loaded in a DFC may contain NONFUEL HARDWARE consistent with Table B2-5. SNF assembly lattices not containing the nominal number of fuel rods specified in Table B2-3 must contain solid filler rods that displace a volume equal to, or greater than, that of the fuel rod that the filler rod replaces. SNF assemblies may have stainless steel rods inserted to displace guide tube "dashpot" water. NONFUEL HARDWARE cool times shall be in accordance with Tables B2-5, B2-6, and B2-7. Alternatively, the ^{60}Co curie limits in Tables B2-6 and B2-7 may be used to establish site-specific NONFUEL HARDWARE constraints. Alternatively, the ^{60}Co curie limits in Tables B2-6 and B2-7 may be used to establish site-specific NONFUEL HARDWARE constraints.

E. Spacers may be used in a TSC to axially position PWR UNDAMAGED SNF ASSEMBLIES, and DFCs to facilitate handling and operation.

F. Unenriched fuel assemblies and unirradiated (i.e., not inserted in-core) fuel assemblies are not authorized for loading. Low enriched, unenriched, and/or annular fuel pellet axial end blankets are permitted, provided that the nominal length of the end blanket is not greater than six (6) inches.

G. RCCs are restricted to fuel storage locations No. 11, 12, 13, 18, 19, 20, 25, 26 and 27 (Figure B2-3). Minimum RCC cool times are:

Minimum Cool Time (years)	Maximum Exposure (GWd/MTU)
10[a]	180
14	270
20	360

(continued)

[a] 2.5 years for the WE 14x14 RCC in uniform and four-zone preferential loading and 5.0 years for the CE 16x16 RCC in uniform and four-zone preferential loading (footnote not applicable for PMTC payloads)

Table B2-1 TSC with PWR Fuel Limits (continued)

H. One Neutron Source, or Neutron Source Assembly (NSA) is permitted to be loaded in a TSC in fuel storage locations No. 11, 12, 13, 18, 19, 20, 25, 26 or 27 (Figure B2-1). Neutron source assemblies may contain source rods attached to hardware similar in configuration to guide tube plug devices (thimble plugs) and burnable absorbers, in addition to containing burnable poison rodlets and/or thimble plug rodlets. For NSAs containing absorber rodlets, the BPAA cool time and burnup/exposure or hardware ^{60}Co curie limit listed in Table B2-6 are applied to the neutron sources. NSAs having only thimble plug rodlets require the thimble plug restriction in Table B2-7 to be applied. Combination NSAs, containing both thimble plug and burnable absorber rodlets must apply the more limiting of the two minimum cool time/curie limit.

I. Fuel assemblies may contain any number of unirradiated (i.e., not inserted in-core) nonfuel solid filler fuel replacement rods. Activated stainless steel rods are limited to 5 per assembly at a maximum burnup/exposure of 32.5 GWd/MTU.

J. Fuel assemblies may contain an HFRA at a maximum burnup/exposure of 4.0 GWd/MTU and a minimum cool time of 16 years.

Table B2-2 PWR Fuel Assembly Characteristics

Characteristic	14×14	14×14	15×15	15×15	16×16	17×17
Max Initial Enrichment (wt % ^{235}U)	5.0	5.0	5.0	5.0	5.0	5.0
Min Initial Enrichment (wt % ^{235}U)	1.3	1.3	1.3	1.3	1.3	1.3
Number of Fuel Rods	176	179	204	208	236	264
Max Assembly Average Burnup (MWd/MTU)	60,000	60,000	60,000	60,000	60,000	60,000
Peak Average Rod Burnup (MWd/MTU)	62,500	62,500	62,500	62,500	62,500	62,500
Min Cool Time (years)	4	4[2]	4	4	4	4
Max Weight (lb) per Storage Location	See Note 1	See Note 1	See Note 1	See Note 1	See Note 1	See Note 1
Max Decay Heat (Watts) per Preferential Storage Location	1,200	1,800	1,200	1,200	1, 800	1,200

- All reported enrichment values are nominal preirradiation fabrication values.
- Maximum initial enrichment is based on a minimum soluble boron concentration in the spent fuel pool water. Required soluble boron content is fuel type and enrichment specific. Minimum soluble boron content varies between 1,500 and 2,500 ppm. Maximum initial enrichment represents the peak fuel rod enrichment for variably-enriched fuel assemblies.

Notes:

1. Maximum weight per storage location is as detailed in Table B2-1
2. Minimum cool time of 2.5 years for WE 14x14 PWR fuel for uniform and four-zone preferential loading

Table B2-3 Bounding PWR Fuel Assembly Loading Criteria

Assembly Type	No. of Fuel Rods	No. of Guide Tubes[1]	Geometry[2]						
			Max Pitch (inch)	Min Clad OD (inch)	Min Clad Thick. (inch)	Max Pellet OD (inch)	Max Active Length (inch)	Max Load (MTU)
BW15H1	208	17	0.568	0.43	0.0265	0.3686	144.0	0.4858
BW15H2	208	17	0.568	0.43	0.025	0.3735	144.0	0.4988
BW15H3	208	17	0.568	0.428	0.023	0.3742	144.0	0.5006
BW15H4	208	17	0.568	0.414	0.022	0.3622	144.0	0.4690
BW17H1	264	25	0.502	0.377	0.022	0.3252	144.0	0.4799
CE14H1	176	5	0.58	0.44	0.026	0.3805	137.0	0.4167
CE16H1	236	5	0.5063	0.382	0.025	0.325	150.0	0.4463
WE14H1	179	17	0.556	0.40	0.0162	0.3674	145.2	0.4188
WE15H1	204	21	0.563	0.422	0.0242	0.3669	144.0	0.4720
WE15H2	204	21	0.563	0.417	0.0265	0.357	144.0	0.4469
WE17H1	264	25	0.496	0.372	0.0205	0.3232	144.0	0.4740
WE17H2	264	25	0.496	0.36	0.0225	0.3088	144.0	0.4327

1 Combined number of guide and instrument tubes.
2 Assembly characteristics represent cold, unirradiated, nominal configurations.

Note: Amendment No. 2 removed the enrichment/soluble boron limits from this table, along with the note pertaining to them. This information is now presented in Table B2-4.

Table B2-4 Bounding PWR Fuel Assembly Loading Criteria – Enrichment/Soluble Boron Limits

TSC with Undamaged PWR Fuel Basket Assembly Max. Initial Enrichment (wt % ^{235}U)

	Absorber[a] 0.036 ^{10}B g/cm^2					Absorber[a] 0.030 ^{10}B g/cm^2					Absorber[a] 0.027 ^{10}B g/cm^2				
Soluble Boron	1500 (ppm)	1750 (ppm)	2000 (ppm)	2250 (ppm)	2500 (ppm)	1500 (ppm)	1750 (ppm)	2000 (ppm)	2250 (ppm)	2500 (ppm)	1500 (ppm)	1750 (ppm)	2000 (ppm)	2250 (ppm)	2500 (ppm)
BW15H1	3.7%	4.1%	4.4%	4.7%	5.0%	3.6%	4.0%	4.2%	4.5%	4.8%	3.6%	3.9%	4.2%	4.5%	4.8%
BW15H2	3.7%	4.0%	4.3%	4.6%	4.9%	3.6%	3.9%	4.2%	4.5%	4.8%	3.6%	3.8%	4.1%	4.4%	4.7%
BW15H3	3.7%	4.0%	4.3%	4.6%	4.9%	3.6%	3.9%	4.2%	4.4%	4.7%	3.5%	3.8%	4.1%	4.4%	4.7%
BW15H4	3.8%	4.2%	4.5%	4.8%	5.0%	3.7%	4.1%	4.4%	4.7%	5.0%	3.7%	4.0%	4.3%	4.6%	5.0%
BW17H1	3.7%	4.0%	4.3%	4.6%	4.9%	3.6%	3.9%	4.2%	4.5%	4.8%	3.6%	3.9%	4.1%	4.5%	4.7%
CE14H1	4.5%	4.8%	5.0%	5.0%	5.0%	4.3%	4.7%	5.0%	5.0%	5.0%	4.3%	4.6%	5.0%	5.0%	5.0%
CE16H1	4.4%	4.8%	5.0%	5.0%	5.0%	4.3%	4.6%	5.0%	5.0%	5.0%	4.2%	4.6%	4.9%	5.0%	5.0%
WE14H1	4.7%	5.0%	5.0%	5.0%	5.0%	4.6%	5.0%	5.0%	5.0%	5.0%	4.5%	5.0%	5.0%	5.0%	5.0%
WE15H1	3.8%	4.2%	4.5%	4.8%	5.0%	3.7%	4.1%	4.4%	4.7%	5.0%	3.7%	4.0%	4.3%	4.6%	4.9%
WE15H2	4.0%	4.4%	4.7%	5.0%	5.0%	3.9%	4.2%	4.6%	4.9%	5.0%	3.8%	4.2%	4.5%	4.8%	5.0%
WE17H1	3.7%	4.1%	4.4%	4.7%	5.0%	3.7%	4.0%	4.3%	4.6%	4.9%	3.6%	3.9%	4.2%	4.5%	4.9%
WE17H2	4.0%	4.3%	4.7%	5.0%	5.0%	3.9%	4.3%	4.6%	4.9%	5.0%	3.8%	4.2%	4.5%	4.9%	5.0%

TSC with Damaged PWR Fuel Basket Assembly Max. Initial Enrichment (wt % ^{235}U)

BW15H1	3.7%	4.0%	4.3%	4.6%	4.9%	3.6%	3.[illegible]%	4.2%	4.5%	4.7%	3.6%	3.8%	4.1%	4.4%	4.7%
BW15H2	3.6%	3.9%	4.2%	4.5%	4.8%	3.6%	3.8%	4.1%	4.4%	4.7%	3.5%	3.8%	4.1%	4.3%	4.6%
BW15H3	3.6%	3.9%	4.2%	4.5%	4.8%	3.5%	3.8%	4.1%	4.4%	4.6%	3.5%	3.8%	4.0%	4.3%	4.6%
BW15H4	3.8%	4.1%	4.4%	4.7%	5.0%	3.7%	4.0%	4.3%	4.6%	4.9%	3.6%	3.9%	4.2%	4.5%	4.8%
BW17H1	3.6%	3.9%	4.2%	4.5%	4.8%	3.6%	3.9%	4.1%	4.4%	4.7%	3.5%	3.8%	4.1%	4.4%	4.6%
CE14H1	4.4%	4.8%	5.0%	5.0%	5.0%	4.3%	4.7%	5.0%	5.0%	5.0%	4.3%	4.6%	4.9%	5.0%	5.0%
CE16H1	4.4%	4.7%	5.0%	5.0%	5.0%	4.2%	4.6%	5.0%	5.0%	5.0%	4.2%	4.5%	4.9%	5.0%	5.0%
WE14H1	4.6%	5.0%	5.0%	5.0%	5.0%	4.5%	5.0%	5.0%	5.0%	5.0%	4.5%	4.9%	5.0%	5.0%	5.0%
WE15H1	3.8%	4.1%	4.4%	4.7%	5.0%	3.7%	4.0%	4.3%	4.6%	4.9%	3.6%	4.0%	4.3%	4.6%	4.8%
WE15H2	3.9%	4.3%	4.6%	4.9%	5.0%	3.8%	4.2%	4.5%	4.8%	5.0%	3.8%	4.1%	4.4%	4.7%	5.0%
WE17H1	3.7%	4.0%	4.3%	4.6%	4.9%	3.6%	3.9%	4.2%	4.5%	4.8%	3.6%	3.9%	4.2%	4.5%	4.8%
WE17H2	3.9%	4.3%	4.6%	5.0%	5.0%	3.9%	4.2%	4.5%	4.9%	5.0%	3.8%	4.1%	4.5%	4.8%	5.0%

- Specified soluble boron concentrations are independent of whether an assembly contains a nonfuel insert.

[a] Borated aluminum neutron absorber sheet effective areal ^{10}B density.

Table B2-5 Additional SNF Assembly Cool Time Required to Load NONFUEL HARDWARE

Assy		Uniform	Three-Zone A	Three-Zone B	Three-Zone C	Four-Zone A	Four-Zone B1	Four-Zone B2	Four-Zone C
CE 14x14	BPAA/HFRA	--	--	--	--	--	--	--	--
	GTPD/NSA	--	--	--	--	--	--	--	--
	RCC	0.2	0.2	0.1	0.2	--	--	--	--
WE 14x14	BPAA/HFRA	0.5	0.5	0.2	0.7	1.4	0.1	0.1	0.7
	GTPD/NSA	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1
	RCC	0.7	2.3	0.7	4.1	2.2	0.2	0.1	1.0
WE 15x15	BPAA/HFRA	0.5	0.6	0.2	0.8	--	--	--	--
	GTPD/NSA	0.1	0.1	0.1	0.1	--	--	--	--
	RCC	3.1	3.4	1.5	4.5	--	--	--	--
B&W 15x15	BPAA/HFRA	0.1	0.1	0.1	0.1	--	--	--	--

[a] WE14x14 Uniform and four-zone preferential are evaluated using RCC with 2.5-year minimum cool time

	GTPD/NSA	0.1	0.1	0.1	0.1	--	--	--	--
	RCC	0.2	0.2	0.1	0.2	--	--	--	--
CE 16x16	BPAA/HFRA	--	--	--	--	--	--	--	--
	GTPD/NSA	--	--	--	--	--	--	--	--
	RCC[a]	0.4[b]	0.2	0.1	0.3	0.8	0.1	0.1	0.4
WE 17x17	BPAA/HFRA	0.5	0.6	0.2	0.7	--	--	--	--
	GTPD/NSA	0.1	0.1	0.1	0.1	--	--	--	--
	RCC	2.9	3.3	1.4	4.3	--	--	--	--
B&W 17x17	BPAA/HFRA	0.1	0.1	0.1	0.1	--	--	--	--
	GTPD/NSA	0.1	0.1	0.1	0.1	--	--	--	--
	RCC	0.2	0.2	0.1	0.2	--	--	--	--

Note: Additional SNF assembly cooling time to be added to the minimum SNF assembly cool time based on SNF assembly initial enrichment and SNF assembly average burnup listed in Tables B2-15 through B2-22 and B2-25 through B2-43.

[a] CE16x16 Uniform and four-zone preferential are evaluated using RCC with 5-year minimum cool time

[b] 0.4 years for RCC in the PMTC (reduced storage location heat load). For all other cask types, 0.3 years for RCC 5-year minimum cool time or 0.2 years for RCC with 10-year minimum cool time

Table B2-6 Allowed BPAA/NSA Burnup and Cool Time Combinations

Maximum Burnup (GWd/MTU)	Minimum Cool Time (yrs)				
	WE 14×14	WE 15×15	B&W 15×15	WE 17×17	B&W 17×17
10	0.5	0.5	0.5	0.5	0.5
15	0.5	0.5	0.5	0.5	0.5
20	0.5	1.0	2.0	2.0	0.5
25	1.0	2.5	3.5	3.5	1.0
30	2.5	4.0	5.0	5.0	2.5
32.5	3.0	4.5	6.0	6.0	3.0
35	3.5	5.0	6.0	6.0	3.5
37.5	4.0	6.0	7.0	7.0	4.0
40	4.5	6.0	7.0	7.0	4.5
45	5.0	7.0	8.0	8.0	6.0
50	6.0	8.0	9.0	9.0	7.0
55	7.0	8.0	10.0	9.0	7.0
60	7.0	9.0	10.0	10.0	8.0
65	8.0	10.0	12.0	12.0	8.0
70	8.0	10.0	12.0	12.0	9.0
Max ^{60}Co Activity (Ci)	718	733	19	637	26

Note: Specified minimum cool times for BPRAs are independent of the required minimum cool times for the fuel assembly containing the BPRA.

Table B2-7 Allowed GTPD/NSA Burnup and Cool Time Combinations

Maximum Burnup (GWd/MTU)	Minimum Cool Time (yrs)				
	WE 14×14	WE 15×15	B&W 15×15	WE 17×17	B&W 17×17
45	2.0	3.5	7.0	5.0	6.0
90	6.0	7.0	10.0	9.0	10.0
135	7.0	9.0	12.0	10.0	12.0
180	8.0	9.0	14.0	12.0	12.0
^{60}Co Activity (Ci)	63.5	64.1	56.9	64.0	63.6

Note: Specified minimum cool times for thimble plugs are independent of the required minimum cool times for the fuel assembly containing the thimble plug.

Table B2-8 PWR Fuel Preferential Loading Pattern Definitions

Three-Zone

Zone Description (see Figure B2-2)	Designator	Maximum Heat Load (W/assy)	# Assemblies
Inner Zone	A	922	9
Middle Zone	B	1,200	12
Outer Zone	C	800	16

Four-Zone

Zone Description (see Figure B2-2)	Designator	Maximum Heat Load (W/assy)	# Assemblies
Inner Zone	A	513	9
Middle Zone	B1	1,300	8
	B2	1,800	4
Outer Zone	C	830	16

Figure B2-1 Schematic of 37-Assembly PWR Basket

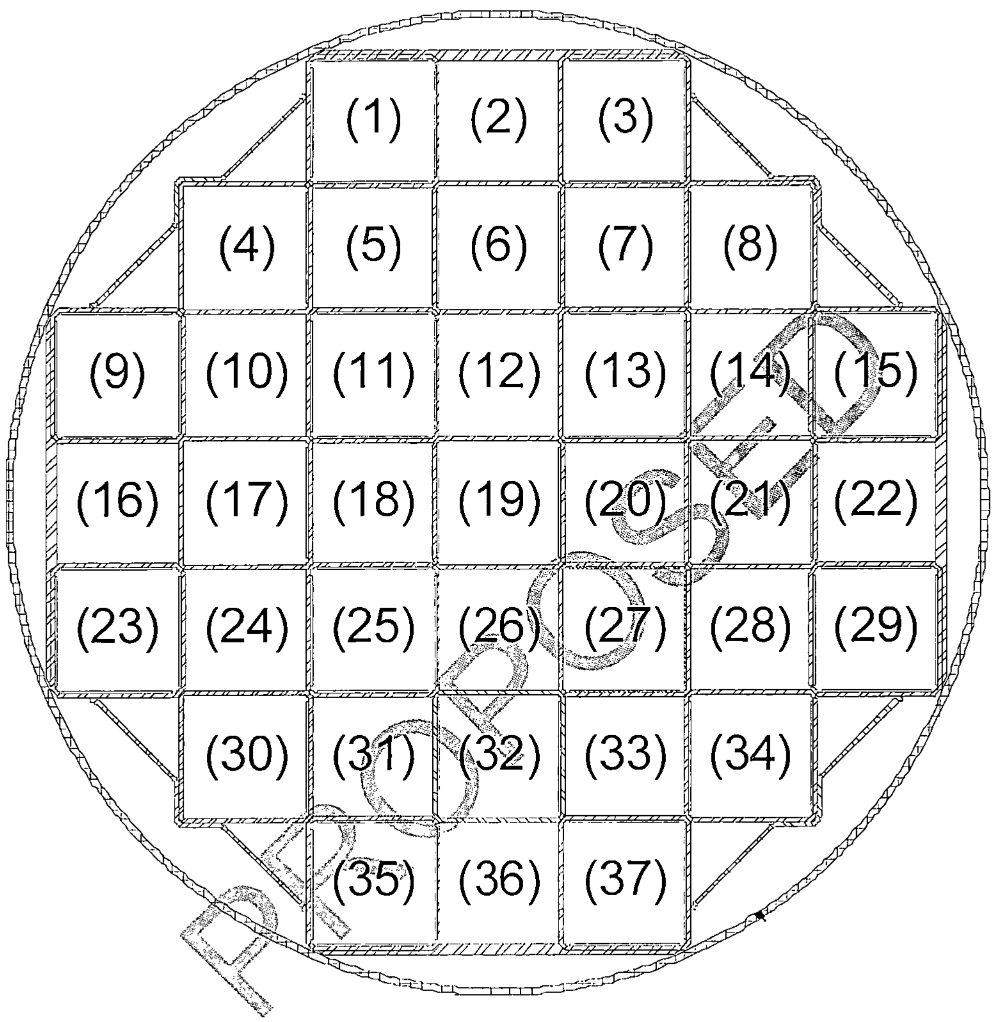
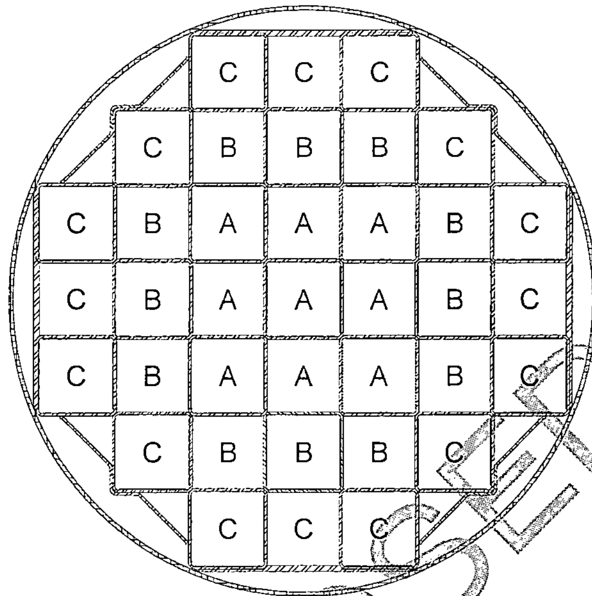
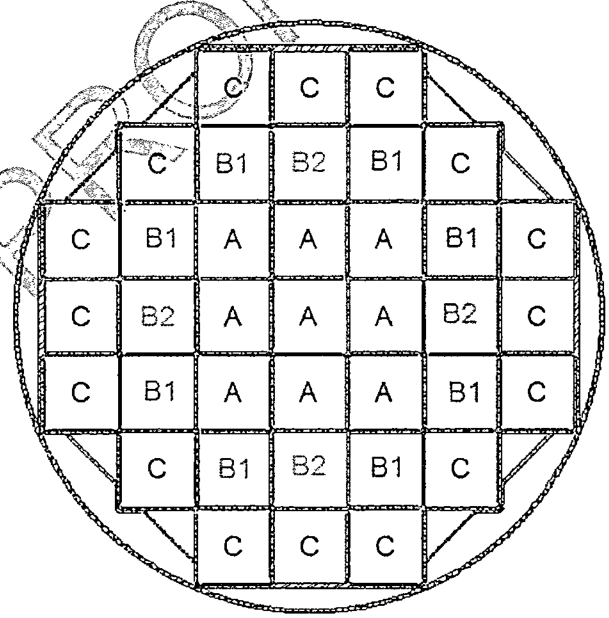


Figure B2-2 Schematic of 37-Assembly PWR Basket Preferential Loading Patterns

Three-Zone

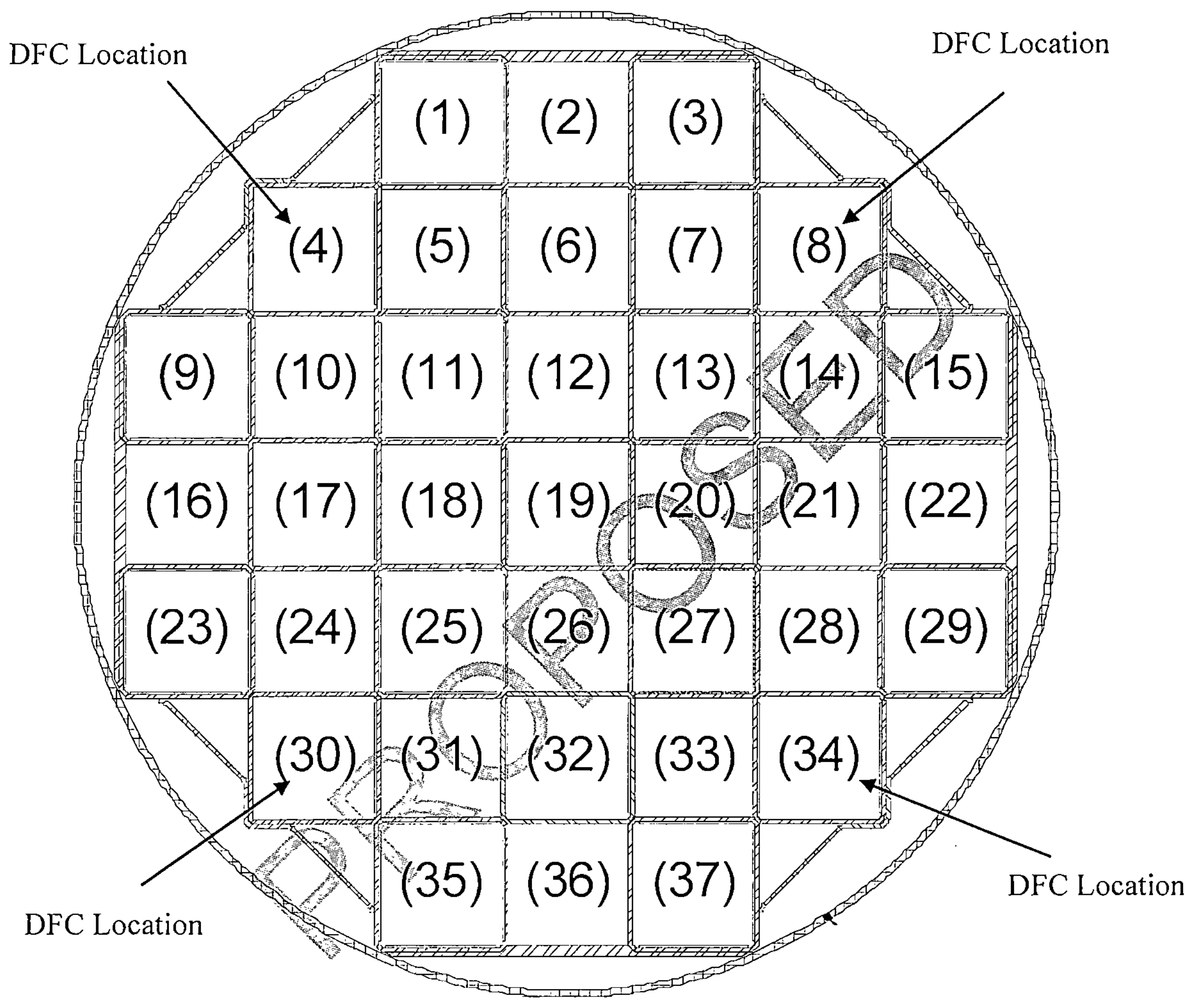


Four-Zone



Refer to Table B2-8 for Maximum Heat Loads

Figure B2-3 Schematic of DF Basket Assembly Configuration for PWR SNF with DFCs



DFC designated locations may contain a loaded DFC or a PWR UNDAMAGED SNF ASSEMBLY.

Table B2-9 TSC with BWR Fuel Limits

I. BWR FUEL

A. Allowable Contents

1. Uranium BWR UNDAMAGED FUEL assemblies listed in Tables B2-10 and B2-11 and meeting the following specifications:

a. Cladding Type:	Zirconium-based alloy.
b. Enrichment: Post-irradiation Cooling Time and Assembly Average Burnup	Generic maximum INITIAL PEAK PLANAR-AVERAGE ENRICHMENTS are shown in Table B2-10. The physical characteristics of the different BWR SNF ASSEMBLIES are defined in Table B2-11. Fuel type specific enrichment limits for the 87-assembly and 82-assembly BWR fuel basket configurations are defined in Table B2-12 as a function of neutron absorber areal density. Combined minimum enrichment, maximum SNF assembly average burnup and minimum cool time limits are shown in Table B2-23 and Table B2-24. For SNF assembly average burnup levels below those shown in Table B2-23 and Table B2-24, an SNF assembly minimum cool time is specified in Table B2-14, provided that the minimum initial SNF assembly average enrichment limits are applied.
c. Decay Heat per SNF Assembly:	≤ 379 watts
d. Nominal Fresh Fuel Design SNF Assembly Length (in.):	≤ 176.2
e. Nominal Fresh Fuel Design SNF Assembly Width (in.):	≤ 5.52
f. SNF Assembly Weight (lb):	≤ 704, including channels

B. Quantity per TSC: Up to 87 BWR UNDAMAGED SNF ASSEMBLIES. With the exception of the designated nonfuel locations in the 82-assembly basket configuration, fuel storage locations not containing a fuel assembly shall have an empty fuel cell insert installed. Prior to use of the 86 and 82-assembly configurations, the cell fuel storage locations as noted and shown in Figures B2-4 and B2-5 must be physically blocked to prevent fuel assembly loading, respectively.

(continued)

Table B2-9 TSC with BWR Fuel Limits (continued)

C. BWR fuel assemblies may be unchanneled, or channeled with zirconium-based alloy channels.

D. BWR fuel assemblies with stainless steel channels are not authorized.

E. SNF Assembly lattices possessing less than the nominal number of undamaged fuel rods (see Table B2-11) must contain solid filler rods that displace a volume equal to, or greater than, that of the fuel rod that the filler rod replaces.

F. Spacers may be used in a TSC to axially position BWR SNF assemblies to facilitate handling.

G. Unirradiated (i.e., not inserted in-core) fuel assemblies are not authorized for loading. Unenriched axial blankets are permitted, provided that the nominal length of the blanket is not greater than six (6) inches.

H. Allowable SNF assembly locations for the 86-assembly fuel basket configuration is shown in Figure B2-4.

I. Allowable SNF assembly locations for the standard and alternate 82-assembly fuel basket configurations are shown in Figure B2-5.

Table B2-10 BWR SNF Assembly Characteristics

Characteristic	Fuel Class			
	7×7	8×8	9×9	10×10
Max Initial Enrichment (wt % ^{235}U)	4.5	4.5	4.5	4.5
Number of Fuel Rods	48/49	59/60/61/ 62/63/64	72/74[a]/76/ 79/80	91[a]/92[a]/ 96[a]/100
Max Assembly Average Burnup (MWd/MTU)	60,000	60,000	60,000	60,000
Peak Average Rod Burnup (MWd/MTU)	62,500	62,500	62,500	62,500
Min Cool Time (years)	4	4	4	4
Min Average Enrichment (wt % ^{235}U)	0.7	0.7	0.7	0.7
Max Weight (lb) per Storage Location	704	704	704	704
Max Decay Heat (Watts) per Storage Location	379	379	379	379

- Each BWR fuel assembly may include a zirconium-based alloy channel.
- Assembly weight includes the weight of the channel.
- Maximum initial enrichment is the peak planar-average enrichment.
- Water rods may occupy more than one fuel lattice location. Fuel assembly to contain nominal number of water rods for the specific assembly design.
- All enrichment values are nominal preirradiation fabrication values.
- Spacers may be used to axially position fuel assemblies to facilitate handling.

[a] Assemblies may contain partial-length fuel rods.

Table B2-11 BWR SNF Assembly Loading Criteria

			Geometry[3,4]						
Assembly Type	Number of Fuel Rods	Number of Partial Length Rods[1]	Max Pitch (inch)	Min Clad OD (inch)	Min Clad Thick. (inch)	Max Pellet OD (inch)	Max Active Length (inch)	Max Loading (MTU)
B7_48A	48	N/A	0.7380	0.5700	0.03600	0.4900	144.0	0.1981
B7_49A	49	N/A	0.7380	0.5630	0.03200	0.4880	146.0	0.2034
B7_49B	49	N/A	0.7380	0.5630	0.03200	0.4910	150.0	0.2115
B8_59A	59	N/A	0.6400	0.4930	0.03400	0.4160	150.0	0.1828
B8_60A	60	N/A	0.6417	0.4840	0.03150	0.4110	150.0	0.1815
B8_60B	60	N/A	0.6400	0.4830	0.03000	0.4140	150.0	0.1841
B8_61B	61	N/A	0.6400	0.4830	0.03000	0.4140	150.0	0.1872
B8_62A	62	N/A	0.6417	0.4830	0.02900	0.4160	150.0	0.1921
B8_63A	63	N/A	0.6420	0.4840	0.02725	0.4195	150.0	0.1985
B8_64A	64	N/A	0.6420	0.4840	0.02725	0.4195	150.0	0.2017
B8_64B[5]	64	N/A	0.6090	0.4576	0.02900	0.3913	150.0	0.1755
B9_72A	72	N/A	0.5720	0.4330	0.02600	0.3740	150.0	0.1803
B9_74A	74[2]	8	0.5720	0.4240	0.02390	0.3760	150.0	0.1873
B9_76A	76	N/A	0.5720	0.4170	0.02090	0.3750	150.0	0.1914
B9_79A	79	N/A	0.5720	0.4240	0.02390	0.3760	150.0	0.2000
B9_80A	80	N/A	0.5720	0.4230	0.02950	0.3565	150.0	0.1821
B10_91A	91[2]	8	0.5100	0.3957	0.02385	0.3420	150.0	0.1906
B10_92A	92[2]	14	0.5100	0.4040	0.02600	0.3455	150.0	0.1966
B10_96A[5]	96[2]	12	0.4880	0.3780	0.02430	0.3224	150.0	0.1787
B10_100A[5]	100	N/A	0.4880	0.3780	0.02430	0.3224	150.0	0.1861

[1] Location of the partial length rods is illustrated in Figure B2-6.
[2] Assemblies may contain partial-length fuel rods.
[3] Assembly characteristics represent cold, unirradiated, nominal configurations.
[4] Maximum channel thickness allowed is 120 mils (nominal).
[5] Composed of four subchannel clusters.

Note: Amendment No. 2 removed the enrichment/soluble boron limits from this table. This information is now presented in Table B2-12.

Table B2-12 BWR SNF Assembly Loading Criteria – Enrichment Limits for 87-Assembly and 82-Assembly Configurations

	Max. Initial Enrichment[a] (wt % ^{235}U)					
	Absorber[b] 0.027 ^{10}B g/cm^2		Absorber 0.0225 ^{10}B g/cm^2		Absorber 0.02 ^{10}B g/cm^2	
	87-Assy Basket	82-Assy Basket	87-Assy Basket	82-Assy Basket	87-Assy Basket	82-Assy Basket
B7_48A	4.0%	4.5%	3.7%	4.5%	3.6%	4.4%
B7_49A	3.8%	4.5%	3.6%	4.4%	3.5%	4.3%
B7_49B	3.8%	4.5%	3.6%	4.4%	3.5%	4.2%
B8_59A	3.9%	4.5%	3.7%	4.5%	3.6%	4.3%
B8_60A	3.8%	4.5%	3.7%	4.4%	3.5%	4.2%
B8_60B	3.8%	4.5%	3.6%	4.3%	3.5%	4.2%
B8_61B	3.8%	4.5%	3.6%	4.3%	3.5%	4.2%
B8_62A	3.8%	4.5%	3.6%	4.3%	3.5%	4.1%
B8_63A	3.8%	4.5%	3.6%	4.3%	3.4%	4.2%
B8_64A	3.8%	4.5%	3.[illegible]%	4.3%	3.5%	4.2%
B8_64B	3.6%	4.3%	3.4%	4.1%	3.3%	4.0%
B9_72A	3.8%	4.5%	3.6%	4.3%	3.4%	4.1%
B9_74A	3.7% [c]	4.3%	3.4%	4.1%	3.4%	4.0%
B9_76A	3.5%	[illegible].2%	3.4%	4.0%	3.3%	3.9%
B9_79A	3.7%	4.4%	3.4%	4.2%	3.3%	4.0%
B9_80A	3.8%	4.5%	3.6%	4.3%	3.5%	4.2%
B10_91A	3.7%	4.5%[d]	3.6%	4.3%	3.5%	4.1%
B10_92A	3.8%	4.5%[d]	3.6%	4.3%	3.5%	4.1%
B10_96A	3.7%	4.3%	3.5%	4.1%	3.4%	4.0%
B10_100A	3.6%	4.4%	3.5%	4.1%	3.4%	4.0%

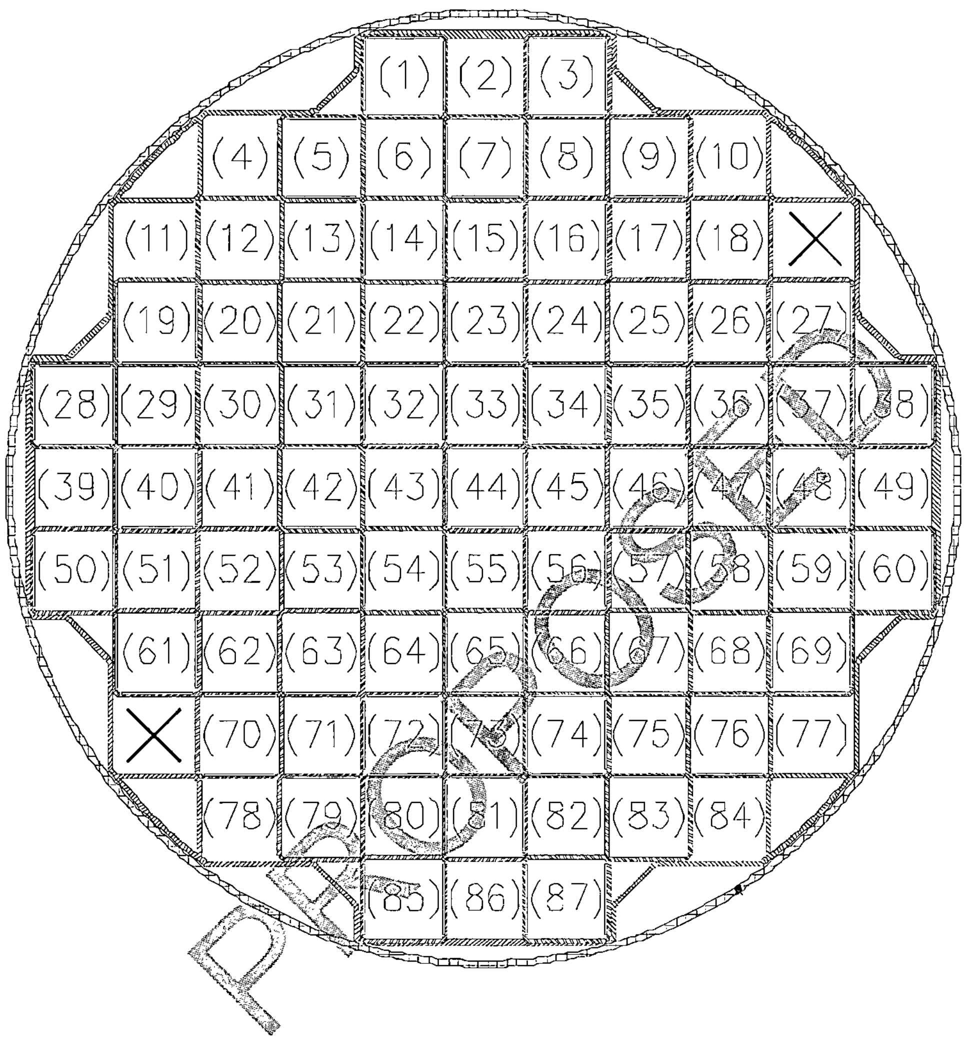
[a] Maximum planar average.

[b] Borated aluminum neutron absorber sheet effective areal ^{10}B density.

[c] 3.85% in the 86-assembly basket configuration

[d] 4.55% in the alternate 82-assembly basket configuration

Figure B2-4 Schematic of 87-Assembly BWR Basket



Note – Cell location 44 must have an empty fuel cell insert installed in order to use the 86-assembly configuration.

Figure B2-5 Schematic of 82-Assembly BWR Basket

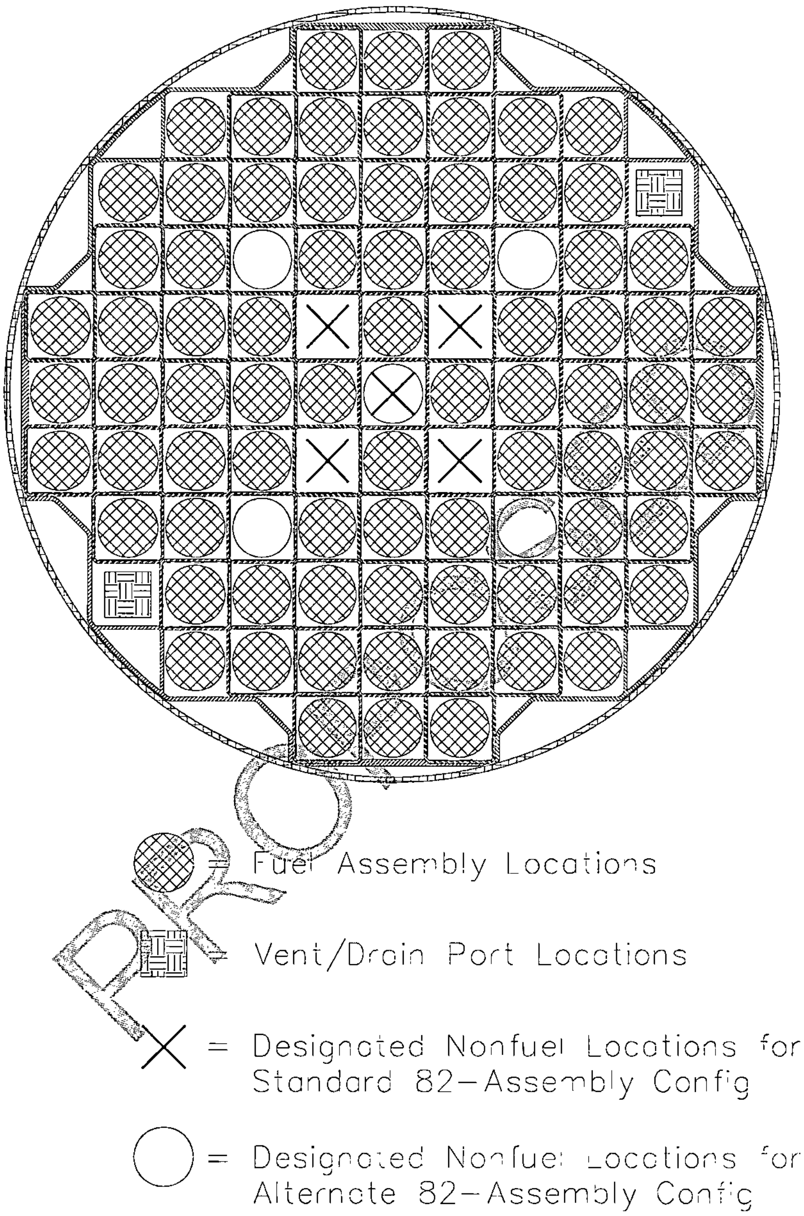
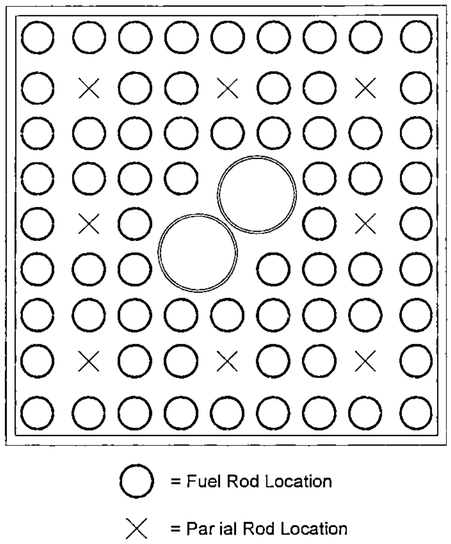
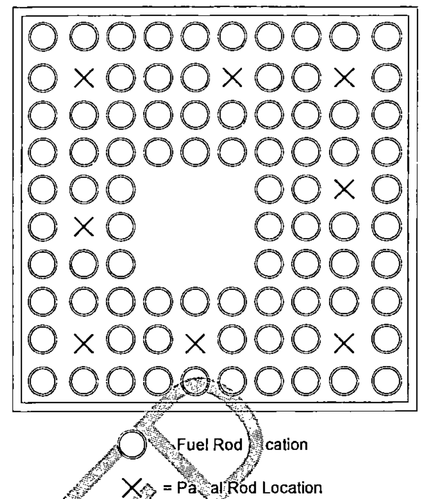


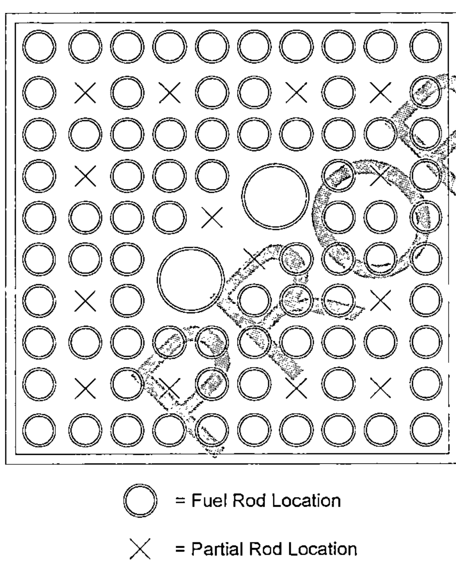
Figure B2-6 BWR Partial Length Fuel Rod Location Sketches



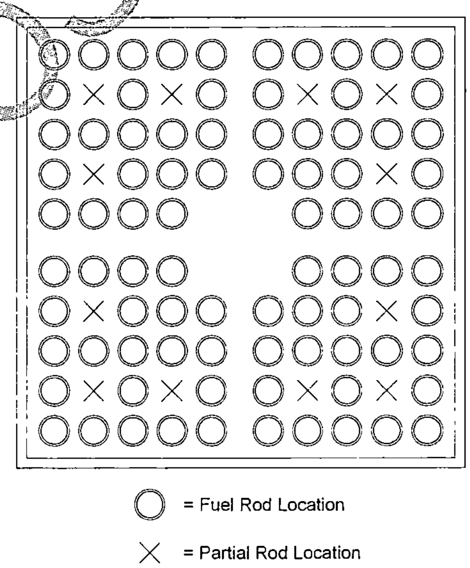
B9_74A 8 Partial Length Rods



B10_91A 8 Partial Length Rods



B10_92A 14 Partial Length Rods



B10_96A 12 Partial Length Rods

Table B2-13 PWR Loading Table – Low SNF Assembly Average Burnup Enrichment Limits

Max. Assembly Avg. Burnup (MWd/MTU)	Min. Assembly Avg. Initial Enrichment (wt% ^{235}U)	Minimum Cool Time (yrs)			
Heat Load per Assy	--	959 W	800 W	922 W	1,200 W
10,000	1.3	4.0	4.0	4.0	4.0
15,000	1.5	4.0	4.0	4.0	4.0
20,000	1.7	4.0	4.0	4.0	4.0
25,000	1.9	4.0	4.3	4.0	4.0
30,000	2.1	4.4	5.2	4.5	4.0

Table B2-14 BWR Loading Table – Low SNF Assembly Average Burnup Enrichment Limits

Max. Assembly Avg. Burnup (MWd/MTU)	Min. Assembly Avg. Initial Enrichment (wt% ^{235}U)	Minimum Cool Time (yrs)
5,000	0.7	4.0
10,000	1.3	4.0
15,000	1.5	4.0
20,000	1.7	4.0
25,000	1.9	4.0
30,000	2.1	4.3

Table B2-15 Loading Table for PWR Fuel – 959 W/Assembly

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	30 < Assembly Average Burnup ≤ 32.5 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	4.1	4.1	4.6	4.7	4.4	4.7	4.7
2.3 ≤ E < 2.5	4.0	4.1	4.5	4.7	4.4	4.6	4.6
2.5 ≤ E < 2.7	4.0	4.0	4.5	4.6	4.3	4.6	4.6
2.7 ≤ E < 2.9	4.0	4.0	4.5	4.5	4.3	4.5	4.5
2.9 ≤ E < 3.1	4.0	4.0	4.4	4.5	4.2	4.5	4.5
3.1 ≤ E < 3.3	4.0	4.0	4.4	4.5	4.2	4.5	4.5
3.3 ≤ E < 3.5	4.0	4.0	4.3	4.4	4.2	4.4	4.4
3.5 ≤ E < 3.7	4.0	4.0	4.3	4.4	4.1	4.4	4.4
3.7 ≤ E < 3.9	4.0	4.0	4.3	4.4	4.1	4.4	4.4
3.9 ≤ E < 4.1	4.0	4.0	4.2	4.3	4.0	4.3	4.3
4.1 ≤ E < 4.3	4.0	4.0	4.2	4.3	4.0	4.3	4.3
4.3 ≤ E < 4.5	4.0	4.0	4.2	4.3	4.0	4.3	4.3
4.5 ≤ E < 4.7	4.0	4.0	4.1	4.2	4.0	4.2	4.2
4.7 ≤ E < 4.9	4.0	4.0	4.1	4.2	4.0	4.2	4.2
E ≥ 4.9	4.0	4.0	4.[illegible]	4.2	4.0	4.2	4.2

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	32.5 < Assembly Average Burnup ≤ 35 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	4.3	4.4	5.0	5.1	4.7	5.0	5.0
2.5 ≤ E < 2.7	4.3	4.4	4.9	5.0	4.7	5.0	5.0
2.7 ≤ E < 2.9	4.2	4.3	4.8	5.0	4.6	4.9	4.9
2.9 ≤ E < 3.1	4.2	4.3	4.8	4.9	4.6	4.9	4.9
3.1 ≤ E < 3.3	4.1	4.2	4.7	4.9	4.5	4.8	4.8
3.3 ≤ E < 3.5	4.1	4.2	4.7	4.8	4.5	4.8	4.8
3.5 ≤ E < 3.7	4.1	4.1	4.6	4.8	4.4	4.7	4.7
3.7 ≤ E < 3.9	4.0	4.1	4.6	4.7	4.4	4.7	4.7
3.9 ≤ E < 4.1	4.0	4.1	4.6	4.7	4.4	4.7	4.7
4.1 ≤ E < 4.3	4.0	4.0	4.5	4.7	4.3	4.6	4.6
4.3 ≤ E < 4.5	4.0	4.0	4.5	4.6	4.3	4.6	4.6
4.5 ≤ E < 4.7	4.0	4.0	4.5	4.6	4.3	4.6	4.6
4.7 ≤ E < 4.9	4.0	4.0	4.4	4.6	4.3	4.5	4.5
E ≥ 4.9	4.0	4.0	4.4	4.5	4.2	4.5	4.5

Table B2-15 Loading Table for PWR Fuel – 959 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	35 < Assembly Average Burnup ≤ 37.5 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	4.7	4.8	5.5	5.7	5.2	5.6	5.6
2.5 ≤ E < 2.7	4.6	4.7	5.4	5.6	5.1	5.5	5.5
2.7 ≤ E < 2.9	4.6	4.7	5.3	5.5	5.0	5.4	5.4
2.9 ≤ E < 3.1	4.5	4.6	5.3	5.4	5.0	5.4	5.4
3.1 ≤ E < 3.3	4.5	4.5	5.2	5.4	4.9	5.3	5.3
3.3 ≤ E < 3.5	4.4	4.5	5.1	5.3	4.9	5.2	5.2
3.5 ≤ E < 3.7	4.4	4.5	5.0	5.2	4.8	5.2	5.2
3.7 ≤ E < 3.9	4.3	4.4	5.0	5.2	4.8	5.1	5.1
3.9 ≤ E < 4.1	4.3	4.4	5.0	5.1	4.7	5.1	5.1
4.1 ≤ E < 4.3	4.3	4.4	4.9	5.1	4.7	5.0	5.0
4.3 ≤ E < 4.5	4.2	4.3	4.9	5.0	4.7	5.0	5.0
4.5 ≤ E < 4.7	4.2	4.3	4.9	5.0	4.6	5.0	5.0
4.7 ≤ E < 4.9	4.2	4.3	4.8	5.0	4.6	4.9	4.9
E ≥ 4.9	4.1	4.2	4.8	4.9	4.5	4.9	4.9
Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	37.5 < Assembly Average Burnup ≤ 40 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	5.0	5.2	5.9	6.1	5.6	6.0	6.0
2.7 ≤ E < 2.9	5.0	5.1	5.9	6.0	5.5	5.9	5.9
2.9 ≤ E < 3.1	4.9	5.0	5.8	6.0	5.5	5.9	5.9
3.1 ≤ E < 3.3	4.9	4.9	5.7	5.9	5.4	5.8	5.8
3.3 ≤ E < 3.5	4.8	4.9	5.7	5.8	5.3	5.7	5.7
3.5 ≤ E < 3.7	4.7	4.8	5.6	5.8	5.2	5.7	5.7
3.7 ≤ E < 3.9	4.7	4.8	5.5	5.7	5.2	5.6	5.6
3.9 ≤ E < 4.1	4.6	4.8	5.5	5.7	5.1	5.6	5.6
4.1 ≤ E < 4.3	4.6	4.7	5.4	5.6	5.1	5.5	5.5
4.3 ≤ E < 4.5	4.5	4.7	5.4	5.6	5.0	5.5	5.5
4.5 ≤ E < 4.7	4.5	4.6	5.3	5.5	5.0	5.4	5.4
4.7 ≤ E < 4.9	4.5	4.6	5.3	5.5	5.0	5.4	5.4
E ≥ 4.9	4.5	4.5	5.2	5.4	4.9	5.4	5.4

Table B2-15 Loading Table for PWR Fuel – 959 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	40 < Assembly Average Burnup ≤ 41 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	5.3	5.4	6.2	6.4	5.8	6.3	6.3
2.7 ≤ E < 2.9	5.2	5.3	6.1	6.3	5.7	6.2	6.2
2.9 ≤ E < 3.1	5.1	5.2	6.0	6.2	5.7	6.1	6.1
3.1 ≤ E < 3.3	5.0	5.1	5.9	6.1	5.6	6.0	6.0
3.3 ≤ E < 3.5	4.9	5.1	5.9	6.0	5.5	5.9	5.9
3.5 ≤ E < 3.7	4.9	5.0	5.8	6.0	5.5	5.9	5.9
3.7 ≤ E < 3.9	4.8	4.9	5.7	5.9	5.4	5.8	5.8
3.9 ≤ E < 4.1	4.8	4.9	5.7	5.9	5.3	5.8	5.8
4.1 ≤ E < 4.3	4.7	4.9	5.6	5.8	5.3	5.7	5.7
4.3 ≤ E < 4.5	4.7	4.8	5.6	5.8	5.2	5.7	5.7
4.5 ≤ E < 4.7	4.7	4.8	5.5	5.7	5.2	5.6	5.6
4.7 ≤ E < 4.9	4.6	4.7	5.5	5.7	5.1	5.6	5.6
E ≥ 4.9	4.6	4.7	5.5	5.6	5.1	5.6	5.6
Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	**41 < Assembly Average Burnup ≤ 42 GWd/MTU Minimum Cooling Time (years)**						
	CE 14×14	**WE 14×14**	**WE 15×15**	**B&W 15×15**	**CE 16×16**	**WE 17×17**	**B&W 17×17**
2.1 ≤ E < 2.3	-		-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	5.5	5.6	6.5	6.7	6.0	6.6	6.6
2.7 ≤ E < 2.9	5.4	5.5	6.4	6.6	5.9	6.5	6.5
2.9 ≤ E < 3.1	5.3	5.4	6.3	6.5	5.9	6.4	6.4
3.1 ≤ E < 3.3	5.2	5.3	6.2	6.4	5.8	6.3	6.3
3.3 ≤ E < 3.5	5.1	5.3	6.1	6.3	5.7	6.2	6.2
3.5 ≤ E < 3.7	5.0	5.2	6.0	6.2	5.7	6.1	6.1
3.7 ≤ E < 3.9	5.0	5.1	5.9	6.2	5.6	6.0	6.0
3.9 ≤ E < 4.1	4.9	5.1	5.9	6.1	5.5	6.0	6.0
4.1 ≤ E < 4.3	4.9	5.0	5.8	6.0	5.5	5.9	5.9
4.3 ≤ E < 4.5	4.9	5.0	5.8	6.0	5.4	5.9	5.9
4.5 ≤ E < 4.7	4.8	4.9	5.7	5.9	5.4	5.8	5.8
4.7 ≤ E < 4.9	4.8	4.9	5.7	5.9	5.3	5.8	5.8
E ≥ 4.9	4.7	4.9	5.7	5.9	5.3	5.8	5.8

Table B2-15 Loading Table for PWR Fuel – 959 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	42 < Assembly Average Burnup ≤ 43 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	5.7	5.8	6.8	7.0	6.3	6.9	6.9
2.7 ≤ E < 2.9	5.6	5.7	6.7	6.9	6.2	6.8	6.8
2.9 ≤ E < 3.1	5.5	5.6	6.6	6.8	6.0	6.7	6.7
3.1 ≤ E < 3.3	5.4	5.6	6.5	6.7	6.0	6.6	6.6
3.3 ≤ E < 3.5	5.3	5.5	6.4	6.6	5.9	6.5	6.5
3.5 ≤ E < 3.7	5.3	5.4	6.3	6.5	5.9	6.4	6.4
3.7 ≤ E < 3.9	5.2	5.3	6.2	6.5	5.8	6.3	6.3
3.9 ≤ E < 4.1	5.1	5.3	6.1	6.4	5.7	6.2	6.2
4.1 ≤ E < 4.3	5.0	5.2	6.0	6.3	5.7	6.2	6.1
4.3 ≤ E < 4.5	5.0	5.2	6.0	6.2	5.6	6.1	6.1
4.5 ≤ E < 4.7	5.0	5.1	5.9	6.2	5.6	6.0	6.0
4.7 ≤ E < 4.9	4.9	5.0	5.9	6.1	5.5	6.0	6.0
E ≥ 4.9	4.9	5.0	5.8	6.0	5.5	6.0	5.9

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	43 < Assembly Average Burnup ≤ 44 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	5.9	6.0	7.1	7.4	6.6	7.2	7.2
2.7 ≤ E < 2.9	5.8	5.9	7.0	7.3	6.5	7.0	7.0
2.9 ≤ E < 3.1	5.7	5.8	6.9	7.1	6.4	6.9	6.9
3.1 ≤ E < 3.3	5.6	5.8	6.8	7.0	6.2	6.8	6.8
3.3 ≤ E < 3.5	5.5	5.7	6.7	6.9	6.1	6.8	6.7
3.5 ≤ E < 3.7	5.5	5.6	6.6	6.8	6.0	6.7	6.7
3.7 ≤ E < 3.9	5.4	5.6	6.5	6.8	6.0	6.6	6.6
3.9 ≤ E < 4.1	5.3	5.5	6.4	6.7	5.9	6.5	6.5
4.1 ≤ E < 4.3	5.3	5.4	6.3	6.6	5.9	6.4	6.4
4.3 ≤ E < 4.5	5.2	5.4	6.2	6.5	5.8	6.4	6.4
4.5 ≤ E < 4.7	5.1	5.3	6.2	6.5	5.8	6.3	6.3
4.7 ≤ E < 4.9	5.1	5.3	6.1	6.4	5.7	6.2	6.2
E ≥ 4.9	5.0	5.2	6.0	6.3	5.7	6.2	6.2

Table B2-15 Loading Table for PWR Fuel – 959 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	44 < Assembly Average Burnup ≤ 45 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	6.0	6.2	7.3	7.7	6.7	7.4	7.4
2.9 ≤ E < 3.1	5.9	6.0	7.2	7.6	6.6	7.3	7.3
3.1 ≤ E < 3.3	5.8	6.0	7.0	7.4	6.5	7.2	7.1
3.3 ≤ E < 3.5	5.7	5.9	6.9	7.3	6.4	7.0	7.0
3.5 ≤ E < 3.7	5.7	5.8	6.8	7.2	6.3	6.9	6.9
3.7 ≤ E < 3.9	5.6	5.8	6.8	7.0	6.2	6.9	6.9
3.9 ≤ E < 4.1	5.5	5.7	6.7	7.0	6.2	6.8	6.8
4.1 ≤ E < 4.3	5.5	5.6	6.6	6.9	6.1	6.7	6.7
4.3 ≤ E < 4.5	5.4	5.6	6.5	6.8	6.0	6.7	6.6
4.5 ≤ E < 4.7	5.3	5.5	6.5	6.7	6.0	6.6	6.6
4.7 ≤ E < 4.9	5.3	5.5	6.4	6.7	5.9	6.5	6.5
E ≥ 4.9	5.2	5.4	6.3	6.6	5.9	6.5	6.5

<u>Note:</u> **For fuel assembly average burnup greater than 45 GWd/MTU, cool time tables have been revised to account for a 5% margin in heat load.**

Table B2-16 Loading Table for PWR Fuel – 911 W/Assembly

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	45 < Assembly Average Burnup ≤ 46 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	6.7	6.9	8.5	9.0	7.7	8.6	8.6
2.9 ≤ E < 3.1	6.6	6.8	8.3	8.8	7.5	8.4	8.4
3.1 ≤ E < 3.3	6.5	6.7	8.1	8.6	7.4	8.2	8.2
3.3 ≤ E < 3.5	6.4	6.6	8.0	8.5	7.3	8.1	8.1
3.5 ≤ E < 3.7	6.3	6.5	7.8	8.3	7.1	8.0	7.9
3.7 ≤ E < 3.9	6.2	6.4	7.7	8.2	7.0	7.8	7.8
3.9 ≤ E < 4.1	6.1	6.3	7.6	8.0	6.9	7.7	7.7
4.1 ≤ E < 4.3	6.0	6.2	7.5	7.9	6.9	7.7	7.6
4.3 ≤ E < 4.5	6.0	6.2	7.4	7.8	6.8	7.6	7.6
4.5 ≤ E < 4.7	5.9	6.1	7.3	7.8	6.7	7.5	7.5
4.7 ≤ E < 4.9	5.9	6.0	7.2	7.7	6.7	7.4	7.4
E ≥ 4.9	5.8	6.0	7.2	7.6	6.6	7.3	7.3

Table B2-16 Loading Table for PWR Fuel – 911 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	46 < Assembly Average Burnup ≤ 47 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	7.0	7.3	9.0	9.6	8.0	9.1	9.1
2.9 ≤ E < 3.1	6.9	7.1	8.8	9.4	7.9	8.9	8.9
3.1 ≤ E < 3.3	6.8	7.0	8.6	9.2	7.8	8.7	8.7
3.3 ≤ E < 3.5	6.7	6.9	8.4	9.0	7.6	8.6	8.6
3.5 ≤ E < 3.7	6.6	6.8	8.3	8.8	7.5	8.4	8.4
3.7 ≤ E < 3.9	6.5	6.7	8.1	8.7	7.4	8.3	8.3
3.9 ≤ E < 4.1	6.4	6.6	8.0	8.5	7.3	8.1	8.1
4.1 ≤ E < 4.3	6.3	6.5	7.9	8.4	7.2	8.0	8.0
4.3 ≤ E < 4.5	6.2	6.5	7.8	8.3	7.1	7.9	7.9
4.5 ≤ E < 4.7	6.1	6.4	7.7	8.2	7.0	7.9	7.8
4.7 ≤ E < 4.9	6.0	6.3	7.6	8.1	6.9	7.8	7.8
E ≥ 4.9	6.0	6.2	7.6	8.0	6.9	7.7	7.7

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	47 < Assembly Average Burnup ≤ 48 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	7.4	7.7	9.6	10.3	8.6	9.7	9.7
2.9 ≤ E < 3.1	7.2	7.6	9.4	10.0	8.4	9.5	9.5
3.1 ≤ E < 3.3	7.1	7.4	9.1	9.8	8.2	9.3	9.3
3.3 ≤ E < 3.5	7.0	7.2	8.9	9.6	8.0	9.1	9.0
3.5 ≤ E < 3.7	6.9	7.1	8.8	9.4	7.9	8.9	8.9
3.7 ≤ E < 3.9	6.7	7.0	8.6	9.2	7.8	8.8	8.7
3.9 ≤ E < 4.1	6.7	6.9	8.5	9.0	7.6	8.6	8.6
4.1 ≤ E < 4.3	6.6	6.8	8.4	8.9	7.6	8.5	8.5
4.3 ≤ E < 4.5	6.5	6.7	8.2	8.8	7.4	8.4	8.4
4.5 ≤ E < 4.7	6.4	6.7	8.1	8.7	7.4	8.3	8.3
4.7 ≤ E < 4.9	6.3	6.6	8.0	8.6	7.3	8.2	8.2
E ≥ 4.9	6.2	6.5	7.9	8.5	7.2	8.1	8.1

Table B2-16 Loading Table for PWR Fuel – 911 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	48 < Assembly Average Burnup ≤ 49 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	7.8	8.1	10.2	11.1	9.0	10.4	10.4
2.9 ≤ E < 3.1	7.6	7.9	10.0	10.8	8.8	10.1	10.1
3.1 ≤ E < 3.3	7.5	7.8	9.7	10.5	8.6	9.9	9.8
3.3 ≤ E < 3.5	7.3	7.6	9.5	10.2	8.5	9.7	9.6
3.5 ≤ E < 3.7	7.2	7.5	9.3	10.0	8.3	9.5	9.4
3.7 ≤ E < 3.9	7.0	7.4	9.1	9.8	8.2	9.3	9.3
3.9 ≤ E < 4.1	6.9	7.2	9.0	9.6	8.0	9.1	9.1
4.1 ≤ E < 4.3	6.8	7.1	8.8	9.5	7.9	9.0	9.0
4.3 ≤ E < 4.5	6.8	7.0	8.7	9.3	7.8	8.9	8.9
4.5 ≤ E < 4.7	6.7	6.9	8.6	9.2	7.7	8.8	8.7
4.7 ≤ E < 4.9	6.6	6.9	8.5	9.1	7.6	8.7	8.6
E ≥ 4.9	6.5	6.8	8.4	9.0	7.6	8.6	8.5
Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	**49 < Assembly Average Burnup ≤ 50 GWd/MTU Minimum Cooling Time (years)**						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	8.0	8.3	10.7	11.6	9.4	10.9	10.9
3.1 ≤ E < 3.3	7.8	8.1	10.4	11.3	9.1	10.6	10.6
3.3 ≤ E < 3.5	7.7	7.9	10.1	11.0	9.0	10.3	10.3
3.5 ≤ E < 3.7	7.5	7.8	9.9	10.8	8.8	10.0	10.0
3.7 ≤ E < 3.9	7.4	7.6	9.7	10.5	8.6	9.9	9.9
3.9 ≤ E < 4.1	7.3	7.5	9.5	10.3	8.5	9.7	9.7
4.1 ≤ E < 4.3	7.1	7.4	9.4	10.1	8.3	9.6	9.5
4.3 ≤ E < 4.5	7.0	7.3	9.2	9.9	8.2	9.4	9.4
4.5 ≤ E < 4.7	6.9	7.2	9.1	9.8	8.1	9.3	9.2
4.7 ≤ E < 4.9	6.9	7.1	9.0	9.6	8.0	9.1	9.1
E ≥ 4.9	6.8	7.0	8.9	9.5	7.9	9.0	9.0

Table B2-16 Loading Table for PWR Fuel – 911 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	50 < Assembly Average Burnup ≤ 51 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	8.3	8.7	11.5	12.3	10.0	11.6	11.6
3.1 ≤ E < 3.3	8.0	8.5	11.2	12.0	9.8	11.3	11.3
3.3 ≤ E < 3.5	7.9	8.3	10.9	11.7	9.5	11.1	11.1
3.5 ≤ E < 3.7	7.8	8.1	10.6	11.5	9.3	10.8	10.8
3.7 ≤ E < 3.9	7.6	8.0	10.4	11.3	9.1	10.6	10.6
3.9 ≤ E < 4.1	7.5	7.9	10.1	11.1	9.0	10.4	10.4
4.1 ≤ E < 4.3	7.4	7.8	10.0	10.9	8.8	10.2	10.1
4.3 ≤ E < 4.5	7.3	7.6	9.8	10.6	8.7	10.0	10.0
4.5 ≤ E < 4.7	7.1	7.5	9.7	10.5	8.6	9.8	9.8
4.7 ≤ E < 4.9	7.0	7.4	9.5	10.3	8.5	9.7	9.7
E ≥ 4.9	7.0	7.3	9.4	10.1	8.3	9.6	9.6

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	51 < Assembly Average Burnup ≤ 52 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	8.8	9.3	12.2	13.0	10.7	12.4	12.4
3.1 ≤ E < 3.3	8.5	9.0	11.9	12.6	10.4	12.1	12.0
3.3 ≤ E < 3.5	8.3	8.8	11.6	12.3	10.1	11.8	11.8
3.5 ≤ E < 3.7	8.1	8.6	11.4	11.9	9.9	11.6	11.5
3.7 ≤ E < 3.9	8.0	8.5	11.1	11.7	9.7	11.3	11.3
3.9 ≤ E < 4.1	7.9	8.3	10.9	11.5	9.5	11.1	11.1
4.1 ≤ E < 4.3	7.7	8.1	10.7	11.3	9.3	10.9	10.9
4.3 ≤ E < 4.5	7.6	8.0	10.5	11.1	9.2	10.7	10.7
4.5 ≤ E < 4.7	7.5	7.9	10.3	11.0	9.0	10.5	10.5
4.7 ≤ E < 4.9	7.4	7.8	10.1	10.8	8.9	10.3	10.3
E ≥ 4.9	7.3	7.7	10.0	10.6	8.8	10.2	10.2

PROPOSED

Table B2-16 Loading Table for PWR Fuel – 911 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	52 < Assembly Average Burnup ≤ 53 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	9.3	9.8	12.8	13.8	11.4	13.3	13.3
3.1 ≤ E < 3.3	9.0	9.6	12.4	13.5	11.2	13.0	13.0
3.3 ≤ E < 3.5	8.8	9.3	12.1	13.2	10.9	12.6	12.6
3.5 ≤ E < 3.7	8.6	9.1	11.8	12.8	10.6	12.3	12.3
3.7 ≤ E < 3.9	8.4	9.0	11.5	12.6	10.3	12.0	12.0
3.9 ≤ E < 4.1	8.2	8.8	11.3	12.3	10.1	11.8	11.8
4.1 ≤ E < 4.3	8.1	8.6	11.1	12.0	9.9	11.6	11.6
4.3 ≤ E < 4.5	8.0	8.5	10.9	11.8	9.7	11.4	11.4
4.5 ≤ E < 4.7	7.9	8.3	10.7	11.7	9.6	11.2	11.2
4.7 ≤ E < 4.9	7.8	8.2	10.6	11.5	9.4	11.1	11.0
E ≥ 4.9	7.7	8.1	10.4	11.3	9.3	10.9	10.9

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	53 < Assembly Average Burnup ≤ 54 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	9.8	10.5	13.6	14.9	12.2	14.2	14.2
3.1 ≤ E < 3.3	9.6	10.2	13.3	14.4	11.8	13.8	13.8
3.3 ≤ E < 3.5	9.3	9.9	12.9	14.0	11.6	13.5	13.5
3.5 ≤ E < 3.7	9.1	9.7	12.6	13.7	11.3	13.2	13.2
3.7 ≤ E < 3.9	8.9	9.5	12.3	13.4	11.0	12.9	12.9
3.9 ≤ E < 4.1	8.7	9.3	12.0	13.2	10.8	12.6	12.6
4.1 ≤ E < 4.3	8.6	9.1	11.8	12.9	10.6	12.4	12.4
4.3 ≤ E < 4.5	8.4	8.9	11.6	12.6	10.4	12.1	12.1
4.5 ≤ E < 4.7	8.3	8.8	11.4	12.4	10.1	11.9	11.9
4.7 ≤ E < 4.9	8.1	8.7	11.3	12.2	10.0	11.8	11.7
E ≥ 4.9	8.0	8.8	11.1	12.0	9.9	11.6	11.6

Table B2-16 Loading Table for PWR Fuel – 911 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	54 < Assembly Average Burnup ≤ 55 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	10.1	10.9	14.1	15.4	12.7	14.8	14.8
3.3 ≤ E < 3.5	9.9	10.6	13.8	15.0	12.3	14.4	14.4
3.5 ≤ E < 3.7	9.6	10.3	13.5	14.7	12.0	14.0	14.0
3.7 ≤ E < 3.9	9.4	10.1	13.1	14.3	11.8	13.8	13.8
3.9 ≤ E < 4.1	9.2	9.8	12.9	14.0	11.5	13.5	13.5
4.1 ≤ E < 4.3	9.0	9.7	12.6	13.8	11.3	13.3	13.2
4.3 ≤ E < 4.5	8.9	9.5	12.3	13.5	11.1	13.0	13.0
4.5 ≤ E < 4.7	8.7	9.3	12.1	13.3	10.9	12.8	12.7
4.7 ≤ E < 4.9	8.6	9.1	11.9	13.1	10.7	12.6	12.5
E ≥ 4.9	8.5	9.0	11.7	1[illegible].9	10.5	12.3	12.3

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	55 < Assembly Average Burnup ≤ 56 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	10.9	11.6	15.1	16.5	13.1	15.8	15.8
3.3 ≤ E < 3.5	10.5	11.3	14.7	16.0	12.8	15.4	15.4
3.5 ≤ E < 3.7	10.2	11.0	14.3	15.7	12.4	15.1	15.0
3.7 ≤ E < 3.9	9.9	10.8	14.0	15.3	12.1	14.7	14.7
3.9 ≤ E < 4.1	9.7	10.5	13.7	15.0	11.9	14.4	14.4
4.1 ≤ E < 4.3	9.5	10.2	13.4	14.7	11.7	14.1	14.1
4.3 ≤ E < 4.5	9.3	10.0	13.2	14.5	11.4	13.8	13.8
4.5 ≤ E < 4.7	9.2	9.9	12.9	14.2	11.2	13.6	13.6
4.7 ≤ E < 4.9	9.0	9.7	12.7	13.9	11.1	13.4	13.4
E ≥ 4.9	8.9	9.5	12.5	13.8	10.9	13.2	13.2

Table B2-16 Loading Table for PWR Fuel – 911 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	56 < Assembly Average Burnup ≤ 57 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	11.5	12.3	16.0	17.4	14.0	16.8	16.8
3.3 ≤ E < 3.5	11.2	12.0	15.6	17.1	13.6	16.4	16.4
3.5 ≤ E < 3.7	10.9	11.7	15.3	16.7	13.3	16.0	16.0
3.7 ≤ E < 3.9	10.6	11.4	14.9	16.3	13.0	15.7	15.6
3.9 ≤ E < 4.1	10.3	11.2	14.6	16.0	12.6	15.4	15.3
4.1 ≤ E < 4.3	10.1	10.9	14.2	15.7	12.4	15.1	15.1
4.3 ≤ E < 4.5	9.9	10.7	14.0	15.4	12.1	14.8	14.8
4.5 ≤ E < 4.7	9.7	10.5	13.8	15.2	11.9	14.5	14.5
4.7 ≤ E < 4.9	9.5	10.3	13.6	14.9	11.7	14.2	14.2
E ≥ 4.9	9.4	10.1	13.4	14.7	11.5	14.0	14.0

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	57 < Assembly Average Burnup ≤ 58 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	12.2	13.2	17.0	18.5	14.9	17.8	17.7
3.3 ≤ E < 3.5	11.9	12.8	16.7	18.1	14.5	17.4	17.4
3.5 ≤ E < 3.7	11.6	12.4	16.2	17.7	14.1	17.0	17.0
3.7 ≤ E < 3.9	11.3	12.1	15.9	17.3	13.8	16.7	16.6
3.9 ≤ E < 4.1	11.0	11.9	15.6	17.0	13.5	16.3	16.3
4.1 ≤ E < 4.3	10.7	11.6	15.3	16.7	13.2	16.0	16.0
4.3 ≤ E < 4.5	10.5	11.4	15.0	16.4	12.9	15.7	15.7
4.5 ≤ E < 4.7	10.3	11.2	14.7	16.1	12.7	15.5	15.4
4.7 ≤ E < 4.9	10.0	10.9	14.4	15.8	12.4	15.2	15.2
E ≥ 4.9	9.9	10.8	14.2	15.6	12.2	15.0	14.9

Table B2-16 Loading Table for PWR Fuel – 911 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	58 < Assembly Average Burnup ≤ 59 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	13.0	14.0	18.0	19.5	15.8	18.8	18.8
3.3 ≤ E < 3.5	12.6	13.6	17.6	19.1	15.4	18.4	18.4
3.5 ≤ E < 3.7	12.2	13.3	17.2	18.7	15.0	18.0	18.0
3.7 ≤ E < 3.9	11.9	12.9	16.9	18.3	14.6	17.7	17.7
3.9 ≤ E < 4.1	11.6	12.6	16.5	18.0	14.3	17.4	17.3
4.1 ≤ E < 4.3	11.4	12.3	16.2	17.7	14.0	17.0	17.0
4.3 ≤ E < 4.5	11.1	12.0	15.9	17.4	13.7	16.7	16.7
4.5 ≤ E < 4.7	10.9	11.8	15.6	17.1	13.5	16.4	16.4
4.7 ≤ E < 4.9	10.7	11.6	15.4	16.8	13.2	16.1	16.1
E ≥ 4.9	10.5	11.4	15.1	16.6	13.0	15.9	15.9

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	59 < Assembly Average Burnup ≤ 60 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	-	-	-	-	-	-	-
3.3 ≤ E < 3.5	13.4	14.4	18.6	20.1	16.3	19.0	19.0
3.5 ≤ E < 3.7	13.0	14.1	18.2	19.7	15.9	18.6	18.5
3.7 ≤ E < 3.9	12.7	13.7	17.8	19.4	15.5	18.2	18.1
3.9 ≤ E < 4.1	12.3	13.4	17.5	19.0	15.2	17.9	17.8
4.1 ≤ E < 4.3	12.0	13.1	17.1	18.7	14.9	17.5	17.5
4.3 ≤ E < 4.5	11.8	12.8	16.8	18.4	14.6	17.2	17.2
4.5 ≤ E < 4.7	11.6	12.6	16.5	18.0	14.3	16.9	16.9
4.7 ≤ E < 4.9	11.3	12.3	16.2	17.8	14.0	16.6	16.6
E ≥ 4.9	11.2	12.1	16.0	17.6	13.8	16.4	16.3

Table B2-17 Loading Table for PWR Fuel – 1,200 W/Assembly

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	30 < Assembly Average Burnup ≤ 32.5 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	4.0	4.0	4.0	4.0	4.0	4.0	4.0
2.3 ≤ E < 2.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0
2.5 ≤ E < 2.7	4.0	4.0	4.0	4.0	4.0	4.0	4.0
2.7 ≤ E < 2.9	4.0	4.0	4.0	4.0	4.0	4.0	4.0
2.9 ≤ E < 3.1	4.0	4.0	4.0	4.0	4.0	4.0	4.0
3.1 ≤ E < 3.3	4.0	4.0	4.0	4.0	4.0	4.0	4.0
3.3 ≤ E < 3.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0
3.5 ≤ E < 3.7	4.0	4.0	4.0	4.0	4.0	4.0	4.0
3.7 ≤ E < 3.9	4.0	4.0	4.0	4.0	4.0	4.0	4.0
3.9 ≤ E < 4.1	4.0	4.0	4.0	4.0	4.0	4.0	4.0
4.1 ≤ E < 4.3	4.0	4.0	4.0	4.0	4.0	4.0	4.0
4.3 ≤ E < 4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0
4.5 ≤ E < 4.7	4.0	4.0	4.0	4.0	4.0	4.0	4.0
4.7 ≤ E < 4.9	4.0	4.0	4.0	4.0	4.0	4.0	4.0
E ≥ 4.9	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	**32.5 < Assembly Average Burnup ≤ 35 GWd/MTU Minimum Cooling Time (years)**						
	CE 14×14	**WE 14×14**	**WE 15×15**	**B&W 15×15**	**CE 16×16**	**WE 17×17**	**B&W 17×17**
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	4.0	4.0	4.0	4.1	4.0	4.1	4.1
2.5 ≤ E < 2.7	4.0	4.0	4.0	4.1	4.0	4.0	4.0
2.7 ≤ E < 2.9	4.0	4.0	4.0	4.0	4.0	4.0	4.0
2.9 ≤ E < 3.1	4.0	4.0	4.0	4.0	4.0	4.0	4.0
3.1 ≤ E < 3.3	4.0	4.0	4.0	4.0	4.0	4.0	4.0
3.3 ≤ E < 3.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0
3.5 ≤ E < 3.7	4.0	4.0	4.0	4.0	4.0	4.0	4.0
3.7 ≤ E < 3.9	4.0	4.0	4.0	4.0	4.0	4.0	4.0
3.9 ≤ E < 4.1	4.0	4.0	4.0	4.0	4.0	4.0	4.0
4.1 ≤ E < 4.3	4.0	4.0	4.0	4.0	4.0	4.0	4.0
4.3 ≤ E < 4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0
4.5 ≤ E < 4.7	4.0	4.0	4.0	4.0	4.0	4.0	4.0
4.7 ≤ E < 4.9	4.0	4.0	4.0	4.0	4.0	4.0	4.0
E ≥ 4.9	4.0	4.0	4.0	4.0	4.0	4.0	4.0

Table B2-17 Loading Table for PWR Fuel – 1,200 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	35 < Assembly Average Burnup ≤ 37.5 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	4.0	4.0	4.3	4.4	4.2	4.4	4.4
2.5 ≤ E < 2.7	4.0	4.0	4.3	4.4	4.1	4.4	4.4
2.7 ≤ E < 2.9	4.0	4.0	4.2	4.3	4.1	4.3	4.3
2.9 ≤ E < 3.1	4.0	4.0	4.2	4.3	4.0	4.3	4.3
3.1 ≤ E < 3.3	4.0	4.0	4.1	4.2	4.0	4.2	4.2
3.3 ≤ E < 3.5	4.0	4.0	4.1	4.2	4.0	4.2	4.2
3.5 ≤ E < 3.7	4.0	4.0	4.0	4.2	4.0	4.2	4.2
3.7 ≤ E < 3.9	4.0	4.0	4.0	4.1	4.0	4.1	4.1
3.9 ≤ E < 4.1	4.0	4.0	4.0	4.1	4.0	4.1	4.1
4.1 ≤ E < 4.3	4.0	4.0	4.0	4.0	4.0	4.0	4.0
4.3 ≤ E < 4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0
4.5 ≤ E < 4.7	4.0	4.0	4.0	4.0	4.0	4.0	4.0
4.7 ≤ E < 4.9	4.0	4.0	4.0	4.0	4.0	4.0	4.0
E ≥ 4.9	4.0	4.0	4.0	4.0	4.0	4.0	4.0

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	37.5 < Assembly Average Burnup ≤ 40 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	4.0	4.1	4.6	4.8	4.4	4.7	4.7
2.7 ≤ E < 2.9	4.0	4.0	4.6	4.7	4.4	4.7	4.7
2.9 ≤ E < 3.1	4.0	4.0	4.5	4.6	4.3	4.6	4.6
3.1 ≤ E < 3.3	4.0	4.0	4.5	4.6	4.3	4.5	4.5
3.3 ≤ E < 3.5	4.0	4.0	4.4	4.5	4.2	4.5	4.5
3.5 ≤ E < 3.7	4.0	4.0	4.4	4.5	4.2	4.5	4.4
3.7 ≤ E < 3.9	4.0	4.0	4.3	4.4	4.1	4.4	4.4
3.9 ≤ E < 4.1	4.0	4.0	4.3	4.4	4.1	4.4	4.4
4.1 ≤ E < 4.3	4.0	4.0	4.2	4.3	4.1	4.3	4.3
4.3 ≤ E < 4.5	4.0	4.0	4.2	4.3	4.0	4.3	4.3
4.5 ≤ E < 4.7	4.0	4.0	4.2	4.3	4.0	4.3	4.3
4.7 ≤ E < 4.9	4.0	4.0	4.1	4.3	4.0	4.3	4.3
E ≥ 4.9	4.0	4.0	4.1	4.2	4.0	4.2	4.2

Table B2-17 Loading Table for PWR Fuel – 1,200 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	40 < Assembly Average Burnup ≤ 41 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	4.2	4.2	4.8	4.9	4.5	4.9	4.9
2.7 ≤ E < 2.9	4.1	4.2	4.7	4.8	4.5	4.8	4.8
2.9 ≤ E < 3.1	4.0	4.1	4.7	4.8	4.4	4.8	4.7
3.1 ≤ E < 3.3	4.0	4.1	4.6	4.7	4.4	4.7	4.7
3.3 ≤ E < 3.5	4.0	4.0	4.5	4.7	4.4	4.6	4.6
3.5 ≤ E < 3.7	4.0	4.0	4.5	4.6	4.3	4.6	4.6
3.7 ≤ E < 3.9	4.0	4.0	4.4	4.5	4.2	4.5	4.5
3.9 ≤ E < 4.1	4.0	4.0	4.4	4.5	4.2	4.5	4.5
4.1 ≤ E < 4.3	4.0	4.0	4.4	4.5	4.2	4.5	4.5
4.3 ≤ E < 4.5	4.0	4.0	4.3	4.4	4.1	4.4	4.4
4.5 ≤ E < 4.7	4.0	4.0	4.3	4.4	4.1	4.4	4.4
4.7 ≤ E < 4.9	4.0	4.0	4.3	4.4	4.1	4.4	4.4
E ≥ 4.9	4.0	4.0	4.2	4.3	4.0	4.4	4.3

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	41 < Assembly Average Burnup ≤ 42 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	4.3	4.4	4.9	5.1	4.7	5.0	5.0
2.7 ≤ E < 2.9	4.2	4.3	4.9	5.0	4.6	5.0	5.0
2.9 ≤ E < 3.1	4.2	4.2	4.8	4.9	4.6	4.9	4.9
3.1 ≤ E < 3.3	4.1	4.2	4.7	4.9	4.5	4.8	4.8
3.3 ≤ E < 3.5	4.0	4.1	4.7	4.8	4.5	4.8	4.8
3.5 ≤ E < 3.7	4.0	4.1	4.6	4.8	4.4	4.7	4.7
3.7 ≤ E < 3.9	4.0	4.1	4.6	4.7	4.4	4.7	4.7
3.9 ≤ E < 4.1	4.0	4.0	4.5	4.6	4.3	4.6	4.6
4.1 ≤ E < 4.3	4.0	4.0	4.5	4.6	4.3	4.6	4.6
4.3 ≤ E < 4.5	4.0	4.0	4.4	4.6	4.3	4.5	4.5
4.5 ≤ E < 4.7	4.0	4.0	4.4	4.5	4.2	4.5	4.5
4.7 ≤ E < 4.9	4.0	4.0	4.4	4.5	4.2	4.5	4.5
E ≥ 4.9	4.0	4.0	4.3	4.5	4.2	4.5	4.5

Table B2-17 Loading Table for PWR Fuel – 1,200 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	42 < Assembly Average Burnup ≤ 43 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	4.4	4.5	5.1	5.3	4.9	5.2	5.2
2.7 ≤ E < 2.9	4.4	4.4	5.0	5.2	4.8	5.1	5.1
2.9 ≤ E < 3.1	4.3	4.4	5.0	5.1	4.7	5.0	5.0
3.1 ≤ E < 3.3	4.2	4.3	4.9	5.0	4.7	5.0	5.0
3.3 ≤ E < 3.5	4.2	4.3	4.8	5.0	4.6	4.9	4.9
3.5 ≤ E < 3.7	4.1	4.2	4.8	4.9	4.5	4.9	4.9
3.7 ≤ E < 3.9	4.1	4.2	4.7	4.9	4.5	4.8	4.8
3.9 ≤ E < 4.1	4.0	4.1	4.7	4.8	4.4	4.8	4.8
4.1 ≤ E < 4.3	4.0	4.1	4.6	4.8	4.4	4.7	4.7
4.3 ≤ E < 4.5	4.0	4.0	4.6	4.7	4.4	4.7	4.7
4.5 ≤ E < 4.7	4.0	4.0	4.5	4.7	4.3	4.7	4.6
4.7 ≤ E < 4.9	4.0	4.0	4.5	4.6	4.3	4.6	4.6
E ≥ 4.9	4.0	4.0	4.4	4.6	4.3	4.6	4.5

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	43 < Assembly Average Burnup ≤ 44 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	4.5	4.6	5.3	5.5	5.0	5.4	5.4
2.7 ≤ E < 2.9	4.5	4.6	5.2	5.4	4.9	5.3	5.3
2.9 ≤ E < 3.1	4.4	4.5	5.1	5.3	4.9	5.2	5.2
3.1 ≤ E < 3.3	4.4	4.4	5.0	5.2	4.8	5.2	5.2
3.3 ≤ E < 3.5	4.3	4.4	5.0	5.1	4.7	5.1	5.1
3.5 ≤ E < 3.7	4.2	4.3	4.9	5.1	4.7	5.0	5.0
3.7 ≤ E < 3.9	4.2	4.3	4.9	5.0	4.6	5.0	5.0
3.9 ≤ E < 4.1	4.1	4.3	4.8	5.0	4.6	4.9	4.9
4.1 ≤ E < 4.3	4.1	4.2	4.8	4.9	4.5	4.9	4.9
4.3 ≤ E < 4.5	4.1	4.2	4.7	4.9	4.5	4.8	4.8
4.5 ≤ E < 4.7	4.0	4.2	4.7	4.8	4.5	4.8	4.8
4.7 ≤ E < 4.9	4.0	4.1	4.6	4.8	4.4	4.8	4.7
E ≥ 4.9	4.0	4.1	4.6	4.8	4.4	4.7	4.7

PROPOSED

Table B2-17 Loading Table for PWR Fuel – 1,200 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	44 < Assembly Average Burnup ≤ 45 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	4.6	4.7	5.4	5.6	5.1	5.5	5.5
2.9 ≤ E < 3.1	4.5	4.6	5.3	5.5	5.0	5.4	5.4
3.1 ≤ E < 3.3	4.5	4.6	5.2	5.4	4.9	5.4	5.4
3.3 ≤ E < 3.5	4.4	4.5	5.2	5.4	4.9	5.3	5.3
3.5 ≤ E < 3.7	4.4	4.5	5.1	5.3	4.8	5.2	5.2
3.7 ≤ E < 3.9	4.3	4.4	5.0	5.2	4.8	5.1	5.1
3.9 ≤ E < 4.1	4.3	4.4	5.0	5.1	4.7	5.1	5.1
4.1 ≤ E < 4.3	4.2	4.3	4.9	5.1	4.7	5.0	5.0
4.3 ≤ E < 4.5	4.2	4.3	4.9	5.0	4.6	5.0	5.0
4.5 ≤ E < 4.7	4.1	4.2	4.8	5.0	4.6	4.9	4.9
4.7 ≤ E < 4.9	4.1	4.2	4.8	4.9	4.5	4.9	4.9
E ≥ 4.9	4.0	4.2	4.7	4.9	4.5	4.9	4.8

Note: For fuel assembly average burnup greater than 45 GWd/MTU, cool time tables have been revised to account for a 5% margin in heat load.

Table B2-18 Loading Table for PWR Fuel – 1,140 W/Assembly

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	45 < Assembly Average Burnup ≤ 46 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	5.0	5.2	6.0	6.2	5.6	6.0	6.0
2.9 ≤ E < 3.1	5.0	5.1	5.9	6.0	5.5	6.0	6.0
3.1 ≤ E < 3.3	4.9	5.0	5.8	6.0	5.5	5.9	5.9
3.3 ≤ E < 3.5	4.8	4.9	5.7	5.9	5.4	5.8	5.8
3.5 ≤ E < 3.7	4.8	4.9	5.6	5.8	5.3	5.7	5.7
3.7 ≤ E < 3.9	4.7	4.8	5.6	5.8	5.2	5.7	5.7
3.9 ≤ E < 4.1	4.6	4.8	5.5	5.7	5.1	5.6	5.6
4.1 ≤ E < 4.3	4.6	4.7	5.4	5.6	5.1	5.5	5.6
4.3 ≤ E < 4.5	4.5	4.6	5.4	5.6	5.0	5.5	5.5
4.5 ≤ E < 4.7	4.5	4.6	5.3	5.5	5.0	5.4	5.4
4.7 ≤ E < 4.9	4.4	4.6	5.3	5.5	4.9	5.4	5.4
E ≥ 4.9	4.4	4.5	5.2	5.4	4.9	5.4	5.3

Table B2-18 Loading Table for PWR Fuel – 1,140 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	46 < Assembly Average Burnup ≤ 47 GWd/MTU Minimum Cooling Time (years)						
	CE 14x14	WE 14x14	WE 15x15	B&W 15x15	CE 16x16	WE 17x17	B&W 17x17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	5.2	5.4	6.2	6.5	5.8	6.3	6.3
2.9 ≤ E < 3.1	5.1	5.3	6.1	6.4	5.7	6.2	6.2
3.1 ≤ E < 3.3	5.0	5.2	6.0	6.2	5.6	6.1	6.1
3.3 ≤ E < 3.5	5.0	5.1	5.9	6.1	5.6	6.0	6.0
3.5 ≤ E < 3.7	4.9	5.0	5.8	6.0	5.5	5.9	5.9
3.7 ≤ E < 3.9	4.8	5.0	5.8	6.0	5.4	5.9	5.9
3.9 ≤ E < 4.1	4.8	4.9	5.7	5.9	5.3	5.8	5.8
4.1 ≤ E < 4.3	4.7	4.8	5.6	5.8	5.3	5.8	5.7
4.3 ≤ E < 4.5	4.7	4.8	5.6	5.8	5.2	5.7	5.7
4.5 ≤ E < 4.7	4.6	4.7	5.5	5.7	5.2	5.6	5.6
4.7 ≤ E < 4.9	4.6	4.7	5.5	5.7	5.1	5.6	5.6
E ≥ 4.9	4.5	4.7	5.4	5.6	5.0	5.5	5.5

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	47 < Assembly Average Burnup ≤ 48 GWd/MTU Minimum Cooling Time (years)						
	CE 14x14	WE 14x14	WE 15x15	B&W 15x15	CE 16x16	WE 17x17	B&W 17x17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	5.4	5.6	6.5	6.8	6.0	6.6	6.6
2.9 ≤ E < 3.1	5.3	5.5	6.4	6.6	5.9	6.5	6.5
3.1 ≤ E < 3.3	5.2	5.4	6.2	6.5	5.8	6.4	6.4
3.3 ≤ E < 3.5	5.1	5.3	6.1	6.4	5.8	6.2	6.2
3.5 ≤ E < 3.7	5.0	5.2	6.0	6.3	5.7	6.2	6.1
3.7 ≤ E < 3.9	5.0	5.1	5.9	6.2	5.6	6.0	6.0
3.9 ≤ E < 4.1	4.9	5.0	5.9	6.1	5.5	6.0	6.0
4.1 ≤ E < 4.3	4.9	5.0	5.8	6.0	5.5	5.9	5.9
4.3 ≤ E < 4.5	4.8	4.9	5.8	6.0	5.4	5.9	5.9
4.5 ≤ E < 4.7	4.8	4.9	5.7	5.9	5.3	5.8	5.8
4.7 ≤ E < 4.9	4.7	4.9	5.7	5.8	5.3	5.8	5.8
E ≥ 4.9	4.7	4.8	5.6	5.8	5.2	5.7	5.7

Table B2-18 Loading Table for PWR Fuel – 1,140 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	48 < Assembly Average Burnup ≤ 49 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	5.6	5.8	6.8	7.0	6.3	6.9	6.9
2.9 ≤ E < 3.1	5.5	5.7	6.7	6.9	6.1	6.8	6.7
3.1 ≤ E < 3.3	5.4	5.6	6.5	6.8	6.0	6.6	6.6
3.3 ≤ E < 3.5	5.3	5.5	6.4	6.7	5.9	6.5	6.5
3.5 ≤ E < 3.7	5.2	5.4	6.3	6.6	5.9	6.4	6.4
3.7 ≤ E < 3.9	5.2	5.3	6.2	6.5	5.8	6.3	6.3
3.9 ≤ E < 4.1	5.1	5.2	6.1	6.4	5.7	6.2	6.2
4.1 ≤ E < 4.3	5.0	5.2	6.0	6.3	5.7	6.1	6.1
4.3 ≤ E < 4.5	5.0	5.1	5.9	6.2	5.6	6.0	6.0
4.5 ≤ E < 4.7	4.9	5.0	5.9	6.1	5.5	6.0	6.0
4.7 ≤ E < 4.9	4.8	5.0	5.8	6.0	5.5	5.9	5.9
E ≥ 4.9	4.8	4.9	5.8	6.0	5.4	5.9	5.9

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	49 < Assembly Average Burnup ≤ 50 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	5.7	5.8	6.9	7.3	6.4	7.0	7.0
3.1 ≤ E < 3.3	5.6	5.7	6.8	7.1	6.3	6.9	6.9
3.3 ≤ E < 3.5	5.5	5.6	6.7	7.0	6.2	6.8	6.8
3.5 ≤ E < 3.7	5.4	5.5	6.6	6.9	6.0	6.7	6.7
3.7 ≤ E < 3.9	5.4	5.5	6.5	6.8	6.0	6.6	6.6
3.9 ≤ E < 4.1	5.3	5.4	6.4	6.7	5.9	6.5	6.5
4.1 ≤ E < 4.3	5.2	5.3	6.3	6.6	5.8	6.4	6.4
4.3 ≤ E < 4.5	5.1	5.2	6.2	6.5	5.8	6.3	6.3
4.5 ≤ E < 4.7	5.0	5.2	6.1	6.4	5.7	6.2	6.2
4.7 ≤ E < 4.9	5.0	5.1	6.0	6.3	5.7	6.2	6.2
E ≥ 4.9	4.9	5.0	6.0	6.2	5.6	6.1	6.1

Table B2-18 Loading Table for PWR Fuel – 1,140 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	50 < Assembly Average Burnup ≤ 51 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	5.8	6.0	7.3	7.6	6.7	7.4	7.4
3.1 ≤ E < 3.3	5.8	5.9	7.1	7.5	6.6	7.2	7.2
3.3 ≤ E < 3.5	5.7	5.8	7.0	7.3	6.4	7.1	7.0
3.5 ≤ E < 3.7	5.6	5.7	6.8	7.2	6.3	6.9	6.9
3.7 ≤ E < 3.9	5.5	5.7	6.7	7.0	6.2	6.9	6.8
3.9 ≤ E < 4.1	5.4	5.6	6.6	6.9	6.1	6.8	6.8
4.1 ≤ E < 4.3	5.3	5.5	6.5	6.8	6.0	6.7	6.7
4.3 ≤ E < 4.5	5.2	5.4	6.4	6.8	6.0	6.6	6.6
4.5 ≤ E < 4.7	5.2	5.4	6.4	6.7	5.9	6.5	6.5
4.7 ≤ E < 4.9	5.1	5.3	6.3	6.6	5.8	6.4	6.4
E ≥ 4.9	5.0	5.2	6.2	6.5	5.8	6.4	6.3

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	51 < Assembly Average Burnup ≤ 52 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	6.0	6.3	7.6	7.9	6.9	7.7	7.7
3.1 ≤ E < 3.3	5.9	6.1	7.5	7.7	6.8	7.6	7.6
3.3 ≤ E < 3.5	5.8	6.0	7.3	7.6	6.7	7.4	7.4
3.5 ≤ E < 3.7	5.8	5.9	7.1	7.4	6.6	7.3	7.3
3.7 ≤ E < 3.9	5.7	5.9	7.0	7.3	6.5	7.1	7.1
3.9 ≤ E < 4.1	5.6	5.8	6.9	7.1	6.4	7.0	7.0
4.1 ≤ E < 4.3	5.5	5.7	6.8	7.0	6.3	6.9	6.9
4.3 ≤ E < 4.5	5.4	5.6	6.7	6.9	6.2	6.8	6.8
4.5 ≤ E < 4.7	5.4	5.6	6.6	6.8	6.1	6.8	6.8
4.7 ≤ E < 4.9	5.3	5.5	6.5	6.8	6.0	6.7	6.7
E ≥ 4.9	5.2	5.4	6.5	6.7	6.0	6.6	6.6

Table B2-18 Loading Table for PWR Fuel – 1,140 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	52 < Assembly Average Burnup ≤ 53 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	6.3	6.5	7.9	8.3	7.3	8.1	8.1
3.1 ≤ E < 3.3	6.2	6.4	7.7	8.1	7.1	7.9	7.9
3.3 ≤ E < 3.5	6.0	6.3	7.5	7.9	7.0	7.8	7.8
3.5 ≤ E < 3.7	5.9	6.1	7.4	7.8	6.9	7.6	7.6
3.7 ≤ E < 3.9	5.8	6.1	7.2	7.6	6.7	7.5	7.5
3.9 ≤ E < 4.1	5.8	6.0	7.1	7.5	6.6	7.4	7.3
4.1 ≤ E < 4.3	5.7	5.9	7.0	7.4	6.5	7.2	7.2
4.3 ≤ E < 4.5	5.6	5.8	6.9	7.2	6.4	7.1	7.1
4.5 ≤ E < 4.7	5.5	5.7	6.8	7.1	6.4	7.0	7.0
4.7 ≤ E < 4.9	5.5	5.7	6.7	7.0	6.3	6.9	6.9
E ≥ 4.9	5.4	5.6	6.6	6.9	6.2	6.9	6.9

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	53 < Assembly Average Burnup ≤ 54 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	6.6	6.8	8.3	8.8	7.6	8.6	8.6
3.1 ≤ E < 3.3	6.4	6.7	8.0	8.6	7.5	8.3	8.3
3.3 ≤ E < 3.5	6.3	6.5	7.9	8.3	7.3	8.2	8.1
3.5 ≤ E < 3.7	6.1	6.4	7.7	8.1	7.1	8.0	8.0
3.7 ≤ E < 3.9	6.0	6.3	7.6	8.0	7.0	7.9	7.8
3.9 ≤ E < 4.1	5.9	6.2	7.4	7.8	6.9	7.7	7.7
4.1 ≤ E < 4.3	5.9	6.1	7.3	7.7	6.8	7.6	7.6
4.3 ≤ E < 4.5	5.8	6.0	7.2	7.6	6.7	7.5	7.5
4.5 ≤ E < 4.7	5.7	5.9	7.0	7.5	6.6	7.4	7.3
4.7 ≤ E < 4.9	5.7	5.9	7.0	7.4	6.5	7.2	7.2
E ≥ 4.9	5.6	5.9	6.9	7.3	6.4	7.1	7.1

Table B2-18 Loading Table for PWR Fuel – 1,140 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	54 < Assembly Average Burnup ≤ 55 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	6.7	6.9	8.5	9.0	7.8	8.8	8.8
3.3 ≤ E < 3.5	6.6	6.8	8.3	8.8	7.6	8.6	8.6
3.5 ≤ E < 3.7	6.4	6.7	8.1	8.6	7.5	8.4	8.4
3.7 ≤ E < 3.9	6.3	6.6	7.9	8.4	7.3	8.2	8.2
3.9 ≤ E < 4.1	6.2	6.5	7.8	8.2	7.2	8.0	8.0
4.1 ≤ E < 4.3	6.1	6.3	7.6	8.1	7.0	7.9	7.9
4.3 ≤ E < 4.5	6.0	6.2	7.5	7.9	7.0	7.8	7.8
4.5 ≤ E < 4.7	5.9	6.1	7.4	7.8	6.9	7.7	7.7
4.7 ≤ E < 4.9	5.9	6.0	7.3	7.7	6.8	7.6	7.6
E ≥ 4.9	5.8	6.0	7.2	7.6	6.7	7.5	7.5

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	55 < Assembly Average Burnup ≤ 56 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	6.9	7.3	8.9	9.6	8.0	9.3	9.3
3.3 ≤ E < 3.5	6.8	7.1	8.7	9.3	7.8	9.0	9.0
3.5 ≤ E < 3.7	6.7	6.9	8.5	9.1	7.7	8.8	8.9
3.7 ≤ E < 3.9	6.6	6.8	8.3	8.9	7.5	8.7	8.7
3.9 ≤ E < 4.1	6.4	6.7	8.1	8.7	7.4	8.5	8.5
4.1 ≤ E < 4.3	6.3	6.6	8.0	8.5	7.2	8.3	8.3
4.3 ≤ E < 4.5	6.2	6.5	7.9	8.4	7.1	8.2	8.1
4.5 ≤ E < 4.7	6.1	6.4	7.7	8.2	7.0	8.0	8.0
4.7 ≤ E < 4.9	6.0	6.3	7.6	8.1	6.9	7.9	7.9
E ≥ 4.9	6.0	6.2	7.5	8.0	6.8	7.8	7.8

Table B2-18 Loading Table for PWR Fuel – 1,140 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	56 < Assembly Average Burnup ≤ 57 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	7.3	7.6	9.4	10.1	8.4	9.8	9.8
3.3 ≤ E < 3.5	7.1	7.4	9.2	9.9	8.2	9.6	9.6
3.5 ≤ E < 3.7	6.9	7.3	9.0	9.6	8.0	9.4	9.3
3.7 ≤ E < 3.9	6.8	7.1	8.8	9.4	7.9	9.1	9.1
3.9 ≤ E < 4.1	6.7	7.0	8.6	9.2	7.7	8.9	8.9
4.1 ≤ E < 4.3	6.6	6.9	8.4	9.0	7.6	8.8	8.8
4.3 ≤ E < 4.5	6.5	6.8	8.2	8.8	7.5	8.6	8.6
4.5 ≤ E < 4.7	6.4	6.7	8.1	8.7	7.3	8.5	8.4
4.7 ≤ E < 4.9	6.3	6.6	8.0	8.5	7.2	8.3	8.3
E ≥ 4.9	6.2	6.5	7.8	8.4	7.1	8.2	8.2

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	57 < Assembly Average Burnup ≤ 58 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	7.6	8.0	10.0	10.8	8.9	10.5	10.4
3.3 ≤ E < 3.5	7.4	7.8	9.7	10.5	8.7	10.2	10.1
3.5 ≤ E < 3.7	7.2	7.6	9.5	10.2	8.4	9.9	9.9
3.7 ≤ E < 3.9	7.1	7.5	9.3	9.9	8.2	9.7	9.6
3.9 ≤ E < 4.1	6.9	7.3	9.0	9.7	8.1	9.5	9.4
4.1 ≤ E < 4.3	6.8	7.1	8.8	9.5	7.9	9.2	9.2
4.3 ≤ E < 4.5	6.7	7.0	8.7	9.3	7.8	9.0	9.0
4.5 ≤ E < 4.7	6.6	6.9	8.5	9.1	7.7	8.9	8.9
4.7 ≤ E < 4.9	6.5	6.8	8.4	8.9	7.5	8.7	8.7
E ≥ 4.9	6.4	6.7	8.2	8.8	7.4	8.6	8.6

Table B2-18 Loading Table for PWR Fuel – 1,140 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	58 < Assembly Average Burnup ≤ 59 GWd/MTU Minimum Cooling Time (years)						
	CE 14x14	WE 14x14	WE 15x15	B&W 15x15	CE 16x16	WE 17x17	B&W 17x17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	7.9	8.4	10.7	11.5	9.4	11.1	11.1
3.3 ≤ E < 3.5	7.8	8.2	10.3	11.2	9.1	10.8	10.8
3.5 ≤ E < 3.7	7.6	8.0	10.0	10.9	8.9	10.5	10.5
3.7 ≤ E < 3.9	7.4	7.8	9.8	10.6	8.7	10.2	10.2
3.9 ≤ E < 4.1	7.2	7.6	9.5	10.3	8.5	10.0	9.9
4.1 ≤ E < 4.3	7.1	7.5	9.3	10.0	8.3	9.8	9.7
4.3 ≤ E < 4.5	7.0	7.3	9.1	9.8	8.1	9.6	9.5
4.5 ≤ E < 4.7	6.9	7.2	8.9	9.6	8.0	9.4	9.4
4.7 ≤ E < 4.9	6.8	7.1	8.8	9.5	7.9	9.2	9.2
E ≥ 4.9	6.7	7.0	8[illegible]	9.3	7.8	9.0	9.0
Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	59 < Assembly Average Burnup ≤ 60 GWd/MTU Minimum Cooling Time (years)						
	CE 14x14	WE 14x14	WE 15x15	B&W 15x15	CE 16x16	WE 17x17	B&W 17x17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	-	-	-	-	-	-	-
3.3 ≤ E < 3.5	8.1	8.6	11.0	11.8	9.6	11.2	11.2
3.5 ≤ E < 3.7	7.9	8.4	10.7	11.5	9.4	10.9	10.8
3.7 ≤ E < 3.9	7.7	8.2	10.3	11.2	9.1	10.6	10.5
3.9 ≤ E < 4.1	7.6	8.0	10.1	11.0	8.9	10.3	10.3
4.1 ≤ E < 4.3	7.4	7.8	9.8	10.7	8.7	10.0	10.0
4.3 ≤ E < 4.5	7.3	7.7	9.6	10.4	8.5	9.8	9.8
4.5 ≤ E < 4.7	7.1	7.6	9.4	10.2	8.4	9.7	9.6
4.7 ≤ E < 4.9	7.0	7.4	9.2	10.0	8.2	9.5	9.4
E ≥ 4.9	6.9	7.3	9.1	9.8	8.1	9.3	9.3

Table B2-19 Loading Table for PWR Fuel – 922 W/Assembly

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	30 < Assembly Average Burnup ≤ 32.5 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	4.2	4.3	4.8	4.9	4.6	4.9	4.9
2.3 ≤ E < 2.5	4.2	4.2	4.7	4.8	4.5	4.8	4.8
2.5 ≤ E < 2.7	4.1	4.2	4.7	4.8	4.5	4.8	4.8
2.7 ≤ E < 2.9	4.1	4.1	4.6	4.7	4.4	4.7	4.7
2.9 ≤ E < 3.1	4.0	4.1	4.6	4.7	4.4	4.7	4.7
3.1 ≤ E < 3.3	4.0	4.0	4.5	4.6	4.3	4.6	4.6
3.3 ≤ E < 3.5	4.0	4.0	4.5	4.6	4.3	4.6	4.6
3.5 ≤ E < 3.7	4.0	4.0	4.5	4.5	4.3	4.5	4.5
3.7 ≤ E < 3.9	4.0	4.0	4.4	4.5	4.2	4.5	4.5
3.9 ≤ E < 4.1	4.0	4.0	4.4	4.5	4.2	4.5	4.5
4.1 ≤ E < 4.3	4.0	4.0	4.4	4.5	4.2	4.4	4.4
4.3 ≤ E < 4.5	4.0	4.0	4.3	4.4	4.2	4.4	4.4
4.5 ≤ E < 4.7	4.0	4.0	4.3	4.4	4.1	4.4	4.4
4.7 ≤ E < 4.9	4.0	4.0	4.3	4.4	4.1	4.4	4.4
E ≥ 4.9	4.0	4.0	4.3	4.4	4.1	4.4	4.4

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	32.5 < Assembly Average Burnup ≤ 35 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	4.5	4.6	5.2	5.3	4.9	5.3	5.3
2.5 ≤ E < 2.7	4.4	4.5	5.1	5.3	4.9	5.2	5.2
2.7 ≤ E < 2.9	4.4	4.5	5.0	5.2	4.8	5.1	5.1
2.9 ≤ E < 3.1	4.4	4.4	5.0	5.1	4.8	5.1	5.1
3.1 ≤ E < 3.3	4.3	4.4	4.9	5.0	4.7	5.0	5.0
3.3 ≤ E < 3.5	4.3	4.3	4.9	5.0	4.7	5.0	5.0
3.5 ≤ E < 3.7	4.2	4.3	4.8	5.0	4.6	4.9	4.9
3.7 ≤ E < 3.9	4.2	4.3	4.8	4.9	4.6	4.9	4.9
3.9 ≤ E < 4.1	4.1	4.2	4.8	4.9	4.5	4.9	4.9
4.1 ≤ E < 4.3	4.1	4.2	4.7	4.9	4.5	4.8	4.8
4.3 ≤ E < 4.5	4.1	4.2	4.7	4.8	4.5	4.8	4.8
4.5 ≤ E < 4.7	4.0	4.1	4.7	4.8	4.5	4.8	4.8
4.7 ≤ E < 4.9	4.0	4.1	4.6	4.8	4.4	4.7	4.7
E ≥ 4.9	4.0	4.1	4.6	4.7	4.4	4.7	4.7

Table B2-19 Loading Table for PWR Fuel – 922 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	35 < Assembly Average Burnup ≤ 37.5 GWd/MTU Minimum Cooling Time (years)						
	CE 14x14	WE 14x14	WE 15x15	B&W 15x15	CE 16x16	WE 17x17	B&W 17x17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	4.9	5.0	5.7	5.9	5.4	5.8	5.8
2.5 ≤ E < 2.7	4.8	4.9	5.7	5.8	5.3	5.7	5.7
2.7 ≤ E < 2.9	4.8	4.9	5.6	5.8	5.3	5.7	5.7
2.9 ≤ E < 3.1	4.7	4.8	5.5	5.7	5.2	5.6	5.6
3.1 ≤ E < 3.3	4.6	4.7	5.4	5.6	5.1	5.5	5.5
3.3 ≤ E < 3.5	4.6	4.7	5.4	5.6	5.0	5.5	5.5
3.5 ≤ E < 3.7	4.5	4.6	5.3	5.5	5.0	5.4	5.4
3.7 ≤ E < 3.9	4.5	4.6	5.3	5.4	5.0	5.4	5.4
3.9 ≤ E < 4.1	4.5	4.6	5.2	5.4	4.9	5.3	5.3
4.1 ≤ E < 4.3	4.4	4.5	5.2	5.4	4.9	5.3	5.3
4.3 ≤ E < 4.5	4.4	4.5	5.1	5.3	4.9	5.2	5.2
4.5 ≤ E < 4.7	4.4	4.5	5.1	5.3	4.8	5.2	5.2
4.7 ≤ E < 4.9	4.3	4.4	5.0	5.2	4.8	5.2	5.2
E ≥ 4.9	4.3	4.4	5.0	5.2	4.8	5.1	5.1

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	37.5 < Assembly Average Burnup ≤ 40 GWd/MTU Minimum Cooling Time (years)						
	CE 14x14	WE 14x14	WE 15x15	B&W 15x15	CE 16x16	WE 17x17	B&W 17x17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	5.3	5.4	6.2	6.5	5.9	6.3	6.3
2.7 ≤ E < 2.9	5.2	5.3	6.1	6.4	5.8	6.2	6.2
2.9 ≤ E < 3.1	5.1	5.3	6.0	6.3	5.7	6.1	6.1
3.1 ≤ E < 3.3	5.0	5.2	6.0	6.2	5.6	6.0	6.0
3.3 ≤ E < 3.5	5.0	5.1	5.9	6.1	5.6	6.0	6.0
3.5 ≤ E < 3.7	4.9	5.0	5.9	6.0	5.5	5.9	5.9
3.7 ≤ E < 3.9	4.9	5.0	5.8	6.0	5.5	5.9	5.9
3.9 ≤ E < 4.1	4.8	5.0	5.7	5.9	5.4	5.8	5.8
4.1 ≤ E < 4.3	4.8	4.9	5.7	5.9	5.4	5.8	5.8
4.3 ≤ E < 4.5	4.8	4.9	5.7	5.8	5.3	5.8	5.7
4.5 ≤ E < 4.7	4.7	4.8	5.6	5.8	5.3	5.7	5.7
4.7 ≤ E < 4.9	4.7	4.8	5.6	5.8	5.2	5.7	5.7
E ≥ 4.9	4.6	4.8	5.5	5.7	5.2	5.6	5.6

Table B2-19 Loading Table for PWR Fuel – 922 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	40 < Assembly Average Burnup ≤ 41 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	5.5	5.6	6.6	6.8	6.0	6.6	6.6
2.7 ≤ E < 2.9	5.4	5.6	6.4	6.7	6.0	6.5	6.5
2.9 ≤ E < 3.1	5.3	5.5	6.3	6.6	5.9	6.4	6.4
3.1 ≤ E < 3.3	5.3	5.4	6.2	6.5	5.8	6.3	6.3
3.3 ≤ E < 3.5	5.2	5.3	6.1	6.4	5.8	6.3	6.2
3.5 ≤ E < 3.7	5.1	5.3	6.1	6.3	5.7	6.2	6.2
3.7 ≤ E < 3.9	5.0	5.2	6.0	6.2	5.7	6.1	6.1
3.9 ≤ E < 4.1	5.0	5.1	5.9	6.2	5.6	6.0	6.0
4.1 ≤ E < 4.3	5.0	5.1	5.9	6.1	5.6	6.0	6.0
4.3 ≤ E < 4.5	4.9	5.0	5.9	6.0	5.5	5.9	5.9
4.5 ≤ E < 4.7	4.9	5.0	5.8	6.0	5.5	5.9	5.9
4.7 ≤ E < 4.9	4.8	5.0	5.8	6.0	5.4	5.9	5.9
E ≥ 4.9	4.8	4.9	5.7	5.9	5.4	5.8	5.8

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	41 < Assembly Average Burnup ≤ 42 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	5.7	5.9	6.9	7.1	6.4	6.9	6.9
2.7 ≤ E < 2.9	5.6	5.8	6.7	7.0	6.2	6.8	6.8
2.9 ≤ E < 3.1	5.6	5.7	6.6	6.9	6.1	6.7	6.7
3.1 ≤ E < 3.3	5.5	5.6	6.5	6.8	6.0	6.6	6.6
3.3 ≤ E < 3.5	5.4	5.5	6.4	6.7	6.0	6.6	6.5
3.5 ≤ E < 3.7	5.3	5.5	6.4	6.6	5.9	6.5	6.5
3.7 ≤ E < 3.9	5.3	5.4	6.3	6.6	5.9	6.4	6.4
3.9 ≤ E < 4.1	5.2	5.4	6.2	6.5	5.8	6.3	6.3
4.1 ≤ E < 4.3	5.1	5.3	6.1	6.4	5.8	6.3	6.2
4.3 ≤ E < 4.5	5.1	5.2	6.0	6.3	5.7	6.2	6.2
4.5 ≤ E < 4.7	5.0	5.2	6.0	6.3	5.7	6.1	6.1
4.7 ≤ E < 4.9	5.0	5.1	6.0	6.2	5.6	6.1	6.1
E ≥ 4.9	4.9	5.1	5.9	6.2	5.6	6.0	6.0

Table B2-19 Loading Table for PWR Fuel – 922 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	42 < Assembly Average Burnup ≤ 43 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	5.9	6.1	7.2	7.5	6.7	7.3	7.3
2.7 ≤ E < 2.9	5.8	6.0	7.0	7.4	6.5	7.1	7.1
2.9 ≤ E < 3.1	5.8	5.9	6.9	7.3	6.4	7.0	7.0
3.1 ≤ E < 3.3	5.7	5.8	6.8	7.1	6.3	6.9	6.9
3.3 ≤ E < 3.5	5.6	5.8	6.7	7.0	6.2	6.8	6.8
3.5 ≤ E < 3.7	5.5	5.7	6.7	6.9	6.1	6.8	6.7
3.7 ≤ E < 3.9	5.5	5.6	6.6	6.8	6.1	6.7	6.7
3.9 ≤ E < 4.1	5.4	5.6	6.5	6.8	6.0	6.6	6.6
4.1 ≤ E < 4.3	5.3	5.5	6.4	6.7	6.0	6.5	6.5
4.3 ≤ E < 4.5	5.3	5.5	6.4	6.6	5.9	6.5	6.5
4.5 ≤ E < 4.7	5.2	5.4	6.3	6.6	5.9	6.4	6.4
4.7 ≤ E < 4.9	5.2	5.3	6.2	6.5	5.8	6.4	6.4
E ≥ 4.9	5.1	5.3	6.2	6.5	5.8	6.3	6.3

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	43 < Assembly Average Burnup ≤ 44 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	[illegible]	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	6.[illegible]	6.4	7.6	8.0	6.9	7.7	7.7
2.7 ≤ E < 2.9	6.0	6.2	7.4	7.8	6.8	7.5	7.5
2.9 ≤ E < 3.1	6.0	6.1	7.3	7.7	6.7	7.4	7.4
3.1 ≤ E < 3.3	5.9	6.0	7.2	7.5	6.6	7.3	7.3
3.3 ≤ E < 3.5	5.8	6.0	7.0	7.4	6.5	7.1	7.1
3.5 ≤ E < 3.7	5.8	5.9	6.9	7.3	6.4	7.0	7.0
3.7 ≤ E < 3.9	5.7	5.8	6.9	7.2	6.3	7.0	7.0
3.9 ≤ E < 4.1	5.6	5.8	6.8	7.1	6.3	6.9	6.9
4.1 ≤ E < 4.3	5.5	5.7	6.7	7.0	6.2	6.8	6.8
4.3 ≤ E < 4.5	5.5	5.7	6.7	6.9	6.1	6.8	6.8
4.5 ≤ E < 4.7	5.4	5.6	6.6	6.9	6.0	6.7	6.7
4.7 ≤ E < 4.9	5.4	5.6	6.5	6.8	6.0	6.6	6.6
E ≥ 4.9	5.3	5.5	6.5	6.8	6.0	6.6	6.6

Table B2-19 Loading Table for PWR Fuel – 922 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	44 < Assembly Average Burnup ≤ 45 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	6.3	6.6	7.8	8.3	7.1	7.9	7.9
2.9 ≤ E < 3.1	6.2	6.4	7.7	8.1	7.0	7.8	7.8
3.1 ≤ E < 3.3	6.1	6.3	7.6	7.9	6.9	7.7	7.7
3.3 ≤ E < 3.5	6.0	6.2	7.4	7.8	6.8	7.5	7.5
3.5 ≤ E < 3.7	5.9	6.1	7.3	7.7	6.7	7.4	7.4
3.7 ≤ E < 3.9	5.9	6.0	7.2	7.6	6.6	7.3	7.3
3.9 ≤ E < 4.1	5.8	6.0	7.1	7.5	6.6	7.2	7.2
4.1 ≤ E < 4.3	5.7	5.9	7.0	7.4	6.5	7.1	7.1
4.3 ≤ E < 4.5	5.7	5.9	6.9	7.3	6.4	7.0	7.0
4.5 ≤ E < 4.7	5.6	5.8	6.9	7.2	6.3	7.0	7.0
4.7 ≤ E < 4.9	5.6	5.8	6.8	7.1	6.3	6.9	6.9
E ≥ 4.9	5.5	5.7	6.7	7.0	6.2	6.9	6.9

<u>Note:</u> For fuel assembly average burnup greater than 45 GWd/MTU, cool time tables have been revised to account for a 5% margin in heat load.

Table B2-20 Loading Table for PWR Fuel – 876 W/Assembly

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	45 < Assembly Average Burnup ≤ 46 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	7.1	7.4	9.2	9.8	8.2	9.3	9.3
2.9 ≤ E < 3.1	7.0	7.3	9.0	9.6	8.0	9.1	9.0
3.1 ≤ E < 3.3	6.9	7.1	8.8	9.4	7.9	8.9	8.9
3.3 ≤ E < 3.5	6.8	7.0	8.6	9.1	7.8	8[illegible]	8.7
3.5 ≤ E < 3.7	6.7	6.9	8.5	9.0	7.6	8.6	8.6
3.7 ≤ E < 3.9	6.6	6.8	8.3	8.9	7.5	8.5	8.4
3.9 ≤ E < 4.1	6.5	6.7	8.2	8.7	7.4	8.3	8.3
4.1 ≤ E < 4.3	6.4	6.6	8.1	8.6	7.3	8.2	8.2
4.3 ≤ E < 4.5	6.3	6.6	8.0	8.5	7.2	8.1	8.1
4.5 ≤ E < 4.7	6.2	6.5	7.9	8.4	7.2	8.0	8.0
4.7 ≤ E < 4.9	6.2	6.4	7.8	8.3	7.1	8.0	7.9
E ≥ 4.9	6.1	6.4	7.7	8.2	7.0	7.9	7.9

Table B2-20 Loading Table for PWR Fuel – 876 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ²³⁵U (E)	46 < Assembly Average Burnup ≤ 47 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	7.5	7.8	9.8	10.5	8.7	9.9	9.9
2.9 ≤ E < 3.1	7.4	7.7	9.6	10.3	8.5	9.7	9.7
3.1 ≤ E < 3.3	7.2	7.5	9.3	10.0	8.3	9.5	9.5
3.3 ≤ E < 3.5	7.1	7.4	9.1	9.8	8.1	9.3	9.3
3.5 ≤ E < 3.7	7.0	7.2	9.0	9.6	8.0	9.1	9.1
3.7 ≤ E < 3.9	6.9	7.1	8.8	9.4	7.9	9.0	8.9
3.9 ≤ E < 4.1	6.8	7.0	8.7	9.3	7.8	8.8	8.8
4.1 ≤ E < 4.3	6.7	6.9	8.6	9.1	7.7	8.7	8.7
4.3 ≤ E < 4.5	6.6	6.9	8.4	9.0	7.6	8.6	8.6
4.5 ≤ E < 4.7	6.5	6.8	8.3	8.9	7.5	8.5	8.5
4.7 ≤ E < 4.9	6.5	6.7	8.2	8.8	7.5	8.4	8.4
E ≥ 4.9	6.4	6.7	8.[illegible]	8.7	7.4	8.3	8.3

Minimum Initial Assembly Avg. Enrichment wt % ²³⁵U (E)	47 < Assembly Average Burnup ≤ 48 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	7.9	8.3	10.5	11.3	9.2	10.7	10.6
2.9 ≤ E < 3.1	7.7	8.1	10.2	11.1	9.0	10.4	10.3
3.1 ≤ E < 3.3	7.6	7.9	10.0	10.8	8.8	10.1	10.1
3.3 ≤ E < 3.5	7.4	7.8	9.7	10.5	8.7	9.9	9.9
3.5 ≤ E < 3.7	7.3	7.6	9.6	10.3	8.5	9.7	9.7
3.7 ≤ E < 3.9	7.2	7.5	9.4	10.1	8.4	9.5	9.5
3.9 ≤ E < 4.1	7.0	7.4	9.2	9.9	8.2	9.4	9.4
4.1 ≤ E < 4.3	7.0	7.3	9.0	9.7	8.1	9.2	9.2
4.3 ≤ E < 4.5	6.9	7.2	8.9	9.6	8.0	9.1	9.1
4.5 ≤ E < 4.7	6.8	7.1	8.8	9.5	7.9	9.0	9.0
4.7 ≤ E < 4.9	6.7	7.0	8.7	9.4	7.8	8.9	8.9
E ≥ 4.9	6.7	6.9	8.6	9.2	7.7	8.8	8.8

PROPOSED

Table B2-20 Loading Table for PWR Fuel – 876 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	48 < Assembly Average Burnup ≤ 49 GWd/MTU Minimum Cooling Time (years)						
	CE 14x14	WE 14x14	WE 15x15	B&W 15x15	CE 16x16	WE 17x17	B&W 17x17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	8.4	8.8	11.3	12.1	9.9	11.4	11.4
2.9 ≤ E < 3.1	8.2	8.6	11.0	11.8	9.6	11.1	11.1
3.1 ≤ E < 3.3	8.0	8.4	10.7	11.6	9.4	10.9	10.8
3.3 ≤ E < 3.5	7.8	8.2	10.4	11.3	9.2	10.6	10.6
3.5 ≤ E < 3.7	7.7	8.0	10.2	11.1	9.0	10.4	10.4
3.7 ≤ E < 3.9	7.6	7.9	10.0	10.8	8.8	10.2	10.1
3.9 ≤ E < 4.1	7.4	7.8	9.8	10.6	8.7	10.0	9.9
4.1 ≤ E < 4.3	7.3	7.7	9.7	10.4	8.6	9.8	9.8
4.3 ≤ E < 4.5	7.2	7.6	9.5	10.3	8.4	9.7	9.7
4.5 ≤ E < 4.7	7.1	7.5	9.4	10.1	8.3	9.6	9.5
4.7 ≤ E < 4.9	7.0	7.4	9.2	10.0	8.2	9.4	9.4
E ≥ 4.9	6.9	7.3	9.[illegible]	9.8	8.1	9.3	9.3

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	49 < Assembly Average Burnup ≤ 50 GWd/MTU Minimum Cooling Time (years)						
	CE 14x14	WE 14x14	WE 15x15	B&W 15x15	CE 16x16	WE 17x17	B&W 17x17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	8.7	8.9	11.8	12.7	10.2	11.9	11.9
3.1 ≤ E < 3.3	8.4	8.7	11.5	12.4	10.0	11.7	11.6
3.3 ≤ E < 3.5	8.2	8.5	11.2	12.1	9.8	11.4	11.4
3.5 ≤ E < 3.7	8.1	8.4	11.0	11.8	9.6	11.2	11.1
3.7 ≤ E < 3.9	7.9	8.2	10.7	11.6	9.4	10.9	10.9
3.9 ≤ E < 4.1	7.8	8.0	10.5	11.4	9.2	10.7	10.7
4.1 ≤ E < 4.3	7.7	7.9	10.3	11.2	9.0	10.5	10.5
4.3 ≤ E < 4.5	7.6	7.8	10.1	11.0	8.9	10.4	10.3
4.5 ≤ E < 4.7	7.5	7.7	9.9	10.9	8.8	10.2	10.1
4.7 ≤ E < 4.9	7.4	7.6	9.8	10.7	8.7	10.0	10.0
E ≥ 4.9	7.3	7.6	9.7	10.5	8.6	9.9	9.9

Table B2-20 Loading Table for PWR Fuel – 876 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	50 < Assembly Average Burnup ≤ 51 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	8.9	9.5	12.6	13.7	11.0	12.8	12.8
3.1 ≤ E < 3.3	8.7	9.3	12.2	13.3	10.7	12.5	12.4
3.3 ≤ E < 3.5	8.5	9.0	11.9	13.0	10.5	12.1	12.1
3.5 ≤ E < 3.7	8.4	8.8	11.7	12.7	10.[illegible]	11.9	11.9
3.7 ≤ E < 3.9	8.2	8.7	11.5	12.4	10.0	11.7	11.6
3.9 ≤ E < 4.1	8.0	8.5	11.2	12.2	9.8	11.5	11.4
4.1 ≤ E < 4.3	7.9	8.4	11.0	11.9	9.6	11.3	11.2
4.3 ≤ E < 4.5	7.8	8.2	10.9	11.8	9.5	11.1	11.0
4.5 ≤ E < 4.7	7.7	8.1	10.7	11.6	9.3	10.9	10.9
4.7 ≤ E < 4.9	7.6	8.0	10.5	11.4	9.2	10.8	10.7
E ≥ 4.9	7.5	7.9	10.4	11.3	9.1	10.6	10.6
Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	51 < Assembly Average Burnup ≤ 52 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	9.5	10.1	13.5	14.3	11.7	13.7	13.7
3.1 ≤ E < 3.3	9.2	9.8	13.2	13.9	11.5	13.4	13.4
3.3 ≤ E < 3.5	9.0	9.6	12.8	13.6	11.2	13.1	13.0
3.5 ≤ E < 3.7	8.8	9.4	12.5	13.3	10.9	12.8	12.7
3.7 ≤ E < 3.9	8.7	9.2	12.2	13.0	10.7	12.5	12.4
3.9 ≤ E < 4.1	8.5	9.0	12.0	12.8	10.4	12.2	12.2
4.1 ≤ E < 4.3	8.3	8.9	11.8	12.5	10.2	12.0	11.9
4.3 ≤ E < 4.5	8.2	8.7	11.6	12.3	10.0	11.8	11.8
4.5 ≤ E < 4.7	8.1	8.6	11.4	12.1	9.9	11.6	11.6
4.7 ≤ E < 4.9	8.0	8.5	11.2	11.9	9.8	11.5	11.5
E ≥ 4.9	7.9	8.3	11.1	11.8	9.6	11.3	11.3

Table B2-20 Loading Table for PWR Fuel – 876 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	52 < Assembly Average Burnup ≤ 53 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	10.1	10.9	14.0	15.3	12.6	14.7	14.7
3.1 ≤ E < 3.3	9.8	10.5	13.7	14.9	12.2	14.3	14.3
3.3 ≤ E < 3.5	9.6	10.2	13.4	14.6	11.9	14.0	13.9
3.5 ≤ E < 3.7	9.3	10.0	13.1	14.2	11.6	13.7	13.6
3.7 ≤ E < 3.9	9.1	9.9	12.8	13.9	11.4	13.4	13.3
3.9 ≤ E < 4.1	8.9	9.6	12.5	13.7	11.2	13.1	13.1
4.1 ≤ E < 4.3	8.8	9.4	12.2	13.4	11.0	12.9	12.8
4.3 ≤ E < 4.5	8.7	9.2	12.0	13.2	10.8	12.6	12.6
4.5 ≤ E < 4.7	8.5	9.0	11.8	13.0	10.6	12.4	12.4
4.7 ≤ E < 4.9	8.4	8.9	11.7	12.8	10.4	12.2	12.2
E ≥ 4.9	8.3	8.8	11.5	12.6	10.2	12.0	12.0

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	53 < Assembly Average Burnup ≤ 54 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	10.8	11.6	15.1	16.4	13.5	15.7	15.6
3.1 ≤ E < 3.3	10.5	11.3	14.6	15.9	13.1	15.3	15.3
3.3 ≤ E < 3.5	10.1	11.0	14.2	15.6	12.7	14.9	14.9
3.5 ≤ E < 3.7	9.9	10.7	13.9	15.2	12.4	14.6	14.6
3.7 ≤ E < 3.9	9.7	10.4	13.6	14.9	12.1	14.3	14.2
3.9 ≤ E < 4.1	9.5	10.2	13.4	14.6	11.9	14.0	14.0
4.1 ≤ E < 4.3	9.3	9.9	13.1	14.3	11.7	13.7	13.7
4.3 ≤ E < 4.5	9.1	9.8	12.9	14.0	11.5	13.5	13.5
4.5 ≤ E < 4.7	9.0	9.6	12.6	13.8	11.3	13.3	13.3
4.7 ≤ E < 4.9	8.8	9.5	12.4	13.6	11.1	13.1	13.1
E ≥ 4.9	8.7	9.6	12.2	13.4	10.9	12.9	12.9

Table B2-20 Loading Table for PWR Fuel – 876 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	54 < Assembly Average Burnup ≤ 55 GWd/MTU Minimum Cooling Time (years)						
	CE 14x14	WE 14x14	WE 15x15	B&W 15x15	CE 16x16	WE 17x17	B&W 17x17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	11.2	12.0	15.6	17.0	13.9	16.3	16.3
3.3 ≤ E < 3.5	10.9	11.7	15.2	16.6	13.6	15.9	15.9
3.5 ≤ E < 3.7	10.6	11.4	14.9	16.2	13.3	15.6	15.6
3.7 ≤ E < 3.9	10.3	11.2	14.5	15.9	13.0	15.3	15.3
3.9 ≤ E < 4.1	10.0	10.9	14.2	15.6	12.7	15.0	14.9
4.1 ≤ E < 4.3	9.9	10.7	13.9	15.3	12.4	14.7	14.6
4.3 ≤ E < 4.5	9.7	10.5	13.7	15.1	12.2	14.4	14.4
4.5 ≤ E < 4.7	9.5	10.2	13.5	14.8	12.0	14.1	14.1
4.7 ≤ E < 4.9	9.3	10.0	13.3	14.6	11.8	13.9	13.9
E ≥ 4.9	9.2	9.9	13.1	14.3	11.6	13.8	13.7

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	55 < Assembly Average Burnup ≤ 56 GWd/MTU Minimum Cooling Time (years)						
	CE 14x14	WE 14x14	WE 15x15	B&W 15x15	CE 16x16	WE 17x17	B&W 17x17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	11.9	12.8	16.6	18.1	14.5	17.4	17.3
3.3 ≤ E < 3.5	11.5	12.5	16.2	17.6	14.1	17.0	16.9
3.5 ≤ E < 3.7	11.3	12.1	15.8	17.3	13.7	16.6	16.6
3.7 ≤ E < 3.9	11.0	11.8	15.5	17.0	13.4	16.3	16.2
3.9 ≤ E < 4.1	10.7	11.6	15.2	16.6	13.2	15.9	15.9
4.1 ≤ E < 4.3	10.5	11.3	14.9	16.3	12.9	15.7	15.6
4.3 ≤ E < 4.5	10.2	11.1	14.6	16.0	12.6	15.4	15.3
4.5 ≤ E < 4.7	10.0	10.9	14.3	15.8	12.4	15.2	15.1
4.7 ≤ E < 4.9	9.9	10.7	14.1	15.6	12.2	14.9	14.9
E ≥ 4.9	9.7	10.5	13.9	15.3	12.0	14.7	14.6

Table B2-20 Loading Table for PWR Fuel – 876 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	56 < Assembly Average Burnup ≤ 57 GWd/MTU Minimum Cooling Time (years)						
	CE 14x14	WE 14x14	WE 15x15	B&W 15x15	CE 16x16	WE 17x17	B&W 17x17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	12.6	13.6	17.6	19.1	15.5	18.4	18.4
3.3 ≤ E < 3.5	12.3	13.3	17.2	18.7	15.0	18.0	18.0
3.5 ≤ E < 3.7	11.9	13.0	16.8	18.4	14.6	17.7	17.6
3.7 ≤ E < 3.9	11.7	12.6	16.5	18.0	14.3	17.3	17.3
3.9 ≤ E < 4.1	11.4	12.3	16.1	17.7	14.0	17.0	17.0
4.1 ≤ E < 4.3	11.2	12.0	15.8	17.4	13.7	16.7	16.7
4.3 ≤ E < 4.5	10.9	11.8	15.5	17.1	13.5	16.4	16.4
4.5 ≤ E < 4.7	10.7	11.6	15.3	16.8	13.2	16.1	16.1
4.7 ≤ E < 4.9	10.5	11.4	15.1	16.6	13.0	15.8	15.8
E ≥ 4.9	10.3	11.2	14.8	16.3	12.8	15.7	15.6

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	57 < Assembly Average Burnup ≤ 58 GWd/MTU Minimum Cooling Time (years)						
	CE 14x14	WE 14x14	WE 15x15	B&W 15x15	CE 16x16	WE 17x17	B&W 17x17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	13.5	14.5	18.7	20.1	16.4	19.5	19.4
3.3 ≤ E < 3.5	13.1	14.1	18.3	19.8	15.9	19.1	19.0
3.5 ≤ E < 3.7	12.7	13.8	17.9	19.4	15.6	18.7	18.7
3.7 ≤ E < 3.9	12.4	13.4	17.5	19.0	15.3	18.4	18.3
3.9 ≤ E < 4.1	12.1	13.1	17.2	18.7	14.9	18.0	18.0
4.1 ≤ E < 4.3	11.8	12.9	16.9	18.4	14.6	17.7	17.7
4.3 ≤ E < 4.5	11.6	12.6	16.5	18.1	14.3	17.4	17.4
4.5 ≤ E < 4.7	11.4	12.3	16.3	17.8	14.0	17.2	17.1
4.7 ≤ E < 4.9	11.1	12.1	16.0	17.5	13.8	16.9	16.8
E ≥ 4.9	11.0	11.9	15.8	17.3	13.6	16.7	16.6

Table B2-20 Loading Table for PWR Fuel – 876 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	58 < Assembly Average Burnup ≤ 59 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	14.3	15.4	19.7	21.2	17.4	20.5	20.5
3.3 ≤ E < 3.5	13.9	15.0	19.3	20.8	16.9	20.1	20.1
3.5 ≤ E < 3.7	13.5	14.7	18.9	20.4	16.6	19.8	19.7
3.7 ≤ E < 3.9	13.2	14.3	18.5	20.1	16.1	19.4	19.4
3.9 ≤ E < 4.1	12.9	14.0	18.2	19.7	15.8	19.1	19.0
4.1 ≤ E < 4.3	12.6	13.7	17.8	19.4	15.5	18.8	18.7
4.3 ≤ E < 4.5	12.2	13.4	17.6	[illegible]9.1	15.2	18.4	18.4
4.5 ≤ E < 4.7	12.0	13.1	17.3	18.9	14.9	18.2	18.1
4.7 ≤ E < 4.9	11.8	12.9	17.0	18.6	14.7	17.9	17.8
E ≥ 4.9	11.6	12.7	16.8	1[illegible].4	14.5	17.6	17.6

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	59 < Assembly Average Burnup ≤ 60 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	-	-	-	-	-	-	-
3.3 ≤ E < 3.5	14.7	15.9	20.2	21.9	17.9	20.7	20.6
3.5 ≤ E < 3.7	14.3	15.6	19.9	21.5	17.5	20.3	20.2
3.7 ≤ E < 3.9	13.9	15.2	19.5	21.1	17.1	19.9	19.9
3.9 ≤ E < 4.1	13.6	14.9	19.2	20.8	16.8	19.6	19.5
4.1 ≤ E < 4.3	13.3	14.5	18.8	20.5	16.4	19.3	19.2
4.3 ≤ E < 4.5	13.1	14.2	18.5	20.2	16.1	18.9	18.9
4.5 ≤ E < 4.7	12.8	13.9	18.2	19.9	15.8	18.7	18.6
4.7 ≤ E < 4.9	12.5	13.7	18.0	19.6	15.6	18.4	18.3
E ≥ 4.9	12.3	13.5	17.7	19.4	15.4	18.2	18.1

Table B2-21 Loading Table for PWR Fuel – 800 W/Assembly

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	30 < Assembly Average Burnup ≤ 32.5 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	4.8	4.9	5.6	5.7	5.2	5.6	5.6
2.3 ≤ E < 2.5	4.7	4.8	5.5	5.7	5.2	5.6	5.6
2.5 ≤ E < 2.7	4.7	4.8	5.4	5.6	5.1	5.5	5.5
2.7 ≤ E < 2.9	4.6	4.7	5.4	5.5	5.0	5.5	5.5
2.9 ≤ E < 3.1	4.6	4.7	5.3	5.5	5.0	5.4	5.4
3.1 ≤ E < 3.3	4.5	4.6	5.3	5.4	5.0	5.3	5.3
3.3 ≤ E < 3.5	4.5	4.6	5.2	5.4	4.9	5.3	5.3
3.5 ≤ E < 3.7	4.5	4.5	5.1	5.3	4[illegible]	5.2	5.2
3.7 ≤ E < 3.9	4.4	4.5	5.1	5.3	4.8	5.2	5.2
3.9 ≤ E < 4.1	4.4	4.5	5.0	5.2	4.8	5.2	5.1
4.1 ≤ E < 4.3	4.4	4.4	5.0	5.2	4.8	5.1	5.1
4.3 ≤ E < 4.5	4.3	4.4	5.0	5.1	4.8	5.1	5.1
4.5 ≤ E < 4.7	4.3	4.4	5.0	5.1	4.7	5.0	5.0
4.7 ≤ E < 4.9	4.3	4.4	4.9	5.1	4.7	5.0	5.0
E ≥ 4.9	4.3	4.3	4.9	5.0	4.7	5.0	5.0

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	32.5 < Assembly Average Burnup ≤ 35 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	5.2	5.3	6.0	6.3	5.7	6.1	6.1
2.5 ≤ E < 2.7	5.1	5.2	6.0	6.2	5.7	6.0	6.0
2.7 ≤ E < 2.9	5.0	5.2	5.9	6.1	5.6	6.0	6.0
2.9 ≤ E < 3.1	5.0	5.1	5.9	6.0	5.5	5.9	5.9
3.1 ≤ E < 3.3	4.9	5.0	5.8	6.0	5.5	5.9	5.9
3.3 ≤ E < 3.5	4.9	5.0	5.8	5.9	5.4	5.8	5.8
3.5 ≤ E < 3.7	4.9	4.9	5.7	5.9	5.4	5.8	5.8
3.7 ≤ E < 3.9	4.8	4.9	5.7	5.8	5.3	5.8	5.8
3.9 ≤ E < 4.1	4.8	4.9	5.6	5.8	5.3	5.7	5.7
4.1 ≤ E < 4.3	4.7	4.8	5.6	5.8	5.2	5.7	5.7
4.3 ≤ E < 4.5	4.7	4.8	5.5	5.7	5.2	5.6	5.6
4.5 ≤ E < 4.7	4.7	4.8	5.5	5.7	5.2	5.6	5.6
4.7 ≤ E < 4.9	4.6	4.7	5.5	5.7	5.1	5.6	5.6
E ≥ 4.9	4.6	4.7	5.4	5.6	5.1	5.5	5.5

Table B2-21 Loading Table for PWR Fuel – 800 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	35 < Assembly Average Burnup ≤ 37.5 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	5.8	5.9	6.9	7.1	6.4	6.9	6.9
2.5 ≤ E < 2.7	5.7	5.8	6.8	7.0	6.3	6.8	6.8
2.7 ≤ E < 2.9	5.6	5.7	6.7	6.9	6.2	6.7	6.7
2.9 ≤ E < 3.1	5.5	5.7	6.6	6.8	6.1	6.7	6.7
3.1 ≤ E < 3.3	5.5	5.6	6.5	6.8	6.0	6.6	6.6
3.3 ≤ E < 3.5	5.4	5.5	6.4	6.7	6.0	6.5	6.5
3.5 ≤ E < 3.7	5.3	5.5	6.3	6.6	5.9	6.5	6.4
3.7 ≤ E < 3.9	5.3	5.4	6.3	6.5	5.9	6.4	6.4
3.9 ≤ E < 4.1	5.2	5.4	6.2	6.5	5.8	6.3	6.3
4.1 ≤ E < 4.3	5.2	5.3	6.1	6.4	5.8	6.3	6.3
4.3 ≤ E < 4.5	5.1	5.3	6.1	6.4	5.7	6.2	6.2
4.5 ≤ E < 4.7	5.1	5.2	6.0	6.3	5.7	6.2	6.2
4.7 ≤ E < 4.9	5.0	5.2	6.0	6.3	5.7	6.1	6.1
E ≥ 4.9	5.0	5.1	6.0	6.2	5.6	6.1	6.1

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	37.5 < Assembly Average Burnup ≤ 40 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	6.3	6.5	7.7	8.1	7.0	7.8	7.8
2.7 ≤ E < 2.9	6.2	6.4	7.6	8.0	6.9	7.7	7.7
2.9 ≤ E < 3.1	6.1	6.3	7.5	7.8	6.9	7.6	7.6
3.1 ≤ E < 3.3	6.0	6.2	7.4	7.7	6.8	7.4	7.4
3.3 ≤ E < 3.5	5.9	6.1	7.2	7.6	6.7	7.3	7.3
3.5 ≤ E < 3.7	5.9	6.0	7.1	7.5	6.6	7.3	7.2
3.7 ≤ E < 3.9	5.8	6.0	7.1	7.4	6.5	7.2	7.1
3.9 ≤ E < 4.1	5.8	5.9	7.0	7.4	6.5	7.1	7.1
4.1 ≤ E < 4.3	5.7	5.9	6.9	7.3	6.4	7.0	7.0
4.3 ≤ E < 4.5	5.7	5.8	6.9	7.2	6.4	7.0	7.0
4.5 ≤ E < 4.7	5.6	5.8	6.8	7.1	6.3	6.9	6.9
4.7 ≤ E < 4.9	5.6	5.7	6.8	7.1	6.3	6.9	6.9
E ≥ 4.9	5.5	5.7	6.7	7.0	6.2	6.8	6.8

Table B2-21 Loading Table for PWR Fuel – 800 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	40 < Assembly Average Burnup ≤ 41 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	6.6	6.8	8.2	8.7	7.4	8.3	8.3
2.7 ≤ E < 2.9	6.5	6.7	8.0	8.5	7.3	8.1	8.1
2.9 ≤ E < 3.1	6.4	6.6	7.9	8.3	7.2	8.0	8.0
3.1 ≤ E < 3.3	6.3	6.5	7.8	8.2	7.1	7.9	7.9
3.3 ≤ E < 3.5	6.2	6.4	7.7	8.0	7.0	7.8	7.8
3.5 ≤ E < 3.7	6.1	6.3	7.6	8.0	6.9	7.7	7.7
3.7 ≤ E < 3.9	6.0	6.2	7.5	7.9	6.8	7.6	7.6
3.9 ≤ E < 4.1	6.0	6.1	7.4	7.8	6.8	7.5	7.5
4.1 ≤ E < 4.3	5.9	6.1	7.3	7.7	6.7	7.4	7.4
4.3 ≤ E < 4.5	5.9	6.0	7.2	7.6	6.7	7.4	7.3
4.5 ≤ E < 4.7	5.8	6.0	7.1	7.6	6.6	7.3	7.3
4.7 ≤ E < 4.9	5.8	5.9	7.1	7.5	6.6	7.2	7.2
E ≥ 4.9	5.7	5.9	7.0	7.4	6.5	7.2	7.2

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	41 < Assembly Average Burnup ≤ 42 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	6.9	7.1	8.7	9.3	7.8	8.8	8.8
2.7 ≤ E < 2.9	6.8	7.0	8.6	9.0	7.7	8.6	8.6
2.9 ≤ E < 3.1	6.7	6.9	8.4	8.9	7.6	8.5	8.5
3.1 ≤ E < 3.3	6.6	6.8	8.2	8.7	7.5	8.3	8.3
3.3 ≤ E < 3.5	6.5	6.7	8.1	8.6	7.3	8.2	8.2
3.5 ≤ E < 3.7	6.4	6.6	8.0	8.5	7.2	8.1	8.1
3.7 ≤ E < 3.9	6.3	6.5	7.9	8.3	7.1	8.0	8.0
3.9 ≤ E < 4.1	6.2	6.5	7.8	8.2	7.1	7.9	7.9
4.1 ≤ E < 4.3	6.1	6.4	7.7	8.1	7.0	7.8	7.8
4.3 ≤ E < 4.5	6.1	6.3	7.6	8.0	6.9	7.8	7.7
4.5 ≤ E < 4.7	6.0	6.3	7.6	8.0	6.9	7.7	7.7
4.7 ≤ E < 4.9	6.0	6.2	7.5	7.9	6.8	7.6	7.6
E ≥ 4.9	5.9	6.1	7.4	7.8	6.8	7.6	7.6

Table B2-21 Loading Table for PWR Fuel – 800 W/Assembly (continued)

Mimimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	42 < Assembly Average Burnup ≤ 43 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	7.3	7.5	9.3	9.9	8.3	9.4	9.4
2.7 ≤ E < 2.9	7.1	7.4	9.1	9.7	8.1	9.2	9.2
2.9 ≤ E < 3.1	7.0	7.2	8.9	9.5	8.0	9.0	9.0
3.1 ≤ E < 3.3	6.9	7.1	8.8	9.3	7.9	8.9	8.8
3.3 ≤ E < 3.5	6.8	7.0	8.6	9.2	7.8	8.7	8.7
3.5 ≤ E < 3.7	6.7	6.9	8.5	9.0	7.7	8.6	8.6
3.7 ≤ E < 3.9	6.6	6.8	8.4	8.9	7.6	8.5	8.5
3.9 ≤ E < 4.1	6.5	6.8	8.2	8.8	7.5	8.4	8.4
4.1 ≤ E < 4.3	6.5	6.7	8.1	8.7	7.4	8.3	8.3
4.3 ≤ E < 4.5	6.4	6.6	8.0	8.6	7.3	8.2	8.2
4.5 ≤ E < 4.7	6.3	6.6	8.0	8.5	7.2	8.1	8.1
4.7 ≤ E < 4.9	6.2	6.5	7.9	8.4	7.2	8.0	8.0
E ≥ 4.9	6.2	6.4	7.8	8.3	7.1	8.0	8.0

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	43 < Assembly Average Burnup ≤ 44 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	7.7	8.0	10.0	10.8	8.8	10.0	10.1
2.7 ≤ E < 2.9	7.5	7.8	9.7	10.5	8.7	9.9	9.8
2.9 ≤ E < 3.1	7.4	7.7	9.5	10.2	8.5	9.7	9.6
3.1 ≤ E < 3.3	7.2	7.5	9.3	10.0	8.3	9.5	9.4
3.3 ≤ E < 3.5	7.1	7.4	9.2	9.8	8.2	9.3	9.3
3.5 ≤ E < 3.7	7.1	7.3	9.0	9.7	8.0	9.1	9.1
3.7 ≤ E < 3.9	6.9	7.2	8.9	9.5	8.0	9.0	9.0
3.9 ≤ E < 4.1	6.8	7.1	8.8	9.4	7.9	8.9	8.9
4.1 ≤ E < 4.3	6.7	7.0	8.7	9.2	7.8	8.8	8.8
4.3 ≤ E < 4.5	6.7	6.9	8.5	9.1	7.7	8.7	8.7
4.5 ≤ E < 4.7	6.6	6.9	8.5	9.0	7.6	8.6	8.6
4.7 ≤ E < 4.9	6.6	6.8	8.4	8.9	7.6	8.5	8.5
E ≥ 4.9	6.5	6.8	8.3	8.9	7.5	8.5	8.4

PROPOSED

Table B2-21 Loading Table for PWR Fuel – 800 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	44 < Assembly Average Burnup ≤ 45 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	7.9	8.2	10.5	11.4	9.2	10.6	10.6
2.9 ≤ E < 3.1	7.8	8.1	10.2	11.1	9.0	10.4	10.4
3.1 ≤ E < 3.3	7.6	7.9	10.0	10.8	8.8	10.1	10.1
3.3 ≤ E < 3.5	7.5	7.8	9.8	10.6	8.7	9.9	9.9
3.5 ≤ E < 3.7	7.3	7.7	9.6	10.4	8.6	9.8	9.8
3.7 ≤ E < 3.9	7.2	7.6	9.5	10.2	8.4	9.6	9.6
3.9 ≤ E < 4.1	7.1	7.5	9.3	10.0	8.3	9.5	9.5
4.1 ≤ E < 4.3	7.0	7.4	9.2	9.9	8.2	9.4	9.3
4.3 ≤ E < 4.5	7.0	7.3	9.1	9.8	8.1	9.2	9.2
4.5 ≤ E < 4.7	6.9	7.2	9.0	9.7	8.0	9.1	9.1
4.7 ≤ E < 4.9	6.8	7.1	8.9	9.6	7.9	9.0	9.0
E ≥ 4.9	6.8	7.0	8.8	9.5	7.9	9.0	8.9

Note: **For fuel assembly average burnup greater than 45 GWd/MTU, cool time tables have been revised to account for a 5% margin in heat load.**

Table B2-22 Loading Table for PWR Fuel – 760 W/Assembly

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	45 < Assembly Average Burnup ≤ 46 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	9.2	9.8	12.8	13.9	11.2	13.0	13.0
2.9 ≤ E < 3.1	9.0	9.6	12.5	13.6	10.9	12.7	12.7
3.1 ≤ E < 3.3	8.9	9.4	12.1	13.3	10.6	12.4	12.4
3.3 ≤ E < 3.5	8.7	9.1	11.9	13.0	10.4	12.1	12.1
3.5 ≤ E < 3.7	8.6	9.0	11.8	12.8	10.2	11.9	11.9
3.7 ≤ E < 3.9	8.4	8.8	11.6	12.5	10.0	11.8	11.7
3.9 ≤ E < 4.1	8.3	8.7	11.4	12.3	9.9	11.6	11.5
4.1 ≤ E < 4.3	8.1	8.6	11.2	12.2	9.7	11.4	11.4
4.3 ≤ E < 4.5	8.0	8.5	11.1	12.0	9.6	11.3	11.3
4.5 ≤ E < 4.7	7.9	8.4	10.9	11.9	9.5	11.2	11.1
4.7 ≤ E < 4.9	7.9	8.3	10.8	11.7	9.4	11.0	11.0
E ≥ 4.9	7.8	8.2	10.7	11.6	9.3	10.9	10.9

Table B2-22 Loading Table for PWR Fuel – 760 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	46 < Assembly Average Burnup ≤ 47 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	9.9	10.6	13.8	15.0	12.0	13.9	13.9
2.9 ≤ E < 3.1	9.7	10.3	13.5	14.7	11.7	13.7	13.7
3.1 ≤ E < 3.3	9.4	10.0	13.2	14.4	11.4	13.4	13.4
3.3 ≤ E < 3.5	9.2	9.8	12.9	14.0	11.2	13.1	13.1
3.5 ≤ E < 3.7	9.0	9.6	12.7	13.8	11.0	12.9	12.8
3.7 ≤ E < 3.9	8.9	9.4	12.4	13.6	10.8	12.6	12.6
3.9 ≤ E < 4.1	8.8	9.3	12.2	13.4	10.6	12.5	12.4
4.1 ≤ E < 4.3	8.6	9.1	12.0	13.2	10.4	12.2	12.2
4.3 ≤ E < 4.5	8.5	9.0	11.8	13.0	10.3	12.1	12.0
4.5 ≤ E < 4.7	8.4	8.9	11.7	12.8	10.1	11.9	11.9
4.7 ≤ E < 4.9	8.3	8.8	11.6	12.7	10.0	11.8	11.8
E ≥ 4.9	8.2	8.7	11.5	12.5	9.9	11.7	11.7
Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	**47 < Assembly Average Burnup ≤ 48 GWd/MTU Minimum Cooling Time (years)**						
	CE 14×14	**WE 14×14**	**WE 15×15**	**B&W 15×15**	**CE 16×16**	**WE 17×17**	**B&W 17×17**
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	10.6	11.4	14.9	16.1	12.9	15.1	15.1
2.9 ≤ E < 3.1	10.4	11.1	14.5	15.8	12.5	14.7	14.7
3.1 ≤ E < 3.3	10.0	10.8	14.1	15.5	12.2	14.4	14.4
3.3 ≤ E < 3.5	9.9	10.5	13.9	15.2	12.0	14.1	14.0
3.5 ≤ E < 3.7	9.6	10.3	13.6	14.9	11.8	13.8	13.8
3.7 ≤ E < 3.9	9.5	10.1	13.4	14.6	11.6	13.6	13.6
3.9 ≤ E < 4.1	9.3	9.9	13.2	14.4	11.4	13.4	13.4
4.1 ≤ E < 4.3	9.1	9.8	13.0	14.1	11.2	13.2	13.2
4.3 ≤ E < 4.5	9.0	9.6	12.8	14.0	11.1	13.0	13.0
4.5 ≤ E < 4.7	8.9	9.5	12.6	13.8	10.9	12.9	12.8
4.7 ≤ E < 4.9	8.8	9.3	12.4	13.6	10.8	12.7	12.7
E ≥ 4.9	8.7	9.2	12.3	13.5	10.7	12.5	12.5

Table B2-22 Loading Table for PWR Fuel – 760 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	48 < Assembly Average Burnup ≤ 49 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	11.4	12.2	16.0	17.3	13.9	16.2	16.2
2.9 ≤ E < 3.1	11.1	11.8	15.6	17.0	13.5	15.8	15.8
3.1 ≤ E < 3.3	10.8	11.6	15.3	16.6	13.2	15.5	15.5
3.3 ≤ E < 3.5	10.6	11.3	14.9	16.3	12.9	15.2	15.2
3.5 ≤ E < 3.7	10.3	11.1	14.7	16.0	12.[illegible]	14.9	14.9
3.7 ≤ E < 3.9	10.1	10.9	14.4	15.7	12.4	14.6	14.6
3.9 ≤ E < 4.1	9.9	10.7	14.1	15.5	12.1	14.4	14.4
4.1 ≤ E < 4.3	9.7	10.4	13.9	15.2	12.0	14.1	14.1
4.3 ≤ E < 4.5	9.6	10.2	13.7	15.0	11.8	13.9	13.9
4.5 ≤ E < 4.7	9.5	10.1	13.5	14.9	11.7	13.8	13.8
4.7 ≤ E < 4.9	9.3	9.9	13.4	14.6	11.5	13.6	13.6
E ≥ 4.9	9.2	9.8	13.2	14.5	11.4	13.5	13.5

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	49 < Assembly Average Burnup ≤ 50 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	11.9	12.4	16.8	18.2	14.5	17.0	17.0
3.1 ≤ E < 3.3	11.6	12.1	16.4	17.8	14.1	16.6	16.6
3.3 ≤ E < 3.5	11.3	11.8	16.0	17.5	13.8	16.3	16.2
3.5 ≤ E < 3.7	11.1	11.6	15.7	17.2	13.6	16.0	16.0
3.7 ≤ E < 3.9	10.8	11.4	15.5	16.9	13.3	15.7	15.7
3.9 ≤ E < 4.1	10.6	11.2	15.2	16.6	13.1	15.5	15.5
4.1 ≤ E < 4.3	10.4	11.0	14.9	16.3	12.9	15.3	15.2
4.3 ≤ E < 4.5	10.2	10.8	14.7	16.1	12.7	15.0	15.0
4.5 ≤ E < 4.7	10.1	10.6	14.5	15.9	12.5	14.9	14.8
4.7 ≤ E < 4.9	9.9	10.5	14.3	15.7	12.3	14.6	14.6
E ≥ 4.9	9.8	10.3	14.1	15.5	12.2	14.5	14.5

PROPOSED

Table B2-22 Loading Table for PWR Fuel – 760 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	50 < Assembly Average Burnup ≤ 51 GWd/MTU Minimum Cooling Time (years)						
	CE 14x14	WE 14x14	WE 15x15	B&W 15x15	CE 16x16	WE 17x17	B&W 17x17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	12.4	13.4	17.8	19.3	15.6	18.1	18.1
3.1 ≤ E < 3.3	12.1	13.1	17.5	19.0	15.2	17.8	17.8
3.3 ≤ E < 3.5	11.8	12.7	17.2	18.7	14.9	17.4	17.4
3.5 ≤ E < 3.7	11.5	12.4	16.8	18.3	14.5	17.2	17.1
3.7 ≤ E < 3.9	11.3	12.1	16.5	18.0	14.3	16.9	16.8
3.9 ≤ E < 4.1	11.1	11.9	16.2	17.7	14.0	16.6	16.5
4.1 ≤ E < 4.3	10.9	11.7	16.0	17.5	13.8	16.3	16.3
4.3 ≤ E < 4.5	10.7	11.5	15.8	17.3	13.6	16.1	16.0
4.5 ≤ E < 4.7	10.5	11.4	15.5	17.1	13.4	15.8	15.9
4.7 ≤ E < 4.9	10.4	11.2	15.3	16.8	13.2	15.7	15.7
E ≥ 4.9	10.2	11.1	15.2	16.7	13.1	15.5	15.5

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	51 < Assembly Average Burnup ≤ 52 GWd/MTU Minimum Cooling Time (years)						
	CE 14x14	WE 14x14	WE 15x15	B&W 15x15	CE 16x16	WE 17x17	B&W 17x17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	13.3	14.3	19.0	20.1	16.7	19.4	19.3
3.1 ≤ E < 3.3	12.9	14.0	18.6	19.7	16.3	19.0	18.9
3.3 ≤ E < 3.5	12.6	13.6	18.2	19.4	15.9	18.6	18.6
3.5 ≤ E < 3.7	12.3	13.3	17.9	19.1	15.6	18.3	18.3
3.7 ≤ E < 3.9	12.0	13.1	17.6	18.8	15.3	18.0	17.9
3.9 ≤ E < 4.1	11.8	12.8	17.4	18.5	15.0	17.7	17.7
4.1 ≤ E < 4.3	11.6	12.5	17.1	18.2	14.8	17.5	17.4
4.3 ≤ E < 4.5	11.4	12.3	16.8	18.0	14.5	17.3	17.2
4.5 ≤ E < 4.7	11.2	12.1	16.6	17.7	14.4	17.0	17.0
4.7 ≤ E < 4.9	11.1	11.9	16.4	17.5	14.1	16.8	16.8
E ≥ 4.9	10.9	11.8	16.2	17.4	13.9	16.6	16.5

Table B2-22 Loading Table for PWR Fuel – 760 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	52 < Assembly Average Burnup ≤ 53 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	14.2	15.3	19.7	21.3	17.8	20.5	20.5
3.1 ≤ E < 3.3	13.8	15.0	19.3	20.9	17.4	20.1	20.1
3.3 ≤ E < 3.5	13.5	14.6	18.9	20.6	17.1	19.8	19.7
3.5 ≤ E < 3.7	13.1	14.3	18.6	20.3	16.[illegible]	19.5	19.4
3.7 ≤ E < 3.9	12.9	14.2	18.3	19.9	16.4	19.2	19.1
3.9 ≤ E < 4.1	12.6	13.7	18.0	19.6	16.0	18.9	18.8
4.1 ≤ E < 4.3	12.3	13.5	17.7	19.4	15.8	18.6	18.5
4.3 ≤ E < 4.5	12.1	13.2	17.5	[illegible]9.1	15.6	18.4	18.3
4.5 ≤ E < 4.7	11.9	13.0	17.3	18.8	15.3	18.2	18.1
4.7 ≤ E < 4.9	11.8	12.8	17.0	18.7	15.2	17.9	17.8
E ≥ 4.9	11.6	12.6	16.9	1[illegible].5	14.9	17.7	17.7

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	53 < Assembly Average Burnup ≤ 54 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	15.2	16.4	20.9	22.5	18.9	21.7	21.6
3.1 ≤ E < 3.3	14.8	16.0	20.4	22.1	18.5	21.3	21.3
3.3 ≤ E < 3.5	14.4	15.6	20.0	21.8	18.1	21.0	20.9
3.5 ≤ E < 3.7	14.0	15.2	19.7	21.4	17.7	20.6	20.6
3.7 ≤ E < 3.9	13.7	14.9	19.4	21.1	17.4	20.3	20.3
3.9 ≤ E < 4.1	13.4	14.6	19.1	20.8	17.2	20.1	20.0
4.1 ≤ E < 4.3	13.2	14.4	18.9	20.5	16.9	19.8	19.7
4.3 ≤ E < 4.5	12.9	14.1	18.6	20.3	16.6	19.5	19.5
4.5 ≤ E < 4.7	12.7	13.9	18.3	20.1	16.4	19.3	19.2
4.7 ≤ E < 4.9	12.5	13.6	18.1	19.8	16.1	19.0	19.0
E ≥ 4.9	12.4	13.9	17.9	19.6	15.9	18.8	18.8

Table B2-22 Loading Table for PWR Fuel – 760 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	54 < Assembly Average Burnup ≤ 55 GWd/MTU Minimum Cooling Time (years)						
	CE 14x14	WE 14x14	WE 15x15	B&W 15x15	CE 16x16	WE 17x17	B&W 17x17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	15.7	17.1	21.6	23.2	19.6	22.5	22.4
3.3 ≤ E < 3.5	15.4	17.7	21.2	22.9	19.2	22.1	22.1
3.5 ≤ E < 3.7	15.0	16.3	20.9	22.6	18.9	21.8	21.8
3.7 ≤ E < 3.9	14.6	16.0	20.6	22.2	18.5	21.5	21.5
3.9 ≤ E < 4.1	14.4	15.7	20.2	21.9	18.3	21.2	21.2
4.1 ≤ E < 4.3	14.1	15.4	19.9	21.7	18.0	20.9	20.9
4.3 ≤ E < 4.5	13.8	15.1	19.7	21.4	17.7	20.7	20.6
4.5 ≤ E < 4.7	13.6	14.9	19.4	21.2	17.5	20.5	20.4
4.7 ≤ E < 4.9	13.4	14.6	19.2	21.0	17.2	20.2	20.1
E ≥ 4.9	13.2	14.4	19.0	2[illegible].7	17.0	19.9	19.9

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	55 < Assembly Average Burnup ≤ 56 GWd/MTU Minimum Cooling Time (years)						
	CE 14x14	WE 14x14	WE 15x15	B&W 15x15	CE 16x16	WE 17x17	B&W 17x17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	16.8	18.1	22.7	24.4	20.2	23.6	23.6
3.3 ≤ E < 3.5	16.3	17.7	22.4	24.1	19.8	23.3	23.3
3.5 ≤ E < 3.7	15.9	17.3	21.9	23.7	19.5	23.0	22.9
3.7 ≤ E < 3.9	15.6	17.0	21.7	23.4	19.2	22.6	22.6
3.9 ≤ E < 4.1	15.3	16.7	21.4	23.1	18.8	22.4	22.3
4.1 ≤ E < 4.3	15.0	16.4	21.0	22.9	18.5	22.1	22.0
4.3 ≤ E < 4.5	14.8	16.1	20.8	22.6	18.3	21.8	21.8
4.5 ≤ E < 4.7	14.5	15.8	20.5	22.4	17.9	21.6	21.5
4.7 ≤ E < 4.9	14.3	15.6	20.3	22.2	17.8	21.3	21.3
E ≥ 4.9	14.0	15.4	20.0	21.9	17.6	21.1	21.1

Table B2-22 Loading Table for PWR Fuel – 760 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	56 < Assembly Average Burnup ≤ 57 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	17.7	19.2	23.8	25.6	21.3	24.7	24.7
3.3 ≤ E < 3.5	17.3	18.8	23.4	25.2	20.9	24.4	24.4
3.5 ≤ E < 3.7	16.9	18.4	23.1	24.9	20.5	24.0	24.0
3.7 ≤ E < 3.9	16.6	18.1	22.7	24.6	20.2	23.7	23.7
3.9 ≤ E < 4.1	16.2	17.7	22.4	24.3	19.9	23.5	23.5
4.1 ≤ E < 4.3	15.9	17.4	22.2	24.0	19.6	23.2	23.2
4.3 ≤ E < 4.5	15.7	17.1	21.9	23.8	19.3	23.0	22.9
4.5 ≤ E < 4.7	15.4	16.8	21.6	23.5	19.1	22.7	22.6
4.7 ≤ E < 4.9	15.2	16.6	21.4	23.3	18.8	22.5	22.4
E ≥ 4.9	15.0	16.4	21.2	2[illegible].0	18.6	22.2	22.2

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	57 < Assembly Average Burnup ≤ 58 GWd/MTU Minimum Cooling Time (years)						
	CE 14×14	WE 14×14	WE 15×15	B&W 15×15	CE 16×16	WE 17×17	B&W 17×17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	18.8	20.2	24.9	26.7	22.3	25.8	25.8
3.3 ≤ E < 3.5	18.3	19.9	24.6	26.3	22.0	25.5	25.5
3.5 ≤ E < 3.7	17.9	19.5	24.2	26.0	21.6	25.2	25.2
3.7 ≤ E < 3.9	17.6	19.1	23.9	25.7	21.3	24.9	24.8
3.9 ≤ E < 4.1	17.3	18.8	23.6	25.4	20.9	24.6	24.6
4.1 ≤ E < 4.3	16.9	18.4	23.3	25.1	20.6	24.4	24.3
4.3 ≤ E < 4.5	16.6	18.1	23.0	24.9	20.4	24.1	24.0
4.5 ≤ E < 4.7	16.3	17.9	22.8	24.6	20.0	23.8	23.8
4.7 ≤ E < 4.9	16.1	17.6	22.5	24.4	19.9	23.6	23.6
E ≥ 4.9	15.8	17.4	22.3	24.2	19.7	23.4	23.3

Table B2-22 Loading Table for PWR Fuel – 760 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	58 < Assembly Average Burnup ≤ 59 GWd/MTU Minimum Cooling Time (years)						
	CE 14x14	WE 14x14	WE 15x15	B&W 15x15	CE 16x16	WE 17x17	B&W 17x17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	19.8	21.3	25.9	27.7	23.4	26.9	26.9
3.3 ≤ E < 3.5	19.3	20.9	25.6	27.4	23.0	26.7	26.6
3.5 ≤ E < 3.7	18.9	20.5	25.3	27.1	22[illegible]	26.3	26.2
3.7 ≤ E < 3.9	18.6	20.2	24.9	26.8	22.3	26.0	25.9
3.9 ≤ E < 4.1	18.2	19.8	24.6	26.5	22.0	25.7	25.7
4.1 ≤ E < 4.3	17.9	19.5	24.3	26.2	21.7	25.5	25.4
4.3 ≤ E < 4.5	17.6	19.2	24.1	26.0	21.4	25.2	25.2
4.5 ≤ E < 4.7	17.3	18.9	23.9	25.8	21.2	25.0	24.9
4.7 ≤ E < 4.9	17.1	18.7	23.6	25.5	20.9	24.7	24.7
E ≥ 4.9	16.8	18.4	23.4	2[illegible].3	20.7	24.5	24.4

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	59 < Assembly Average Burnup ≤ 60 GWd/MTU Minimum Cooling Time (years)						
	CE 14x14	WE 14x14	WE 15x15	B&W 15x15	CE 16x16	WE 17x17	B&W 17x17
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	-	-	-	-	-	-	-
3.3 ≤ E < 3.5	20.3	22.0	26.7	28.4	24.1	27.2	27.1
3.5 ≤ E < 3.7	20.0	21.5	26.4	28.1	23.7	26.8	26.7
3.7 ≤ E < 3.9	19.6	21.2	26.0	27.8	23.4	26.5	26.5
3.9 ≤ E < 4.1	19.3	20.8	25.7	27.6	23.1	26.2	26.2
4.1 ≤ E < 4.3	18.9	20.5	25.4	27.3	22.7	26.0	25.9
4.3 ≤ E < 4.5	18.6	20.2	25.2	27.1	22.5	25.7	25.6
4.5 ≤ E < 4.7	18.3	20.0	24.9	26.8	22.2	25.5	25.4
4.7 ≤ E < 4.9	18.0	19.7	24.7	26.6	22.0	25.2	25.2
E ≥ 4.9	17.7	19.5	24.4	26.4	21.7	25.0	24.9

Table B2-23 Loading Table for BWR Fuel – 379 W/Assembly

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	30 < Assembly Average Burnup ≤ 32.5 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	4.3	4.6	4.0	4.5	4.0	4.5	4.4
2.3 ≤ E < 2.5	4.2	4.6	4.0	4.5	4.0	4.4	4.4
2.5 ≤ E < 2.7	4.2	4.5	4.0	4.4	4.0	4.4	4.3
2.7 ≤ E < 2.9	4.1	4.5	4.0	4.4	4.0	4.3	4.3
2.9 ≤ E < 3.1	4.1	4.4	4.0	4.3	4.0	4.3	4.2
3.1 ≤ E < 3.3	4.0	4.4	4.0	4.3	4.0	4.2	4.2
3.3 ≤ E < 3.5	4.0	4.3	4.0	4.2	4.0	4.2	4.1
3.5 ≤ E < 3.7	4.0	4.3	4.0	4.2	4.0	4.2	4.1
3.7 ≤ E < 3.9	4.0	4.3	4.0	4.2	4.0	4.1	4.0
3.9 ≤ E < 4.1	4.0	4.2	4.0	4.1	4.0	4.1	4.0
4.1 ≤ E < 4.3	4.0	4.2	4.0	4.1	4.0	4.1	4.0
4.3 ≤ E < 4.5	4.0	4.2	4.0	4.1	4.0	4.0	4.0
4.5 ≤ E < 4.7	4.0	4.1	4.0	4.0	4.0	4.0	4.0
4.7 ≤ E < 4.9	4.0	4.1	4.0	4.0	4.0	4.0	4.0
E ≥ 4.9	4.0	4.1	4.0	4.0	4.0	4.0	4.0

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	32.5 < Assembly Average Burnup ≤ 35 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	4.7	5.0	4.3	4.9	4.0	4.9	4.8
2.5 ≤ E < 2.7	4.6	4.9	4.3	4.8	4.0	4.8	4.7
2.7 ≤ E < 2.9	4.5	4.9	4.2	4.8	4.0	4.7	4.6
2.9 ≤ E < 3.1	4.5	4.8	4.2	4.7	4.0	4.7	4.6
3.1 ≤ E < 3.3	4.4	4.8	4.1	4.7	4.0	4.6	4.5
3.3 ≤ E < 3.5	4.4	4.7	4.0	4.6	4.0	4.6	4.5
3.5 ≤ E < 3.7	4.3	4.7	4.0	4.6	4.0	4.5	4.5
3.7 ≤ E < 3.9	4.3	4.6	4.0	4.5	4.0	4.5	4.4
3.9 ≤ E < 4.1	4.2	4.6	4.0	4.5	4.0	4.5	4.4
4.1 ≤ E < 4.3	4.2	4.5	4.0	4.5	4.0	4.4	4.3
4.3 ≤ E < 4.5	4.2	4.5	4.0	4.4	4.0	4.4	4.3
4.5 ≤ E < 4.7	4.1	4.5	4.0	4.4	4.0	4.4	4.3
4.7 ≤ E < 4.9	4.1	4.5	4.0	4.4	4.0	4.3	4.2
E ≥ 4.9	4.1	4.4	4.0	4.3	4.0	4.3	4.2

Table B2-23 Loading Table for BWR Fuel – 379 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	35 < Assembly Average Burnup ≤ 37.5 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	5.2	5.6	4.7	5.4	4.4	5.4	5.2
2.5 ≤ E < 2.7	5.1	5.5	4.7	5.3	4.3	5.3	5.2
2.7 ≤ E < 2.9	5.0	5.4	4.6	5.3	4.3	5.2	5.1
2.9 ≤ E < 3.1	4.9	5.4	4.5	5.2	4.2	5.1	5.0
3.1 ≤ E < 3.3	4.9	5.3	4.5	5.1	4.1	5.1	4.9
3.3 ≤ E < 3.5	4.8	5.2	4.4	5.0	4.1	5.0	4.9
3.5 ≤ E < 3.7	4.8	5.1	4.4	5.0	4.0	4.9	4.8
3.7 ≤ E < 3.9	4.7	5.1	4.3	4.9	4.0	4.9	4.8
3.9 ≤ E < 4.1	4.6	5.0	4.3	4.9	4.0	4.9	4.7
4.1 ≤ E < 4.3	4.6	5.0	4.3	4.9	4.0	4.8	4.7
4.3 ≤ E < 4.5	4.6	4.9	4.2	4.8	4.0	4.8	4.7
4.5 ≤ E < 4.7	4.5	4.9	4.2	4.8	4.0	4.7	4.6
4.7 ≤ E < 4.9	4.5	4.9	4.1	4.7	4.0	4.7	4.6
E ≥ 4.9	4.5	4.9	4.1	4.7	4.0	4.7	4.6

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	37.5 < Assembly Average Burnup ≤ 40 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	5.7	6.1	5.2	5.9	4.7	5.9	5.7
2.7 ≤ E < 2.9	5.6	6.0	5.1	5.8	4.6	5.8	5.7
2.9 ≤ E < 3.1	5.5	5.9	5.0	5.8	4.6	5.7	5.6
3.1 ≤ E < 3.3	5.5	5.9	4.9	5.7	4.5	5.6	5.5
3.3 ≤ E < 3.5	5.4	5.8	4.9	5.6	4.4	5.6	5.4
3.5 ≤ E < 3.7	5.3	5.7	4.8	5.6	4.4	5.5	5.4
3.7 ≤ E < 3.9	5.2	5.7	4.7	5.5	4.3	5.4	5.3
3.9 ≤ E < 4.1	5.2	5.6	4.7	5.4	4.3	5.4	5.2
4.1 ≤ E < 4.3	5.1	5.6	4.6	5.4	4.3	5.3	5.2
4.3 ≤ E < 4.5	5.0	5.5	4.6	5.3	4.2	5.3	5.1
4.5 ≤ E < 4.7	5.0	5.5	4.5	5.3	4.2	5.2	5.0
4.7 ≤ E < 4.9	5.0	5.4	4.5	5.2	4.1	5.2	5.0
E ≥ 4.9	4.9	5.4	4.5	5.2	4.1	5.1	5.0

Table B2-23 Loading Table for BWR Fuel – 379 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	40 < Assembly Average Burnup ≤ 41 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	6.0	6.5	5.4	6.2	4.9	6.1	6.0
2.7 ≤ E < 2.9	5.9	6.4	5.3	6.1	4.8	6.0	5.9
2.9 ≤ E < 3.1	5.8	6.2	5.2	6.0	4.7	5.9	5.8
3.1 ≤ E < 3.3	5.7	6.1	5.1	5.9	4.7	5.9	5.7
3.3 ≤ E < 3.5	5.6	6.0	5.0	5.9	4.6	5.8	5.6
3.5 ≤ E < 3.7	5.5	6.0	5.0	5.8	4.5	5.7	5.6
3.7 ≤ E < 3.9	5.5	5.9	4.9	5.7	4.5	5.7	5.5
3.9 ≤ E < 4.1	5.4	5.9	4.9	5.7	4.4	5.6	5.5
4.1 ≤ E < 4.3	5.3	5.8	4.8	5.6	4.4	5.5	5.4
4.3 ≤ E < 4.5	5.3	5.8	4.8	5.6	4.4	5.5	5.3
4.5 ≤ E < 4.7	5.2	5.7	4.7	5.5	4.3	5.4	5.3
4.7 ≤ E < 4.9	5.2	5.7	4.7	5.5	4.3	5.4	5.2
E ≥ 4.9	5.1	5.6	4.6	5.4	4.2	5.4	5.2

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	41 < Assembly Average Burnup ≤ 42 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	6.3	6.8	5.6	6.5	5.1	6.4	6.2
2.7 ≤ E < 2.9	6.2	6.7	5.5	6.4	5.0	6.3	6.1
2.9 ≤ E < 3.1	6.0	6.6	5.5	6.3	4.9	6.2	6.0
3.1 ≤ E < 3.3	6.0	6.5	5.4	6.2	4.8	6.1	5.9
3.3 ≤ E < 3.5	5.9	6.4	5.3	6.1	4.8	6.0	5.9
3.5 ≤ E < 3.7	5.8	6.3	5.2	6.0	4.7	5.9	5.8
3.7 ≤ E < 3.9	5.7	6.2	5.1	5.9	4.6	5.9	5.7
3.9 ≤ E < 4.1	5.6	6.1	5.0	5.9	4.6	5.8	5.7
4.1 ≤ E < 4.3	5.6	6.0	5.0	5.8	4.5	5.8	5.6
4.3 ≤ E < 4.5	5.5	6.0	4.9	5.8	4.5	5.7	5.6
4.5 ≤ E < 4.7	5.5	5.9	4.9	5.7	4.5	5.7	5.5
4.7 ≤ E < 4.9	5.4	5.9	4.9	5.7	4.4	5.6	5.5
E ≥ 4.9	5.4	5.8	4.8	5.6	4.4	5.6	5.4

Table B2-23 Loading Table for BWR Fuel – 379 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	42 < Assembly Average Burnup ≤ 43 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	6.6	7.1	5.9	6.8	5.3	6.8	6.6
2.7 ≤ E < 2.9	6.5	7.0	5.8	6.7	5.2	6.6	6.4
2.9 ≤ E < 3.1	6.4	6.9	5.7	6.6	5.1	6.5	6.3
3.1 ≤ E < 3.3	6.3	6.8	5.6	6.5	5.0	6.4	6.2
3.3 ≤ E < 3.5	6.1	6.7	5.5	6.4	4.9	6.3	6.1
3.5 ≤ E < 3.7	6.0	6.6	5.4	6.3	4.9	6.2	6.0
3.7 ≤ E < 3.9	6.0	6.5	5.4	6.2	4.8	6.1	5.9
3.9 ≤ E < 4.1	5.9	6.4	5.3	6.1	4.8	6.0	5.9
4.1 ≤ E < 4.3	5.8	6.3	5.2	6.0	4.7	6.0	5.8
4.3 ≤ E < 4.5	5.8	6.3	5.1	6.0	4.6	5.9	5.8
4.5 ≤ E < 4.7	5.7	6.2	5.1	6.0	4.6	5.9	5.7
4.7 ≤ E < 4.9	5.7	6.1	5.0	5.9	4.6	5.9	5.7
E ≥ 4.9	5.6	6.1	5.0	5.9	4.5	5.8	5.6

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	43 < Assembly Average Burnup ≤ 44 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	7.0	7.6	6.1	7.2	5.5	7.1	6.9
2.7 ≤ E < 2.9	6.8	7.4	6.0	7.0	5.4	6.9	6.7
2.9 ≤ E < 3.1	6.7	7.3	5.9	6.9	5.3	6.8	6.6
3.1 ≤ E < 3.3	6.6	7.1	5.8	6.8	5.2	6.7	6.5
3.3 ≤ E < 3.5	6.5	7.0	5.7	6.7	5.1	6.6	6.4
3.5 ≤ E < 3.7	6.4	6.9	5.7	6.6	5.0	6.5	6.3
3.7 ≤ E < 3.9	6.3	6.8	5.6	6.5	5.0	6.5	6.2
3.9 ≤ E < 4.1	6.2	6.7	5.5	6.4	4.9	6.4	6.1
4.1 ≤ E < 4.3	6.1	6.7	5.5	6.4	4.9	6.3	6.0
4.3 ≤ E < 4.5	6.0	6.6	5.4	6.3	4.8	6.2	6.0
4.5 ≤ E < 4.7	5.9	6.5	5.3	6.2	4.8	6.1	5.9
4.7 ≤ E < 4.9	5.9	6.5	5.3	6.2	4.7	6.1	5.9
E ≥ 4.9	5.8	6.4	5.2	6.1	4.7	6.0	5.9

Table B2-23 Loading Table for BWR Fuel – 379 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	44 < Assembly Average Burnup ≤ 45 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	7.2	7.9	6.3	7.5	5.6	7.4	7.1
2.9 ≤ E < 3.1	7.0	7.7	6.2	7.3	5.5	7.2	6.9
3.1 ≤ E < 3.3	6.9	7.6	6.1	7.1	5.4	7.0	6.8
3.3 ≤ E < 3.5	6.8	7.4	6.0	7.0	5.4	6.9	6.7
3.5 ≤ E < 3.7	6.7	7.3	5.9	6.9	5.3	6.9	6.6
3.7 ≤ E < 3.9	6.6	7.2	5.8	6.8	5.2	6.8	6.5
3.9 ≤ E < 4.1	6.5	7.1	5.8	6.8	5.1	6.7	6.4
4.1 ≤ E < 4.3	6.4	7.0	5.7	6.7	5.0	6.6	6.3
4.3 ≤ E < 4.5	6.3	6.9	5.6	6.6	5.0	6.5	6.3
4.5 ≤ E < 4.7	6.3	6.8	5.6	6.5	4.9	6.4	6.2
4.7 ≤ E < 4.9	6.2	6.8	5.5	6.5	4.9	6.4	6.1
E ≥ 4.9	6.1	6.7	5.4	6.4	4.8	6.3	6.1

Note: For fuel assembly average burnup greater than 45 GWd/MTU, cool time tables have been revised to account for a 5% margin in heat load.

Table B2-24 Loading Table for BWR Fuel – 360 W/Assembly

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	45 < Assembly Average Burnup ≤ 46 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	8.5	9.3	7.3	8.8	6.3	8.6	8.2
2.9 ≤ E < 3.1	8.3	9.0	7.1	8.6	6.2	8.4	8.0
3.1 ≤ E < 3.3	8.1	8.9	7.0	8.4	6.0	8.2	7.9
3.3 ≤ E < 3.5	8.0	8.8	6.8	8.2	6.0	8.0	7.7
3.5 ≤ E < 3.7	7.9	8.6	6.7	8.0	5.9	7.9	7.6
3.7 ≤ E < 3.9	7.7	8.4	6.7	7.9	5.8	7.8	7.5
3.9 ≤ E < 4.1	7.6	8.3	6.6	7.8	5.8	7.7	7.4
4.1 ≤ E < 4.3	7.5	8.2	6.5	7.7	5.7	7.6	7.3
4.3 ≤ E < 4.5	7.4	8.1	6.4	[illegible]	5.6	7.5	7.2
4.5 ≤ E < 4.7	7.3	8.0	6.3	7.6	5.6	7.4	7.1
4.7 ≤ E < 4.9	7.2	7.9	6.2	7.5	5.5	7.4	7.0
E ≥ 4.9	7.1	7.8	6.1	7.4	5.4	7.3	7.0

Table B2-24 Loading Table for BWR Fuel – 360 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	46 < Assembly Average Burnup ≤ 47 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	9.1	10.0	7.7	9.3	6.7	9.2	8.7
2.9 ≤ E < 3.1	8.9	9.8	7.5	9.1	6.5	8.9	8.5
3.1 ≤ E < 3.3	8.7	9.5	7.4	8.9	6.4	8.8	8.3
3.3 ≤ E < 3.5	8.5	9.3	7.2	8.7	6.2	8.6	8.2
3.5 ≤ E < 3.7	8.3	9.1	7.0	8.6	6.1	8.4	8.0
3.7 ≤ E < 3.9	8.2	9.0	7.0	8.4	6.0	8.3	7.9
3.9 ≤ E < 4.1	8.0	8.8	6.9	8.3	6.0	8.1	7.8
4.1 ≤ E < 4.3	7.9	8.7	6.8	8.2	5.9	8.0	7.7
4.3 ≤ E < 4.5	7.8	8.6	6.7	8.1	5.8	7.9	7.6
4.5 ≤ E < 4.7	7.7	8.5	6.6	8.0	5.8	7.9	7.5
4.7 ≤ E < 4.9	7.6	8.4	6.5	7.9	5.7	7.8	7.4
E ≥ 4.9	7.5	8.3	6.5	7.8	5.7	7.7	7.4
Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	**47 < Assembly Average Burnup ≤ 48 GWd/MTU Minimum Cooling Time (years)**						
	BWR/2-3 7×7	**BWR/4-6 7×7**	**BWR/2-3 8×8**	**BWR/4-6 8×8**	**BWR/2-3 9×9**	**BWR/4-6 9×9**	**BWR/4-6 10×10**
2.1 ≤ E < 2.3	-		-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-		-	-	-	-	-
2.7 ≤ E < 2.9	9.8	10.7	8.2	9.9	6.9	9.8	9.3
2.9 ≤ E < 3.1	9.6	10.5	8.0	9.7	6.8	9.5	9.1
3.1 ≤ E < 3.3	9.3	10.2	7.8	9.5	6.7	9.3	8.9
3.3 ≤ E < 3.5	9.1	9.9	7.7	9.3	6.6	9.2	8.7
3.5 ≤ E < 3.7	8.9	9.7	7.5	9.1	6.5	9.0	8.5
3.7 ≤ E < 3.9	8.7	9.6	7.4	8.9	6.3	8.8	8.4
3.9 ≤ E < 4.1	8.6	9.4	7.2	8.8	6.2	8.7	8.2
4.1 ≤ E < 4.3	8.4	9.3	7.1	8.7	6.1	8.6	8.1
4.3 ≤ E < 4.5	8.3	9.1	7.0	8.6	6.0	8.4	8.0
4.5 ≤ E < 4.7	8.1	9.0	6.9	8.5	6.0	8.3	7.9
4.7 ≤ E < 4.9	8.0	8.9	6.9	8.3	5.9	8.2	7.8
E ≥ 4.9	7.9	8.8	6.8	8.2	5.9	8.1	7.8

Table B2-24 Loading Table for BWR Fuel – 360 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	48 < Assembly Average Burnup ≤ 49 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	10.5	11.6	8.7	10.8	7.3	10.6	9.9
2.9 ≤ E < 3.1	10.2	11.3	8.5	10.4	7.1	10.2	9.7
3.1 ≤ E < 3.3	10.0	11.0	8.3	10.1	7.0	9.9	9.4
3.3 ≤ E < 3.5	9.7	10.7	8.1	9.9	6.9	9.8	9.2
3.5 ≤ E < 3.7	9.5	10.5	7.9	9.7	6.8	9.6	9.0
3.7 ≤ E < 3.9	9.3	10.3	7.8	9.5	6.7	9.4	8.9
3.9 ≤ E < 4.1	9.1	10.1	7.7	9.4	6.5	9.2	8.7
4.1 ≤ E < 4.3	9.0	9.9	7.5	9.2	6.4	9.0	8.6
4.3 ≤ E < 4.5	8.8	9.7	7.4	9.1	6.3	8.9	8.5
4.5 ≤ E < 4.7	8.7	9.6	7.3	8.9	6.3	8.8	8.4
4.7 ≤ E < 4.9	8.6	9.5	7.2	8.9	6.2	8.7	8.3
E ≥ 4.9	8.5	9.3	7.1	8.8	6.1	8.6	8.2
Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	49 < Assembly Average Burnup ≤ 50 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	11.0	12.0	9.0	11.2	7.6	11.0	10.3
3.1 ≤ E < 3.3	10.7	11.7	8.8	10.9	7.4	10.7	10.1
3.3 ≤ E < 3.5	10.4	11.5	8.6	10.7	7.2	10.4	9.8
3.5 ≤ E < 3.7	10.2	11.3	8.4	10.4	7.0	10.2	9.7
3.7 ≤ E < 3.9	10.0	11.0	8.2	10.2	7.0	10.0	9.5
3.9 ≤ E < 4.1	9.7	10.8	8.0	10.0	6.8	9.8	9.3
4.1 ≤ E < 4.3	9.6	10.6	7.9	9.8	6.7	9.7	9.1
4.3 ≤ E < 4.5	9.4	10.4	7.8	9.7	6.7	9.5	9.0
4.5 ≤ E < 4.7	9.3	10.2	7.7	9.5	6.6	9.4	8.9
4.7 ≤ E < 4.9	9.1	10.1	7.6	9.4	6.5	9.2	8.7
E ≥ 4.9	9.0	10.0	7.5	9.3	6.4	9.1	8.6

Table B2-24 Loading Table for BWR Fuel – 360 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	50 < Assembly Average Burnup ≤ 51 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	11.8	12.9	9.6	12.0	8.0	11.8	11.1
3.1 ≤ E < 3.3	11.5	12.6	9.4	11.7	7.8	11.5	10.9
3.3 ≤ E < 3.5	11.2	12.3	9.1	11.5	7.6	11.2	10.6
3.5 ≤ E < 3.7	10.9	11.9	8.9	11.1	7.5	11.0	10.3
3.7 ≤ E < 3.9	10.7	11.8	8.7	10.9	7.3	10.7	10.0
3.9 ≤ E < 4.1	10.4	11.6	8.6	10.7	7.2	10.5	9.9
4.1 ≤ E < 4.3	10.3	11.3	8.4	10.5	7.0	10.3	9.7
4.3 ≤ E < 4.5	10.0	11.2	8.3	10.4	7.0	10.1	9.6
4.5 ≤ E < 4.7	9.9	11.0	8.1	10.1	6.8	9.9	9.4
4.7 ≤ E < 4.9	9.8	10.9	8.0	10.0	6.8	9.8	9.3
E ≥ 4.9	9.6	10.7	7.9	9.9	6.7	9.7	9.1

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	51 < Assembly Average Burnup ≤ 52 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	12.7	13.9	10.3	12.9	8.4	12.6	11.9
3.1 ≤ E < 3.3	12.3	13.4	10.0	12.5	8.2	12.3	11.6
3.3 ≤ E < 3.5	11.9	13.2	9.8	12.1	8.0	11.9	11.3
3.5 ≤ E < 3.7	11.7	12.9	9.5	11.9	7.9	11.7	11.0
3.7 ≤ E < 3.9	11.5	12.6	9.3	11.7	7.7	11.4	10.8
3.9 ≤ E < 4.1	11.2	12.4	9.1	11.5	7.6	11.3	10.5
4.1 ≤ E < 4.3	11.0	12.1	8.9	11.3	7.4	11.0	10.3
4.3 ≤ E < 4.5	10.8	11.8	8.8	11.1	7.3	10.9	10.2
4.5 ≤ E < 4.7	10.6	11.7	8.7	10.9	7.2	10.7	10.0
4.7 ≤ E < 4.9	10.5	11.6	8.5	10.7	7.1	10.5	9.9
E ≥ 4.9	10.2	11.4	8.4	10.6	7.0	10.4	9.8

Table B2-24 Loading Table for BWR Fuel – 360 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	52 < Assembly Average Burnup ≤ 53 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	13.6	14.8	11.0	13.7	8.9	13.4	12.7
3.1 ≤ E < 3.3	13.2	14.5	10.7	13.3	8.7	13.1	12.4
3.3 ≤ E < 3.5	12.8	14.1	10.4	13.0	8.5	12.8	12.0
3.5 ≤ E < 3.7	12.6	13.8	10.1	12.7	8.3	12.5	11.8
3.7 ≤ E < 3.9	12.2	13.5	9.8	12.4	8.1	12.2	11.5
3.9 ≤ E < 4.1	11.9	13.2	9.7	12.2	7.9	12.0	11.3
4.1 ≤ E < 4.3	11.7	13.0	9.5	12.0	7.8	11.8	11.1
4.3 ≤ E < 4.5	11.6	12.7	9.3	11.8	7.7	11.5	10.9
4.5 ≤ E < 4.7	11.4	12.5	9.2	11.6	7.6	11.4	10.7
4.7 ≤ E < 4.9	11.2	12.4	9.0	11.5	7.5	11.3	10.5
E ≥ 4.9	11.0	12.1	8.9	11.3	7.4	11.1	10.4

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	53 < Assembly Average Burnup ≤ 54 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	14.5	15.8	11.8	14.6	9.5	14.4	13.6
3.1 ≤ E < 3.3	14.1	15.4	11.4	14.3	9.2	14.0	13.2
3.3 ≤ E < 3.5	13.8	15.1	11.1	13.9	8.9	13.6	12.8
3.5 ≤ E < 3.7	13.4	14.7	10.9	13.6	8.7	13.4	12.6
3.7 ≤ E < 3.9	13.1	14.4	10.6	13.3	8.6	13.1	12.2
3.9 ≤ E < 4.1	12.9	14.1	10.4	13.1	8.4	12.8	12.0
4.1 ≤ E < 4.3	12.6	13.9	10.1	12.8	8.2	12.5	11.8
4.3 ≤ E < 4.5	12.4	13.6	9.9	12.6	8.1	12.3	11.6
4.5 ≤ E < 4.7	12.1	13.4	9.7	12.3	7.9	12.1	11.4
4.7 ≤ E < 4.9	11.9	13.2	9.6	12.2	7.9	11.9	11.2
E ≥ 4.9	11.7	13.1	9.4	12.0	7.8	11.7	11.1

Table B2-24 Loading Table for BWR Fuel – 360 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	54 < Assembly Average Burnup ≤ 55 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	15.0	16.4	12.1	15.2	9.8	14.9	14.1
3.3 ≤ E < 3.5	14.7	16.0	11.9	14.9	9.5	14.6	13.7
3.5 ≤ E < 3.7	14.3	15.7	11.5	14.5	9.3	14.2	13.4
3.7 ≤ E < 3.9	13.9	15.4	11.3	14.2	9.0	13.9	13.1
3.9 ≤ E < 4.1	13.6	15.1	11.1	13.9	8.9	13.6	12.8
4.1 ≤ E < 4.3	13.3	14.7	10.8	13.6	8.7	13.4	12.5
4.3 ≤ E < 4.5	13.1	14.5	10.5	13.4	8.5	13.1	12.3
4.5 ≤ E < 4.7	12.9	14.3	10.4	13.2	8.4	13.0	12.1
4.7 ≤ E < 4.9	12.8	14.1	10.2	13.0	8.3	12.8	11.9
E ≥ 4.9	12.5	13.9	10.0	12.8	8.1	12.5	11.7

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	55 < Assembly Average Burnup ≤ 56 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	15.8	17.5	13.1	16.2	10.4	15.9	15.0
3.3 ≤ E < 3.5	15.5	17.1	12.7	15.8	10.1	15.5	14.6
3.5 ≤ E < 3.7	15.1	16.7	12.3	15.5	9.9	15.2	14.3
3.7 ≤ E < 3.9	14.7	16.3	12.0	15.1	9.7	14.8	13.9
3.9 ≤ E < 4.1	14.4	16.0	11.8	14.9	9.4	14.6	13.6
4.1 ≤ E < 4.3	14.0	15.7	11.5	14.5	9.2	14.3	13.4
4.3 ≤ E < 4.5	13.8	15.4	11.3	14.3	9.0	14.0	13.1
4.5 ≤ E < 4.7	13.7	15.2	11.1	14.1	8.8	13.8	12.9
4.7 ≤ E < 4.9	13.4	15.0	10.9	13.9	8.7	13.7	12.8
E ≥ 4.9	13.3	14.8	10.7	13.7	8.6	13.4	12.5

Table B2-24 Loading Table for BWR Fuel – 360 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	56 < Assembly Average Burnup ≤ 57 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	16.8	18.4	13.8	17.2	11.1	16.9	16.0
3.3 ≤ E < 3.5	16.5	18.1	13.5	16.8	10.9	16.4	15.5
3.5 ≤ E < 3.7	16.0	17.7	13.1	16.4	10.5	16.2	15.2
3.7 ≤ E < 3.9	15.7	17.3	12.9	16.1	10.2	15.7	14.8
3.9 ≤ E < 4.1	15.4	17.1	12.5	15.8	10.0	15.4	14.5
4.1 ≤ E < 4.3	15.1	16.8	12.2	15.4	9.8	15.2	14.3
4.3 ≤ E < 4.5	14.8	16.4	12.0	15.2	9.6	14.8	14.0
4.5 ≤ E < 4.7	14.6	16.2	11.8	15.0	9.4	14.7	13.8
4.7 ≤ E < 4.9	14.3	15.9	11.6	14.7	9.2	14.4	13.5
E ≥ 4.9	14.0	15.7	11.4	14.5	9.0	14.3	13.4

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	57 < Assembly Average Burnup ≤ 58 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	17.8	19.5	14.8	18.2	11.8	17.8	16.8
3.3 ≤ E < 3.5	17.3	19.1	14.4	17.7	11.5	17.5	16.5
3.5 ≤ E < 3.7	17.0	18.7	14.0	17.4	11.2	17.1	16.1
3.7 ≤ E < 3.9	16.6	18.3	13.6	17.0	10.9	16.8	15.7
3.9 ≤ E < 4.1	16.3	17.9	13.3	16.7	10.6	16.4	15.4
4.1 ≤ E < 4.3	15.9	17.7	13.1	16.3	10.3	16.1	15.1
4.3 ≤ E < 4.5	15.7	17.4	12.8	16.1	10.1	15.8	14.8
4.5 ≤ E < 4.7	15.5	17.1	12.5	15.9	9.9	15.5	14.6
4.7 ≤ E < 4.9	15.2	16.9	12.3	15.6	9.8	15.3	14.4
E ≥ 4.9	15.0	16.7	12.1	15.4	9.6	15.1	14.2

Table B2-24 Loading Table for BWR Fuel – 360 W/Assembly (continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	58 < Assembly Average Burnup ≤ 59 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	18.7	20.4	15.7	19.2	12.6	18.9	17.8
3.3 ≤ E < 3.5	18.4	20.0	15.2	18.8	12.2	18.4	17.4
3.5 ≤ E < 3.7	18.0	19.7	14.9	18.4	11.9	18.1	17.1
3.7 ≤ E < 3.9	17.6	19.3	14.5	18.1	11.6	17.7	16.7
3.9 ≤ E < 4.1	17.2	18.9	14.1	17.7	11.2	17.3	16.3
4.1 ≤ E < 4.3	16.9	18.7	13.8	17.4	11.0	17.1	16.1
4.3 ≤ E < 4.5	16.6	18.4	13.6	17.1	10.8	16.8	15.7
4.5 ≤ E < 4.7	16.4	18.0	13.3	16.9	10.6	16.5	15.5
4.7 ≤ E < 4.9	16.1	17.8	13.1	16.6	10.3	16.2	15.3
E ≥ 4.9	15.9	17.6	12.9	16.3	10.2	15.9	15.1

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	59 < Assembly Average Burnup ≤ 60 GWd/MTU Minimum Cooling Time (years)						
	BWR/2-3 7×7	BWR/4-6 7×7	BWR/2-3 8×8	BWR/4-6 8×8	BWR/2-3 9×9	BWR/4-6 9×9	BWR/4-6 10×10
2.1 ≤ E < 2.3	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-	-
2.9 ≤ E < 3.1	-	-	-	-	-	-	-
3.1 ≤ E < 3.3	-	-	-	-	-	-	-
3.3 ≤ E < 3.5	19.3	21.0	16.0	19.7	12.9	19.5	18.4
3.5 ≤ E < 3.7	18.9	20.7	15.6	19.3	12.7	19.1	17.9
3.7 ≤ E < 3.9	18.6	20.3	15.2	19.0	12.3	18.7	17.7
3.9 ≤ E < 4.1	18.2	19.9	14.9	18.7	11.9	18.3	17.3
4.1 ≤ E < 4.3	17.9	19.7	14.5	18.3	11.6	17.9	17.0
4.3 ≤ E < 4.5	17.6	19.4	14.2	18.1	11.4	17.7	16.6
4.5 ≤ E < 4.7	17.3	19.1	14.0	17.7	11.2	17.5	16.4
4.7 ≤ E < 4.9	17.1	18.8	13.8	17.6	11.0	17.2	16.1
E ≥ 4.9	16.9	18.6	13.6	17.3	10.8	16.9	15.9

Table B2-25 Loading Table for PWR Fuel – 959 W/Assembly – WE 14x14 Fuel

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU					
	B ≤10	10< B ≤15	15< B ≤20	20< B ≤25	25< B ≤30	30< B ≤32.5
1.3 ≤ E < 1.5	2.5	-	-	-	-	-
1.5 ≤ E < 1.7	2.5	2.5	-	-	-	-
1.7 ≤ E < 1.9	2.5	2.5	2.9	-	-	-
1.9 ≤ E < 2.1	2.5	2.5	2.9	3.4	-	-
2.1 ≤ E < 2.3	2.5	2.5	2.8	3.3	3.9	4.1
2.3 ≤ E < 2.5	2.5	2.5	2.8	3.3	3.8	4.1
2.5 ≤ E < 2.7	2.5	2.5	2.8	3.3	3.8	4.0
2.7 ≤ E < 2.9	2.5	2.5	2.8	3.2	3.7	4.0
2.9 ≤ E < 3.1	2.5	2.5	2.7	3.2	3.7	3.9
3.1 ≤ E < 3.3	2.5	2.5	2.7	3.2	3.7	3.9
3.3 ≤ E < 3.5	2.5	2.5	2.7	3.2	3.6	3.9
3.5 ≤ E < 3.7	2.5	2.5	2.7	3.1	3.6	3.8
3.7 ≤ E < 3.9	2.5	2.5	2.7	3.1	3.6	3.8
3.9 ≤ E < 4.1	2.5	2.5	2.6	3.1	3.6	3.8
4.1 ≤ E < 4.3	2.5	2.5	2.6	3.1	3.5	3.8
4.3 ≤ E < 4.5	2.5	2.5	2.6	3.0	3.5	3.7
4.5 ≤ E < 4.7	2.5	2.5	2.6	3.0	3.5	3.7
4.7 ≤ E < 4.9	2.5	2.5	2.6	3.0	3.5	3.7
E ≥ 4.9	2.5	2.5	2.6	3.0	3.5	3.7

Table B2-25 Loading Table for PWR Fuel – 959 W/Assembly – WE 14x14 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU					
	32.5< B ≤35	35< B ≤37.5	37.5< B ≤40	40< B ≤41	41< B ≤42	42< B ≤43
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	4.4	4.8	-	-	-	-
2.5 ≤ E < 2.7	4.4	4.7	5.2	5.4	5.6	5.8
2.7 ≤ E < 2.9	4.3	4.7	5.1	5.3	5.5	5.7
2.9 ≤ E < 3.1	4.3	4.6	5.0	5.2	5.4	5.6
3.1 ≤ E < 3.3	4.2	4.5	4.9	5.1	5.3	5.6
3.3 ≤ E < 3.5	4.2	4.5	4.9	5.1	5.3	5.5
3.5 ≤ E < 3.7	4.1	4.5	4.8	5.0	5.2	5.4
3.7 ≤ E < 3.9	4.1	4.4	4.8	4.9	5.1	5.3
3.9 ≤ E < 4.1	4.1	4.4	4.8	4.9	5.1	5.3
4.1 ≤ E < 4.3	4.0	4.4	4.7	4.9	5.0	5.2
4.3 ≤ E < 4.5	4.0	4.3	4.7	4.8	5.0	5.2
4.5 ≤ E < 4.7	4.0	4.3	4.6	4.8	4.9	5.1
4.7 ≤ E < 4.9	4.0	4.3	4.6	4.7	4.9	5.0
E ≥ 4.9	3.9	4.2	4.5	4.7	4.9	5.0

Table B2-25 Loading Table for PWR Fuel – 959 W/Assembly – WE 14x14 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU	
	43< B ≤44	44< B ≤45[a]
1.3 ≤ E < 1.5	-	-
1.5 ≤ E < 1.7	-	-
1.7 ≤ E < 1.9	-	-
1.9 ≤ E < 2.1	-	-
2.1 ≤ E < 2.3	-	-
2.3 ≤ E < 2.5	-	-
2.5 ≤ E < 2.7	6.0	-
2.7 ≤ E < 2.9	5.9	6.2
2.9 ≤ E < 3.1	5.8	6.0
3.1 ≤ E < 3.3	5.8	6.0
3.3 ≤ E < 3.5	5.7	5.9
3.5 ≤ E < 3.7	5.6	5.8
3.7 ≤ E < 3.9	5.6	5.8
3.9 ≤ E < 4.1	5.5	5.7
4.1 ≤ E < 4.3	5.4	5.6
4.3 ≤ E < 4.5	5.4	5.6
4.5 ≤ E < 4.7	5.3	5.5
4.7 ≤ E < 4.9	5.3	5.5
E ≥ 4.9	5.2	5.4

[a] Cool times for burnup over 45 GWd/MTU are in Table B2-16

Table B2-26 Loading Table for PWR Fuel – 513 W/Assembly – WE 14x14 Fuel

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU					
	B ≤10	10< B ≤15	15< B ≤20	20< B ≤25	25< B ≤30	30< B ≤32.5
1.3 ≤ E < 1.5	2.9	-	-	-	-	-
1.5 ≤ E < 1.7	2.9	3.8	-	-	-	-
1.7 ≤ E < 1.9	2.9	3.7	4.5	-	-	-
1.9 ≤ E < 2.1	2.9	3.7	4.5	5.7	-	-
2.1 ≤ E < 2.3	2.8	3.7	4.5	5.7	7.5	8.9
2.3 ≤ E < 2.5	2.8	3.6	4.4	5.6	7.4	8.8
2.5 ≤ E < 2.7	2.8	3.6	4.4	5.6	7.3	8.6
2.7 ≤ E < 2.9	2.8	3.6	4.4	5.5	7.2	8.5
2.9 ≤ E < 3.1	2.8	3.5	4.4	5.5	7.1	8.5
3.1 ≤ E < 3.3	2.8	3.5	4.3	5.5	7.1	8.4
3.3 ≤ E < 3.5	2.8	3.5	4.3	5.4	7.0	8.3
3.5 ≤ E < 3.7	2.7	3.5	4.3	5.4	7.0	8.2
3.7 ≤ E < 3.9	2.7	3.5	4.3	5.4	7.0	8.1
3.9 ≤ E < 4.1	2.7	3.5	4.3	5.3	6.9	8.1
4.1 ≤ E < 4.3	2.7	3.5	4.2	5.3	6.9	8.0
4.3 ≤ E < 4.5	2.7	3.5	4.2	5.3	6.8	8.0
4.5 ≤ E < 4.7	2.7	3.5	4.2	5.2	6.8	7.9
4.7 ≤ E < 4.9	2.7	3.4	4.2	5.2	6.8	7.9
E ≥ 4.9	2.7	3.4	4.2	5.2	6.8	7.9

Table B2-26 Loading Table for PWR Fuel – 513 W/Assembly – WE 14x14 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU					
	32.5< B ≤35	35< B ≤37.5	37.5< B ≤40	40< B ≤41	41< B ≤42	42< B ≤43
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	10.9	13.7	-	-	-	-
2.5 ≤ E < 2.7	10.7	13.5	16.9	18.2	19.7	21.2
2.7 ≤ E < 2.9	10.5	13.3	16.5	18.0	19.4	20.8
2.9 ≤ E < 3.1	10.4	13.1	16.3	17.7	19.2	20.6
3.1 ≤ E < 3.3	10.2	12.8	16.0	17.5	18.9	20.4
3.3 ≤ E < 3.5	10.1	12.7	15.9	17.2	18.7	20.1
3.5 ≤ E < 3.7	10.0	12.5	15.6	17.0	18.4	19.9
3.7 ≤ E < 3.9	9.9	12.4	15.5	16.8	18.2	19.6
3.9 ≤ E < 4.1	9.8	12.3	15.3	16.7	18.0	19.5
4.1 ≤ E < 4.3	9.8	12.1	15.2	16.5	17.9	19.3
4.3 ≤ E < 4.5	9.7	12.0	15.1	16.3	17.7	19.2
4.5 ≤ E < 4.7	9.7	11.9	15.0	16.2	17.6	19.0
4.7 ≤ E < 4.9	9.6	11.9	14.9	16.1	17.5	18.8
E ≥ 4.9	9.5	11.8	14.8	16.0	17.3	18.7

Table B2-26 Loading Table for PWR Fuel – 513 W/Assembly – WE 14x14 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU	
	43< B ≤44	44< B ≤45
1.3 ≤ E < 1.5	-	-
1.5 ≤ E < 1.7	-	-
1.7 ≤ E < 1.9	-	-
1.9 ≤ E < 2.1	-	-
2.1 ≤ E < 2.3	-	-
2.3 ≤ E < 2.5	-	-
2.5 ≤ E < 2.7	22.7	-
2.7 ≤ E < 2.9	22.3	23.8
2.9 ≤ E < 3.1	22.1	23.5
3.1 ≤ E < 3.3	21.8	23.2
3.3 ≤ E < 3.5	21.6	22.9
3.5 ≤ E < 3.7	21.3	22.7
3.7 ≤ E < 3.9	21.1	22.5
3.9 ≤ E < 4.1	20.9	22.3
4.1 ≤ E < 4.3	20.8	22.1
4.3 ≤ E < 4.5	20.6	21.9
4.5 ≤ E < 4.7	20.4	21.8
4.7 ≤ E < 4.9	20.3	21.6
E ≥ 4.9	20.1	21.5

Table B2-27 Loading Table for PWR Fuel – 1300 W/Assembly – WE 14x14 Fuel

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU					
	B ≤10	10< B ≤15	15< B ≤20	20< B ≤25	25< B ≤30	30< B ≤32.5
1.3 ≤ E < 1.5	2.5	-	-	-	-	-
1.5 ≤ E < 1.7	2.5	2.5	-	-	-	-
1.7 ≤ E < 1.9	2.5	2.5	2.5	-	-	-
1.9 ≤ E < 2.1	2.5	2.5	2.5	2.7	-	-
2.1 ≤ E < 2.3	2.5	2.5	2.5	2.6	3.0	3.2
2.3 ≤ E < 2.5	2.5	2.5	2.5	2.6	3.0	3.2
2.5 ≤ E < 2.7	2.5	2.5	2.5	2.6	3.0	3.1
2.7 ≤ E < 2.9	2.5	2.5	2.5	2.6	2.9	3.1
2.9 ≤ E < 3.1	2.5	2.5	2.5	2.5	2.9	3.0
3.1 ≤ E < 3.3	2.5	2.5	2.5	2.5	2.9	3.0
3.3 ≤ E < 3.5	2.5	2.5	2.5	2.5	2.9	3.0
3.5 ≤ E < 3.7	2.5	2.5	2.5	2.5	2.8	3.0
3.7 ≤ E < 3.9	2.5	2.5	2.5	2.5	2.8	3.0
3.9 ≤ E < 4.1	2.5	2.5	2.5	2.5	2.8	2.9
4.1 ≤ E < 4.3	2.5	2.5	2.5	2.5	2.8	2.9
4.3 ≤ E < 4.5	2.5	2.5	2.5	2.5	2.8	2.9
4.5 ≤ E < 4.7	2.5	2.5	2.5	2.5	2.7	2.9
4.7 ≤ E < 4.9	2.5	2.5	2.5	2.5	2.7	2.9
E ≥ 4.9	2.5	2.5	2.5	2.5	2.7	2.8

Table B2-27 Loading Table for PWR Fuel – 1300 W/Assembly – WE 14x14 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU					
	32.5< B ≤35	35< B ≤37.5	37.5< B ≤40	40< B ≤41	41< B ≤42	42< B ≤43
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	3.4	3.6	-	-	-	-
2.5 ≤ E < 2.7	3.3	3.6	3.8	3.9	4.0	4.1
2.7 ≤ E < 2.9	3.3	3.5	3.8	3.9	4.0	4.1
2.9 ≤ E < 3.1	3.3	3.5	3.7	3.8	3.9	4.0
3.1 ≤ E < 3.3	3.2	3.4	3.7	3.8	3.9	4.0
3.3 ≤ E < 3.5	3.2	3.4	3.6	3.7	3.8	3.9
3.5 ≤ E < 3.7	3.2	3.4	3.6	3.7	3.8	3.9
3.7 ≤ E < 3.9	3.1	3.4	3.6	3.6	3.8	3.9
3.9 ≤ E < 4.1	3.1	3.3	3.5	3.6	3.7	3.8
4.1 ≤ E < 4.3	3.1	3.3	3.5	3.6	3.7	3.8
4.3 ≤ E < 4.5	3.0	3.3	3.5	3.6	3.6	3.8
4.5 ≤ E < 4.7	3.0	3.2	3.4	3.5	3.6	3.7
4.7 ≤ E < 4.9	3.0	3.2	3.4	3.5	3.6	3.7
E ≥ 4.9	3.0	3.2	3.4	3.5	3.5	3.7

Table B2-27 Loading Table for PWR Fuel – 1300 W/Assembly – WE 14x14 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU	
	43< B ≤44	44< B ≤45
1.3 ≤ E < 1.5	-	-
1.5 ≤ E < 1.7	-	-
1.7 ≤ E < 1.9	-	-
1.9 ≤ E < 2.1	-	-
2.1 ≤ E < 2.3	-	-
2.3 ≤ E < 2.5	-	-
2.5 ≤ E < 2.7	4.3	-
2.7 ≤ E < 2.9	4.2	4.3
2.9 ≤ E < 3.1	4.2	4.3
3.1 ≤ E < 3.3	4.1	4.2
3.3 ≤ E < 3.5	4.0	4.2
3.5 ≤ E < 3.7	4.0	4.1
3.7 ≤ E < 3.9	4.0	4.0
3.9 ≤ E < 4.1	3.9	4.0
4.1 ≤ E < 4.3	3.9	4.0
4.3 ≤ E < 4.5	3.8	3.9
4.5 ≤ E < 4.7	3.9	3.9
4.7 ≤ E < 4.9	3.8	3.9
E ≥ 4.9	3.8	3.8

Table B2-28 Loading Table for PWR Fuel – 1800 W/Assembly – WE 14x14 Fuel

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU					
	B ≤10	10< B ≤15	15< B ≤20	20< B ≤25	25< B ≤30	30< B ≤32.5
1.3 ≤ E < 1.5	2.5	-	-	-	-	-
1.5 ≤ E < 1.7	2.5	2.5	-	-	-	-
1.7 ≤ E < 1.9	2.5	2.5	2.5	-	-	-
1.9 ≤ E < 2.1	2.5	2.5	2.5	2.5	-	-
2.1 ≤ E < 2.3	2.5	2.5	2.5	2.5	2.5	2.5
2.3 ≤ E < 2.5	2.5	2.5	2.5	2.5	2.5	2.5
2.5 ≤ E < 2.7	2.5	2.5	2.5	2.5	2.5	2.5
2.7 ≤ E < 2.9	2.5	2.5	2.5	2.5	2.5	2.5
2.9 ≤ E < 3.1	2.5	2.5	2.5	2.5	2.5	2.5
3.1 ≤ E < 3.3	2.5	2.5	2.5	2.5	2.5	2.5
3.3 ≤ E < 3.5	2.5	2.5	2.5	2.5	2.5	2.5
3.5 ≤ E < 3.7	2.5	2.5	2.5	2.5	2.5	2.5
3.7 ≤ E < 3.9	2.5	2.5	2.5	2.5	2.5	2.5
3.9 ≤ E < 4.1	2.5	2.5	2.5	2.5	2.5	2.5
4.1 ≤ E < 4.3	2.5	2.5	2.5	2.5	2.5	2.5
4.3 ≤ E < 4.5	2.5	2.5	2.5	2.5	2.5	2.5
4.5 ≤ E < 4.7	2.5	2.5	2.5	2.5	2.5	2.5
4.7 ≤ E < 4.9	2.5	2.5	2.5	2.5	2.5	2.5
E ≥ 4.9	2.5	2.5	2.5	2.5	2.5	2.5

Table B2-28 Loading Table for PWR Fuel – 1800 W/Assembly – WE 14x14 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU					
	32.5< B ≤35	35< B ≤37.5	37.5< B ≤40	40< B ≤41	41< B ≤42	42< B ≤43
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	2.6	2.7	-	-	-	-
2.5 ≤ E < 2.7	2.5	2.7	2.9	2.9	3.0	3.1
2.7 ≤ E < 2.9	2.5	2.7	2.8	2.9	3.0	3.0
2.9 ≤ E < 3.1	2.5	2.6	2.8	2.9	2.9	3.0
3.1 ≤ E < 3.3	2.5	2.6	2.8	2.8	2.9	3.0
3.3 ≤ E < 3.5	2.5	2.6	2.7	2.8	2.9	2.9
3.5 ≤ E < 3.7	2.5	2.5	2.7	2.8	2.8	2.9
3.7 ≤ E < 3.9	2.5	2.5	2.7	2.7	2.8	2.9
3.9 ≤ E < 4.1	2.5	2.5	2.6	2.7	2.8	2.8
4.1 ≤ E < 4.3	2.5	2.5	2.6	2.7	2.8	2.8
4.3 ≤ E < 4.5	2.5	2.5	2.6	2.7	2.7	2.8
4.5 ≤ E < 4.7	2.5	2.5	2.6	2.6	2.7	2.8
4.7 ≤ E < 4.9	2.5	2.5	2.5	2.6	2.7	2.7
E ≥ 4.9	2.5	2.5	2.5	2.6	2.6	2.7

Table B2-28 Loading Table for PWR Fuel – 1800 W/Assembly – WE 14x14 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU	
	43< B ≤44	44< B ≤45
1.3 ≤ E < 1.5	-	-
1.5 ≤ E < 1.7	-	-
1.7 ≤ E < 1.9	-	-
1.9 ≤ E < 2.1	-	-
2.1 ≤ E < 2.3	-	-
2.3 ≤ E < 2.5	-	-
2.5 ≤ E < 2.7	3.1	-
2.7 ≤ E < 2.9	3.1	3.2
2.9 ≤ E < 3.1	3.1	3.1
3.1 ≤ E < 3.3	3.0	3.1
3.3 ≤ E < 3.5	3.0	3.1
3.5 ≤ E < 3.7	3.0	3.0
3.7 ≤ E < 3.9	2.9	3.0
3.9 ≤ E < 4.1	2.9	3.0
4.1 ≤ E < 4.3	2.9	2.9
4.3 ≤ E < 4.5	2.8	2.9
4.5 ≤ E < 4.7	2.9	2.9
4.7 ≤ E < 4.9	2.8	2.9
E ≥ 4.9	2.8	2.8

Table B2-29 Loading Table for PWR Fuel – 830 W/Assembly – WE 14x14 Fuel

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU					
	B ≤10	10< B ≤15	15< B ≤20	20< B ≤25	25< B ≤30	30< B ≤32.5
1.3 ≤ E < 1.5	2.5	-	-	-	-	-
1.5 ≤ E < 1.7	2.5	2.7	-	-	-	-
1.7 ≤ E < 1.9	2.5	2.7	3.2	-	-	-
1.9 ≤ E < 2.1	2.5	2.7	3.2	3.8	-	-
2.1 ≤ E < 2.3	2.5	2.6	3.1	3.7	4.4	4.7
2.3 ≤ E < 2.5	2.5	2.6	3.1	3.7	4.3	4.6
2.5 ≤ E < 2.7	2.5	2.6	3.1	3.6	4.3	4.6
2.7 ≤ E < 2.9	2.5	2.6	3.0	3.6	4.2	4.5
2.9 ≤ E < 3.1	2.5	2.5	3.0	3.6	4.2	4.5
3.1 ≤ E < 3.3	2.5	2.5	3.0	3.5	4.2	4.5
3.3 ≤ E < 3.5	2.5	2.5	3.0	3.5	4.1	4.4
3.5 ≤ E < 3.7	2.5	2.5	3.0	3.5	4.1	4.4
3.7 ≤ E < 3.9	2.5	2.5	3.0	3.5	4.0	4.4
3.9 ≤ E < 4.1	2.5	2.5	2.9	3.5	4.0	4.3
4.1 ≤ E < 4.3	2.5	2.5	2.9	3.4	4.0	4.3
4.3 ≤ E < 4.5	2.5	2.5	2.9	3.4	4.0	4.3
4.5 ≤ E < 4.7	2.5	2.5	2.9	3.4	4.0	4.2
4.7 ≤ E < 4.9	2.5	2.5	2.9	3.4	3.9	4.2
E ≥ 4.9	2.5	2.5	2.9	3.4	3.9	4.2

Table B2-29 Loading Table for PWR Fuel – 830 W/Assembly – WE 14x14 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU					
	32.5< B ≤35	35< B ≤37.5	37.5< B ≤40	40< B ≤41	41< B ≤42	42< B ≤43
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	5.1	5.6	-	-	-	-
2.5 ≤ E < 2.7	5.0	5.6	6.1	6.4	6.8	7.1
2.7 ≤ E < 2.9	5.0	5.5	6.0	6.3	6.6	6.9
2.9 ≤ E < 3.1	4.9	5.4	6.0	6.2	6.5	6.8
3.1 ≤ E < 3.3	4.9	5.4	5.9	6.1	6.4	6.7
3.3 ≤ E < 3.5	4.8	5.3	5.8	6.0	6.3	6.6
3.5 ≤ E < 3.7	4.8	5.2	5.8	6.0	6.3	6.6
3.7 ≤ E < 3.9	4.7	5.2	5.7	5.9	6.2	6.5
3.9 ≤ E < 4.1	4.7	5.1	5.7	5.9	6.1	6.4
4.1 ≤ E < 4.3	4.6	5.1	5.6	5.8	6.0	6.3
4.3 ≤ E < 4.5	4.6	5.0	5.6	5.8	6.0	6.2
4.5 ≤ E < 4.7	4.6	5.0	5.5	5.7	5.9	6.2
4.7 ≤ E < 4.9	4.5	5.0	5.5	5.7	5.9	6.1
E ≥ 4.9	4.5	4.9	5.4	5.6	5.9	6.0

Table B2-29 Loading Table for PWR Fuel – 830 W/Assembly – WE 14x14 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU	
	43< B ≤44	44< B ≤45
1.3 ≤ E < 1.5	-	-
1.5 ≤ E < 1.7	-	-
1.7 ≤ E < 1.9	-	-
1.9 ≤ E < 2.1	-	-
2.1 ≤ E < 2.3	-	-
2.3 ≤ E < 2.5	-	-
2.5 ≤ E < 2.7	7.5	-
2.7 ≤ E < 2.9	7.3	7.7
2.9 ≤ E < 3.1	7.2	7.6
3.1 ≤ E < 3.3	7.0	7.5
3.3 ≤ E < 3.5	6.9	7.3
3.5 ≤ E < 3.7	6.8	7.2
3.7 ≤ E < 3.9	6.8	7.1
3.9 ≤ E < 4.1	6.7	7.0
4.1 ≤ E < 4.3	6.6	6.9
4.3 ≤ E < 4.5	6.6	6.8
4.5 ≤ E < 4.7	6.5	6.8
4.7 ≤ E < 4.9	6.4	6.7
E ≥ 4.9	6.4	6.7

Note: **For fuel assembly average burnup greater than 45 GWd/MTU, cool time tables have been revised to account for a 5% margin in heat load.**

Table B2-30 Loading Table for PWR Fuel – 487 W/Assembly – WE 14x14 Fuel

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU					
	45< B ≤46	46< B ≤47	47< B ≤48	48< B ≤49	49< B ≤50	50< B ≤51
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-
2.7 ≤ E < 2.9	27.9	29.3	30.7	32.0	-	-
2.9 ≤ E < 3.1	27.6	29.0	30.4	31.8	32.7	33.9
3.1 ≤ E < 3.3	27.4	28.8	30.2	31.6	32.4	33.7
3.3 ≤ E < 3.5	27.1	28.5	30.0	31.4	32.2	33.6
3.5 ≤ E < 3.7	26.9	28.3	29.7	31.1	32.0	33.3
3.7 ≤ E < 3.9	26.7	28.1	29.5	30.9	31.8	33.1
3.9 ≤ E < 4.1	26.6	27.9	29.4	30.8	31.6	32.9
4.1 ≤ E < 4.3	26.3	27.8	29.2	30.6	31.4	33.5
4.3 ≤ E < 4.5	26.1	27.5	29.0	30.3	31.2	32.6
4.5 ≤ E < 4.7	26.0	27.4	28.8	30.2	31.1	32.4
4.7 ≤ E < 4.9	25.9	27.3	28.6	30.1	30.9	32.3
E ≥ 4.9	25.8	27.1	28.5	30.0	30.8	32.1

Table B2-30 Loading Table for PWR Fuel – 487 W/Assembly – WE 14x14 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU					
	51< B ≤52	52< B ≤53	53< B ≤54	54< B ≤55	55< B ≤56	56< B ≤57
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-
2.9 ≤ E < 3.1	35.2	36.4	37.7	-	-	-
3.1 ≤ E < 3.3	35.0	36.2	37.4	38.8	39.8	41.0
3.3 ≤ E < 3.5	34.8	36.0	37.2	38.5	39.6	40.9
3.5 ≤ E < 3.7	34.5	35.9	3[illegible].1	38.4	39.5	40.7
3.7 ≤ E < 3.9	34.3	35.6	36.9	38.2	39.4	40.5
3.9 ≤ E < 4.1	34.2	35.4	36.7	38.1	39.2	40.4
4.1 ≤ E < 4.3	34.1	35.2	36.6	37.9	39.2	40.2
4.3 ≤ E < 4.5	33.9	35.2	36.4	37.7	39.0	40.2
4.5 ≤ E < 4.7	33.7	35.0	36.3	37.6	38.8	40.0
4.7 ≤ E < 4.9	33.5	34.8	36.1	37.4	38.7	39.8
E ≥ 4.9	33.4	34.7	35.9	37.3	38.6	39.7

Table B2-30 Loading Table for PWR Fuel – 487 W/Assembly – WE 14x14 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU		
	57< B ≤58	58< B ≤59	59< B ≤60
1.3 ≤ E < 1.5	-	-	-
1.5 ≤ E < 1.7	-	-	-
1.7 ≤ E < 1.9	-	-	-
1.9 ≤ E < 2.1	-	-	-
2.1 ≤ E < 2.3	-	-	-
2.3 ≤ E < 2.5	-	-	-
2.5 ≤ E < 2.7	-	-	-
2.7 ≤ E < 2.9	-	-	-
2.9 ≤ E < 3.1	-	-	-
3.1 ≤ E < 3.3	42.1	43.3	-
3.3 ≤ E < 3.5	42.0	43.1	44.1
3.5 ≤ E < 3.7	41.9	43.0	44.1
3.7 ≤ E < 3.9	41.7	42.9	43.9
3.9 ≤ E < 4.1	41.6	42.7	43.8
4.1 ≤ E < 4.3	41.5	42.6	43.7
4.3 ≤ E < 4.5	41.3	42.5	43.6
4.5 ≤ E < 4.7	41.2	42.4	43.5
4.7 ≤ E < 4.9	41.0	42.3	43.4
E ≥ 4.9	40.9	42.1	43.3

Table B2-31 Loading Table for PWR Fuel – 1235 W/Assembly – WE 14x14 Fuel

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU					
	45< B ≤46	46< B ≤47	47< B ≤48	48< B ≤49	49< B ≤50	50< B ≤51
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-
2.7 ≤ E < 2.9	4.7	4.9	5.0	5.2	-	-
2.9 ≤ E < 3.1	4.6	4.8	4.9	5.1	5.2	5.4
3.1 ≤ E < 3.3	4.6	4.7	4.9	5.0	5.1	5.3
3.3 ≤ E < 3.5	4.5	4.6	4.8	4.9	5.0	5.2
3.5 ≤ E < 3.7	4.5	4.6	4.7	4.9	5.0	5.2
3.7 ≤ E < 3.9	4.4	4.5	4.7	4.8	4.9	5.1
3.9 ≤ E < 4.1	4.4	4.5	4.6	4.8	4.9	5.0
4.1 ≤ E < 4.3	4.3	4.4	4.5	4.7	4.8	4.9
4.3 ≤ E < 4.5	4.3	4.4	4.5	4.6	4.8	4.9
4.5 ≤ E < 4.7	4.2	4.3	4.5	4.6	4.7	4.8
4.7 ≤ E < 4.9	4.2	4.3	4.4	4.6	4.7	4.8
E ≥ 4.9	4.1	4.3	4.4	4.5	4.6	4.7

Table B2-31 Loading Table for PWR Fuel – 1235 W/Assembly – WE 14x14 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU					
	51< B ≤52	52< B ≤53	53< B ≤54	54< B ≤55	55< B ≤56	56< B ≤57
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-
2.9 ≤ E < 3.1	5.6	5.8	6.0	-	-	-
3.1 ≤ E < 3.3	5.5	5.7	5.9	6.1	6.4	6.7
3.3 ≤ E < 3.5	5.4	5.6	5.8	6.0	6.3	6.5
3.5 ≤ E < 3.7	5.4	5.5	5.7	5.9	6.1	6.4
3.7 ≤ E < 3.9	5.3	5.5	5.6	5.8	6.0	6.3
3.9 ≤ E < 4.1	5.2	5.4	5.6	5.8	5.9	6.1
4.1 ≤ E < 4.3	5.1	5.3	5.5	5.7	5.9	6.0
4.3 ≤ E < 4.5	5.0	5.2	5.4	5.6	5.8	6.0
4.5 ≤ E < 4.7	5.0	5.1	5.3	5.5	5.7	5.9
4.7 ≤ E < 4.9	4.9	5.1	5.3	5.5	5.6	5.8
E ≥ 4.9	4.9	5.0	5.3	5.4	5.6	5.7

Table B2-31 Loading Table for PWR Fuel – 1235 W/Assembly – WE 14x14 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU		
	57< B ≤58	58< B ≤59	59< B ≤60
1.3 ≤ E < 1.5	-	-	-
1.5 ≤ E < 1.7	-	-	-
1.7 ≤ E < 1.9	-	-	-
1.9 ≤ E < 2.1	-	-	-
2.1 ≤ E < 2.3	-	-	-
2.3 ≤ E < 2.5	-	-	-
2.5 ≤ E < 2.7	-	-	-
2.7 ≤ E < 2.9	-	-	-
2.9 ≤ E < 3.1	-	-	-
3.1 ≤ E < 3.3	6.9	7.2	-
3.3 ≤ E < 3.5	6.8	7.0	7.4
3.5 ≤ E < 3.7	6.7	6.9	7.2
3.7 ≤ E < 3.9	6.5	6.8	7.0
3.9 ≤ E < 4.1	6.4	6.7	6.9
4.1 ≤ E < 4.3	6.3	6.5	6.8
4.3 ≤ E < 4.5	6.2	6.4	6.7
4.5 ≤ E < 4.7	6.1	6.3	6.6
4.7 ≤ E < 4.9	6.0	6.2	6.5
E ≥ 4.9	5.9	6.1	6.4

PROPOSED

Table B2-32 Loading Table for PWR Fuel – 1710 W/Assembly – WE 14x14 Fuel

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU					
	45< B ≤46	46< B ≤47	47< B ≤48	48< B ≤49	49< B ≤50	50< B ≤51
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-
2.7 ≤ E < 2.9	3.4	3.5	3.6	3.7	-	-
2.9 ≤ E < 3.1	3.4	3.5	3.5	3.6	3.7	3.8
3.1 ≤ E < 3.3	3.3	3.4	3.5	3.6	3.6	3.7
3.3 ≤ E < 3.5	3.3	3.4	3.4	3.5	3.6	3.7
3.5 ≤ E < 3.7	3.3	3.3	3.4	3.5	3.5	3.6
3.7 ≤ E < 3.9	3.2	3.3	3.4	3.4	3.5	3.6
3.9 ≤ E < 4.1	3.2	3.3	3.3	3.4	3.5	3.5
4.1 ≤ E < 4.3	3.1	3.2	3.3	3.4	3.4	3.5
4.3 ≤ E < 4.5	3.1	3.2	3.3	3.3	3.4	3.5
4.5 ≤ E < 4.7	3.1	3.2	3.2	3.3	3.4	3.4
4.7 ≤ E < 4.9	3.0	3.1	3.2	3.3	3.4	3.4
E ≥ 4.9	3.0	3.1	3.2	3.2	3.3	3.4

Table B2-32 Loading Table for PWR Fuel – 1710 W/Assembly – WE 14x14 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU					
	51< B ≤52	52< B ≤53	53< B ≤54	54< B ≤55	55< B ≤56	56< B ≤57
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-
2.9 ≤ E < 3.1	3.9	4.0	4.0	-	-	-
3.1 ≤ E < 3.3	3.8	3.9	4.0	4.1	4.2	4.3
3.3 ≤ E < 3.5	3.8	3.9	4.0	4.0	4.2	4.3
3.5 ≤ E < 3.7	3.7	3.8	3.9	4.0	4.1	4.2
3.7 ≤ E < 3.9	3.7	3.8	3.8	3.9	4.0	4.2
3.9 ≤ E < 4.1	3.6	3.7	3.8	3.9	4.0	4.1
4.1 ≤ E < 4.3	3.6	3.7	3.8	3.8	3.9	4.0
4.3 ≤ E < 4.5	3.5	3.6	3.7	3.8	3.9	4.0
4.5 ≤ E < 4.7	3.5	3.6	3.7	3.8	3.9	3.9
4.7 ≤ E < 4.9	3.5	3.5	3.6	3.7	3.8	3.9
E ≥ 4.9	3.4	3.5	3.6	3.7	3.8	3.9

Table B2-32 Loading Table for PWR Fuel – 1710 W/Assembly – WE 14x14 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU		
	57< B ≤58	58< B ≤59	59< B ≤60
1.3 ≤ E < 1.5	-	-	-
1.5 ≤ E < 1.7	-	-	-
1.7 ≤ E < 1.9	-	-	-
1.9 ≤ E < 2.1	-	-	-
2.1 ≤ E < 2.3	-	-	-
2.3 ≤ E < 2.5	-	-	-
2.5 ≤ E < 2.7	-	-	-
2.7 ≤ E < 2.9	-	-	-
2.9 ≤ E < 3.1	-	-	-
3.1 ≤ E < 3.3	4.4	4.6	-
3.3 ≤ E < 3.5	4.4	4.5	4.6
3.5 ≤ E < 3.7	4.3	4.4	4.5
3.7 ≤ E < 3.9	4.3	4.4	4.5
3.9 ≤ E < 4.1	4.2	4.3	4.4
4.1 ≤ E < 4.3	4.1	4.2	4.3
4.3 ≤ E < 4.5	4.1	4.2	4.3
4.5 ≤ E < 4.7	4.0	4.1	4.2
4.7 ≤ E < 4.9	4.0	4.1	4.2
E ≥ 4.9	3.9	4.0	4.1

Table B2-33 Loading Table for PWR Fuel – 788 W/Assembly – WE 14x14 Fuel

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU					
	45< B ≤46	46< B ≤47	47< B ≤48	48< B ≤49	49< B ≤50	50< B ≤51
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-
2.7 ≤ E < 2.9	9.0	9.7	10.4	11.2	-	-
2.9 ≤ E < 3.1	8.9	9.5	10.1	10.9	11.4	12.2
3.1 ≤ E < 3.3	8.7	9.2	9.9	10.6	11.1	11.9
3.3 ≤ E < 3.5	8.5	9.0	9.7	10.3	10.9	11.6
3.5 ≤ E < 3.7	8.4	8.9	9.5	10.1	10.6	11.4
3.7 ≤ E < 3.9	8.2	8.7	9.3	9.9	10.4	11.1
3.9 ≤ E < 4.1	8.1	8.6	9.1	9.7	10.2	10.9
4.1 ≤ E < 4.3	8.0	8.5	9.0	9.5	10.0	10.7
4.3 ≤ E < 4.5	7.9	8.4	8.8	9.4	9.8	10.5
4.5 ≤ E < 4.7	7.8	8.2	8.7	9.3	9.7	10.3
4.7 ≤ E < 4.9	7.7	8.1	8.6	9.1	9.5	10.2
E ≥ 4.9	7.6	8.0	8.5	9.0	9.4	10.0

Table B2-33 Loading Table for PWR Fuel – 788 W/Assembly – WE 14x14 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU					
	51< B ≤52	52< B ≤53	53< B ≤54	54< B ≤55	55< B ≤56	56< B ≤57
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-
2.9 ≤ E < 3.1	13.1	14.0	15.0	-	-	-
3.1 ≤ E < 3.3	12.8	13.6	14.6	15.6	16.6	17.7
3.3 ≤ E < 3.5	12.4	13.3	14.2	15.3	16.2	17.3
3.5 ≤ E < 3.7	12.1	13.0	13.9	14.9	15.9	16.9
3.7 ≤ E < 3.9	11.9	13.0	13.6	14.6	15.5	16.5
3.9 ≤ E < 4.1	11.6	12.5	13.3	14.2	15.2	16.2
4.1 ≤ E < 4.3	11.4	12.2	13.1	13.9	14.9	15.9
4.3 ≤ E < 4.5	11.3	11.9	12.8	13.7	14.7	15.6
4.5 ≤ E < 4.7	11.1	11.8	12.6	13.5	14.4	15.3
4.7 ≤ E < 4.9	10.9	11.6	12.4	13.3	14.1	15.1
E ≥ 4.9	10.7	11.5	12.6	13.1	13.9	14.8

Table B2-33 Loading Table for PWR Fuel – 788 W/Assembly – WE 14x14 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	WE 14x14 Assembly Average Burnup (B) GWd/MTU		
	57< B ≤58	58< B ≤59	59< B ≤60
1.3 ≤ E < 1.5	-	-	-
1.5 ≤ E < 1.7	-	-	-
1.7 ≤ E < 1.9	-	-	-
1.9 ≤ E < 2.1	-	-	-
2.1 ≤ E < 2.3	-	-	-
2.3 ≤ E < 2.5	-	-	-
2.5 ≤ E < 2.7	-	-	-
2.7 ≤ E < 2.9	-	-	-
2.9 ≤ E < 3.1	-	-	-
3.1 ≤ E < 3.3	18.7	19.7	-
3.3 ≤ E < 3.5	18.2	19.3	20.4
3.5 ≤ E < 3.7	17.9	18.9	19.9
3.7 ≤ E < 3.9	17.5	18.6	19.6
3.9 ≤ E < 4.1	17.2	18.2	19.2
4.1 ≤ E < 4.3	16.9	17.9	18.9
4.3 ≤ E < 4.5	16.6	17.6	18.6
4.5 ≤ E < 4.7	16.3	17.3	18.3
4.7 ≤ E < 4.9	16.0	17.0	18.0
E ≥ 4.9	15.8	16.8	17.8

Table B2-34 Loading Table for PWR Fuel – 513 W/Assembly – CE 16x16 Fuel

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU					
	B ≤10	10< B ≤15	15< B ≤20	20< B ≤25	25< B ≤30	30< B ≤32.5
1.3 ≤ E < 1.5	4.0	-	-	-	-	-
1.5 ≤ E < 1.7	4.0	4.0	-	-	-	-
1.7 ≤ E < 1.9	4.0	4.0	4.9	-	-	-
1.9 ≤ E < 2.1	4.0	4.0	4.8	6.1	-	-
2.1 ≤ E < 2.3	4.0	4.0	4.8	6.0	8.2	10.0
2.3 ≤ E < 2.5	4.0	4.0	4.7	6.0	8.1	9.9
2.5 ≤ E < 2.7	4.0	4.0	4.7	6.0	8.1	9.8
2.7 ≤ E < 2.9	4.0	4.0	4.7	5.9	8.0	9.7
2.9 ≤ E < 3.1	4.0	4.0	4.6	5.9	7.9	9.6
3.1 ≤ E < 3.3	4.0	4.0	4.6	5.9	7.9	9.5
3.3 ≤ E < 3.5	4.0	4.0	4.6	5.8	7.9	9.4
3.5 ≤ E < 3.7	4.0	4.0	4.6	5.8	7.8	9.4
3.7 ≤ E < 3.9	4.0	4.0	4.5	5.8	7.8	9.3
3.9 ≤ E < 4.1	4.0	4.0	4.5	5.8	7.7	9.2
4.1 ≤ E < 4.3	4.0	4.0	4.5	5.8	7.7	9.2
4.3 ≤ E < 4.5	4.0	4.0	4.5	5.7	7.7	9.2
4.5 ≤ E < 4.7	4.0	4.0	4.5	5.7	7.6	9.1
4.7 ≤ E < 4.9	4.0	4.0	4.5	5.7	7.6	9.1
E ≥ 4.9	4.0	4.0	4.5	5.7	7.6	9.0

Table B2-34 Loading Table for PWR Fuel – 513 W/Assembly – CE 16x16 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU					
	32.5< B ≤35	35< B ≤37.5	37.5< B ≤40	40< B ≤41	41< B ≤42	42< B ≤43
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	12.5	15.8	-	-	-	-
2.5 ≤ E < 2.7	12.3	15.6	19.2	20.7	22.2	23.7
2.7 ≤ E < 2.9	12.1	15.4	19.0	20.5	22.0	23.4
2.9 ≤ E < 3.1	12.0	15.2	18.8	20.2	21.7	23.2
3.1 ≤ E < 3.3	11.9	15.0	18.5	19.9	21.5	23.0
3.3 ≤ E < 3.5	11.8	14.8	18.4	19.8	21.3	22.8
3.5 ≤ E < 3.7	11.7	14.7	18.2	19.7	21.1	22.5
3.7 ≤ E < 3.9	11.7	14.6	18.0	19.5	20.9	22.3
3.9 ≤ E < 4.1	11.6	14.5	17.9	19.3	20.8	22.2
4.1 ≤ E < 4.3	11.5	14.4	17.8	19.2	20.7	22.1
4.3 ≤ E < 4.5	11.4	14.3	17.7	19.1	20.5	21.9
4.5 ≤ E < 4.7	11.4	14.3	17.6	19.0	20.4	21.8
4.7 ≤ E < 4.9	11.4	14.2	17.5	18.9	20.3	21.7
E ≥ 4.9	11.3	14.1	17.4	18.8	20.2	21.6

Table B2-34 Loading Table for PWR Fuel – 513 W/Assembly – CE 16x16 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU	
	43< B ≤44	44< B ≤45
1.3 ≤ E < 1.5	-	-
1.5 ≤ E < 1.7	-	-
1.7 ≤ E < 1.9	-	-
1.9 ≤ E < 2.1	-	-
2.1 ≤ E < 2.3	-	-
2.3 ≤ E < 2.5	-	-
2.5 ≤ E < 2.7	25.1	-
2.7 ≤ E < 2.9	24.8	26.3
2.9 ≤ E < 3.1	24.6	26.1
3.1 ≤ E < 3.3	24.4	25.8
3.3 ≤ E < 3.5	24.2	25.6
3.5 ≤ E < 3.7	24.0	25.4
3.7 ≤ E < 3.9	23.8	25.3
3.9 ≤ E < 4.1	23.7	25.0
4.1 ≤ E < 4.3	23.6	24.9
4.3 ≤ E < 4.5	23.4	24.8
4.5 ≤ E < 4.7	23.2	24.6
4.7 ≤ E < 4.9	23.1	24.5
E ≥ 4.9	23.0	24.4

Table B2-35 Loading Table for PWR Fuel – 1300 W/Assembly – CE 16x16 Fuel

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU					
	B ≤10	10< B ≤15	15< B ≤20	20< B ≤25	25< B ≤30	30< B ≤32.5
1.3 ≤ E < 1.5	4.0	-	-	-	-	-
1.5 ≤ E < 1.7	4.0	4.0	-	-	-	-
1.7 ≤ E < 1.9	4.0	4.0	4.0	-	-	-
1.9 ≤ E < 2.1	4.0	4.0	4.0	4.0	-	-
2.1 ≤ E < 2.3	4.0	4.0	4.0	4.0	4.0	4.0
2.3 ≤ E < 2.5	4.0	4.0	4.0	4.0	4.0	4.0
2.5 ≤ E < 2.7	4.0	4.0	4.0	4.0	4.0	4.0
2.7 ≤ E < 2.9	4.0	4.0	4.0	4.0	4.0	4.0
2.9 ≤ E < 3.1	4.0	4.0	4.0	4.0	4.0	4.0
3.1 ≤ E < 3.3	4.0	4.0	4.0	4.0	4.0	4.0
3.3 ≤ E < 3.5	4.0	4.0	4.0	4.0	4.0	4.0
3.5 ≤ E < 3.7	4.0	4.0	4.0	4.0	4.0	4.0
3.7 ≤ E < 3.9	4.0	4.0	4.0	4.0	4.0	4.0
3.9 ≤ E < 4.1	4.0	4.0	4.0	4.0	4.0	4.0
4.1 ≤ E < 4.3	4.0	4.0	4.0	4.0	4.0	4.0
4.3 ≤ E < 4.5	4.0	4.0	4.0	4.0	4.0	4.0
4.5 ≤ E < 4.7	4.0	4.0	4.0	4.0	4.0	4.0
4.7 ≤ E < 4.9	4.0	4.0	4.0	4.0	4.0	4.0
E ≥ 4.9	4.0	4.0	4.0	4.0	4.0	4.0

Table B2-35 Loading Table for PWR Fuel – 1300 W/Assembly – CE 16x16 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU					
	32.5< B ≤35	35< B ≤37.5	37.5< B ≤40	40< B ≤41	41< B ≤42	42< B ≤43
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	4.0	4.0	-	-	-	-
2.5 ≤ E < 2.7	4.0	4.0	4.1	4.2	4.3	4.5
2.7 ≤ E < 2.9	4.0	4.0	4.1	4.2	4.3	4.4
2.9 ≤ E < 3.1	4.0	4.0	4.0	4.1	4.2	4.4
3.1 ≤ E < 3.3	4.0	4.0	4.0	4.1	4.2	4.3
3.3 ≤ E < 3.5	4.0	4.0	4.0	4.0	4.1	4.3
3.5 ≤ E < 3.7	4.0	4.0	4.0	4.0	4.1	4.2
3.7 ≤ E < 3.9	4.0	4.0	4.0	4.0	4.0	4.2
3.9 ≤ E < 4.1	4.0	4.0	4.0	4.0	4.0	4.1
4.1 ≤ E < 4.3	4.0	4.0	4.0	4.0	4.0	4.1
4.3 ≤ E < 4.5	4.0	4.0	4.0	4.0	4.0	4.0
4.5 ≤ E < 4.7	4.0	4.0	4.0	4.0	4.0	4.0
4.7 ≤ E < 4.9	4.0	4.0	4.0	4.0	4.0	4.0
E ≥ 4.9	4.0	4.0	4.0	4.0	4.0	4.0

Table B2-35 Loading Table for PWR Fuel – 1300 W/Assembly – CE 16x16 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU	
	43< B ≤44	44< B ≤45
1.3 ≤ E < 1.5	-	-
1.5 ≤ E < 1.7	-	-
1.7 ≤ E < 1.9	-	-
1.9 ≤ E < 2.1	-	-
2.1 ≤ E < 2.3	-	-
2.3 ≤ E < 2.5	-	-
2.5 ≤ E < 2.7	4.6	
2.7 ≤ E < 2.9	4.5	4.7
2.9 ≤ E < 3.1	4.5	4.6
3.1 ≤ E < 3.3	4.4	4.5
3.3 ≤ E < 3.5	4.4	4.5
3.5 ≤ E < 3.7	4.3	4.4
3.7 ≤ E < 3.9	4.3	4.4
3.9 ≤ E < 4.1	4.2	4.3
4.1 ≤ E < 4.3	4.2	4.3
4.3 ≤ E < 4.5	4.2	4.3
4.5 ≤ E < 4.7	4.1	4.2
4.7 ≤ E < 4.9	4.1	4.2
E ≥ 4.9	4.0	4.2

Table B2-36 Loading Table for PWR Fuel – 1800 W/Assembly – CE 16x16 Fuel

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU					
	B ≤10	10< B ≤15	15< B ≤20	20< B ≤25	25< B ≤30	30< B ≤32.5
1.3 ≤ E < 1.5	4.0	-	-	-	-	-
1.5 ≤ E < 1.7	4.0	4.0	-	-	-	-
1.7 ≤ E < 1.9	4.0	4.0	4.0	-	-	-
1.9 ≤ E < 2.1	4.0	4.0	4.0	4.0	-	-
2.1 ≤ E < 2.3	4.0	4.0	4.0	4.0	4.0	4.0
2.3 ≤ E < 2.5	4.0	4.0	4.0	4.0	4.0	4.0
2.5 ≤ E < 2.7	4.0	4.0	4.0	4.0	4.0	4.0
2.7 ≤ E < 2.9	4.0	4.0	4.0	4.0	4.0	4.0
2.9 ≤ E < 3.1	4.0	4.0	4.0	4.0	4.0	4.0
3.1 ≤ E < 3.3	4.0	4.0	4.0	4.0	4.0	4.0
3.3 ≤ E < 3.5	4.0	4.0	4.0	4.0	4.0	4.0
3.5 ≤ E < 3.7	4.0	4.0	4.0	4.0	4.0	4.0
3.7 ≤ E < 3.9	4.0	4.0	4.0	4.0	4.0	4.0
3.9 ≤ E < 4.1	4.0	4.0	4.0	4.0	4.0	4.0
4.1 ≤ E < 4.3	4.0	4.0	4.0	4.0	4.0	4.0
4.3 ≤ E < 4.5	4.0	4.0	4.0	4.0	4.0	4.0
4.5 ≤ E < 4.7	4.0	4.0	4.0	4.0	4.0	4.0
4.7 ≤ E < 4.9	4.0	4.0	4.0	4.0	4.0	4.0
E ≥ 4.9	4.0	4.0	4.0	4.0	4.0	4.0

Table B2-36 Loading Table for PWR Fuel – 1800 W/Assembly – CE 16x16 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU					
	32.5< B ≤35	35< B ≤37.5	37.5< B ≤40	40< B ≤41	41< B ≤42	42< B ≤43
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	4.0	4.0	-	-	-	-
2.5 ≤ E < 2.7	4.0	4.0	4.0	4.0	4.0	4.0
2.7 ≤ E < 2.9	4.0	4.0	4.0	4.0	4.0	4.0
2.9 ≤ E < 3.1	4.0	4.0	4.0	4.0	4.0	4.0
3.1 ≤ E < 3.3	4.0	4.0	4.0	4.0	4.0	4.0
3.3 ≤ E < 3.5	4.0	4.0	4.0	4.0	4.0	4.0
3.5 ≤ E < 3.7	4.0	4.0	4.0	4.0	4.0	4.0
3.7 ≤ E < 3.9	4.0	4.0	4.0	4.0	4.0	4.0
3.9 ≤ E < 4.1	4.0	4.0	4.0	4.0	4.0	4.0
4.1 ≤ E < 4.3	4.0	4.0	4.0	4.0	4.0	4.0
4.3 ≤ E < 4.5	4.0	4.0	4.0	4.0	4.0	4.0
4.5 ≤ E < 4.7	4.0	4.0	4.0	4.0	4.0	4.0
4.7 ≤ E < 4.9	4.0	4.0	4.0	4.0	4.0	4.0
E ≥ 4.9	4.0	4.0	4.0	4.0	4.0	4.0

Table B2-36 Loading Table for PWR Fuel – 1800 W/Assembly – CE 16x16 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU	
	43< B ≤44	44< B ≤45
1.3 ≤ E < 1.5	-	-
1.5 ≤ E < 1.7	-	-
1.7 ≤ E < 1.9	-	-
1.9 ≤ E < 2.1	-	-
2.1 ≤ E < 2.3	-	-
2.3 ≤ E < 2.5	-	-
2.5 ≤ E < 2.7	4.0	
2.7 ≤ E < 2.9	4.0	4.0
2.9 ≤ E < 3.1	4.0	4.0
3.1 ≤ E < 3.3	4.0	4.0
3.3 ≤ E < 3.5	4.0	4.0
3.5 ≤ E < 3.7	4.0	4.0
3.7 ≤ E < 3.9	4.0	4.0
3.9 ≤ E < 4.1	4.0	4.0
4.1 ≤ E < 4.3	4.0	4.0
4.3 ≤ E < 4.5	4.0	4.0
4.5 ≤ E < 4.7	4.0	4.0
4.7 ≤ E < 4.9	4.0	4.0
E ≥ 4.9	4.0	4.0

Table B2-37 Loading Table for PWR Fuel – 830 W/Assembly – CE 16x16 Fuel

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU					
	B ≤10	10< B ≤15	15< B ≤20	20< B ≤25	25< B ≤30	30< B ≤32.5
1.3 ≤ E < 1.5	4.0	-	-	-	-	-
1.5 ≤ E < 1.7	4.0	4.0	-	-	-	-
1.7 ≤ E < 1.9	4.0	4.0	4.0	-	-	-
1.9 ≤ E < 2.1	4.0	4.0	4.0	4.0	-	-
2.1 ≤ E < 2.3	4.0	4.0	4.0	4.0	4.7	5.0
2.3 ≤ E < 2.5	4.0	4.0	4.0	4.0	4.6	5.0
2.5 ≤ E < 2.7	4.0	4.0	4.0	4.0	4.6	4.9
2.7 ≤ E < 2.9	4.0	4.0	4.0	4.0	4.5	4.9
2.9 ≤ E < 3.1	4.0	4.0	4.0	4.0	4.5	4.8
3.1 ≤ E < 3.3	4.0	4.0	4.0	4.0	4.4	4.8
3.3 ≤ E < 3.5	4.0	4.0	4.0	4.0	4.4	4.7
3.5 ≤ E < 3.7	4.0	4.0	4.0	4.0	4.4	4.7
3.7 ≤ E < 3.9	4.0	4.0	4.0	4.0	4.4	4.7
3.9 ≤ E < 4.1	4.0	4.0	4.0	4.0	4.3	4.6
4.1 ≤ E < 4.3	4.0	4.0	4.0	4.0	4.3	4.6
4.3 ≤ E < 4.5	4.0	4.0	4.0	4.0	4.3	4.6
4.5 ≤ E < 4.7	4.0	4.0	4.0	4.0	4.3	4.5
4.7 ≤ E < 4.9	4.0	4.0	4.0	4.0	4.2	4.5
E ≥ 4.9	4.0	4.0	4.0	4.0	4.2	4.5

PROPOSED

Table B2-37 Loading Table for PWR Fuel – 830 W/Assembly – CE 16x16 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU					
	32.5< B ≤35	35< B ≤37.5	37.5< B ≤40	40< B ≤41	41< B ≤42	42< B ≤43
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	5.5	6.0	-	-	-	-
2.5 ≤ E < 2.7	5.4	6.0	6.7	7.0	7.4	7.8
2.7 ≤ E < 2.9	5.4	5.9	6.6	6.9	7.2	7.7
2.9 ≤ E < 3.1	5.3	5.8	6.5	6.8	7.1	7.5
3.1 ≤ E < 3.3	5.2	5.8	6.4	6.7	7.0	7.4
3.3 ≤ E < 3.5	5.2	5.7	6.3	6.6	6.9	7.3
3.5 ≤ E < 3.7	5.1	5.7	6.3	6.6	6.8	7.2
3.7 ≤ E < 3.9	5.1	5.6	6.2	6.5	6.8	7.1
3.9 ≤ E < 4.1	5.0	5.6	6.1	6.4	6.7	7.0
4.1 ≤ E < 4.3	5.0	5.5	6.0	6.4	6.7	6.9
4.3 ≤ E < 4.5	5.0	5.5	6.0	6.3	6.6	6.9
4.5 ≤ E < 4.7	4.9	5.5	6.0	6.2	6.5	6.8
4.7 ≤ E < 4.9	4.9	5.4	5.9	6.2	6.5	6.8
E ≥ 4.9	4.9	5.4	5.9	6.1	6.4	6.7

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Table B2-37 Loading Table for PWR Fuel – 830 W/Assembly – CE 16x16 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU	
	43< B ≤44	44< B ≤45
1.3 ≤ E < 1.5	-	-
1.5 ≤ E < 1.7	-	-
1.7 ≤ E < 1.9	-	-
1.9 ≤ E < 2.1	-	-
2.1 ≤ E < 2.3	-	-
2.3 ≤ E < 2.5	-	-
2.5 ≤ E < 2.7	8.2	
2.7 ≤ E < 2.9	8.0	8.6
2.9 ≤ E < 3.1	7.9	8.4
3.1 ≤ E < 3.3	7.8	8.2
3.3 ≤ E < 3.5	7.7	8.1
3.5 ≤ E < 3.7	7.6	8.0
3.7 ≤ E < 3.9	7.5	7.9
3.9 ≤ E < 4.1	7.4	7.8
4.1 ≤ E < 4.3	7.3	7.7
4.3 ≤ E < 4.5	7.2	7.6
4.5 ≤ E < 4.7	7.1	7.5
4.7 ≤ E < 4.9	7.0	7.4
E ≥ 4.9	7.0	7.4

Note: For fuel assembly average burnup greater than 45 GWd/MTU, cool time tables have been revised to account for a 5% margin in heat load.

Table B2-38 Loading Table for PWR Fuel – 487 W/Assembly – CE 16x16 Fuel

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU					
	45< B ≤46	46< B ≤47	47< B ≤48	48< B ≤49	49< B ≤50	50< B ≤51
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-
2.7 ≤ E < 2.9	30.4	31.8	33.2	34.5	-	-
2.9 ≤ E < 3.1	30.1	31.6	32.9	34.3	35.5	36.8
3.1 ≤ E < 3.3	30.0	31.4	32.7	34.1	35.4	36.7
3.3 ≤ E < 3.5	29.8	31.2	32.6	33.9	35.2	36.6
3.5 ≤ E < 3.7	29.6	31.1	32.5	33.8	35.1	36.3
3.7 ≤ E < 3.9	29.4	30.8	32.3	33.6	34.9	36.3
3.9 ≤ E < 4.1	29.3	30.7	32.1	33.5	34.7	36.1
4.1 ≤ E < 4.3	29.1	30.6	32.0	33.4	34.6	35.9
4.3 ≤ E < 4.5	29.0	30.4	31.9	33.2	34.5	35.9
4.5 ≤ E < 4.7	28.9	30.2	31.7	33.1	34.4	35.7
4.7 ≤ E < 4.9	28.8	30.2	31.5	33.0	34.3	35.6
E ≥ 4.9	28.7	30.1	31.4	32.8	34.2	35.4

Table B2-38 Loading Table for PWR Fuel – 487 W/Assembly – CE 16x16 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU					
	51< B ≤52	52< B ≤53	53< B ≤54	54< B ≤55	55< B ≤56	56< B ≤57
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-
2.9 ≤ E < 3.1	38.1	39.3	40.5	-	-	-
3.1 ≤ E < 3.3	38.0	39.2	40.3	41.5	42.1	43.1
3.3 ≤ E < 3.5	37.8	39.1	40.2	41.4	41.9	43.1
3.5 ≤ E < 3.7	37.6	38.9	40.0	41.2	41.8	42.9
3.7 ≤ E < 3.9	37.6	38.7	39.9	41.1	41.7	42.8
3.9 ≤ E < 4.1	37.4	38.7	39.8	41.1	41.6	42.7
4.1 ≤ E < 4.3	37.3	38.6	39.7	40.9	41.4	42.6
4.3 ≤ E < 4.5	37.2	38.4	39.6	40.9	41.3	42.5
4.5 ≤ E < 4.7	37.0	38.2	39.4	40.8	41.2	42.4
4.7 ≤ E < 4.9	36.9	38.2	39.5	40.7	41.0	42.3
E ≥ 4.9	36.8	38.0	39.3	40.5	40.9	42.1

Table B2-38 Loading Table for PWR Fuel – 487 W/Assembly – CE 16x16 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU		
	57< B ≤58	58< B ≤59	59< B ≤60
1.3 ≤ E < 1.5	-	-	-
1.5 ≤ E < 1.7	-	-	-
1.7 ≤ E < 1.9	-	-	-
1.9 ≤ E < 2.1	-	-	-
2.1 ≤ E < 2.3	-	-	-
2.3 ≤ E < 2.5	-	-	-
2.5 ≤ E < 2.7	-	-	-
2.7 ≤ E < 2.9	-	-	-
2.9 ≤ E < 3.1	-	-	-
3.1 ≤ E < 3.3	44.3	45.3	-
3.3 ≤ E < 3.5	44.1	45.2	46.2
3.5 ≤ E < 3.7	44.0	45.1	46.2
3.7 ≤ E < 3.9	43.9	44.9	46.1
3.9 ≤ E < 4.1	43[illegible]	44.9	46.0
4.1 ≤ E < 4.3	43.7	44.8	45.8
4.3 ≤ E < 4.5	43.7	44.7	45.8
4.5 ≤ E < 4.7	43.5	44.6	45.7
4.7 ≤ E < 4.9	43.4	44.5	45.7
E ≥ 4.9	43.4	44.4	45.6

Table B2-39 Loading Table for PWR Fuel – 1235 W/Assembly – CE 16x16 Fuel

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU					
	45< B ≤46	46< B ≤47	47< B ≤48	48< B ≤49	49< B ≤50	50< B ≤51
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-
2.7 ≤ E < 2.9	5.1	5.3	5.5	5.7	-	-
2.9 ≤ E < 3.1	5.0	5.2	5.4	5.6	5.8	6.0
3.1 ≤ E < 3.3	4.9	5.1	5.3	5.5	5.7	5.9
3.3 ≤ E < 3.5	4.9	5.0	5.2	5.4	5.6	5.8
3.5 ≤ E < 3.7	4.8	5.0	5.1	5.3	5.5	5.7
3.7 ≤ E < 3.9	4.8	4.9	5.0	5.2	5.4	5.6
3.9 ≤ E < 4.1	4.7	4.9	5.0	5.2	5.4	5.6
4.1 ≤ E < 4.3	4.7	4.8	4.9	5.1	5.3	5.5
4.3 ≤ E < 4.5	4.6	4.8	4.9	5.0	5.2	5.4
4.5 ≤ E < 4.7	4.5	4.7	4.8	5.0	5.1	5.3
4.7 ≤ E < 4.9	4.5	4.7	4.8	4.9	5.1	5.3
E ≥ 4.9	4.5	4.6	4.8	4.9	5.0	5.2

Table B2-39 Loading Table for PWR Fuel – 1235 W/Assembly – CE 16x16 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU					
	51< B ≤52	52< B ≤53	53< B ≤54	54< B ≤55	55< B ≤56	56< B ≤57
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-
2.9 ≤ E < 3.1	6.2	6.5	6.7	-	-	-
3.1 ≤ E < 3.3	6.1	6.3	6.6	6.8	7.0	7.3
3.3 ≤ E < 3.5	6.0	6.2	6.5	6.7	6.9	7.1
3.5 ≤ E < 3.7	5.9	6.1	6.3	6.6	6.7	7.0
3.7 ≤ E < 3.9	5.8	6.0	6.2	6.5	6.6	6.9
3.9 ≤ E < 4.1	5.7	5.9	6.1	6.4	6.5	6.8
4.1 ≤ E < 4.3	5.7	5.8	6.0	6.3	6.4	6.7
4.3 ≤ E < 4.5	5.6	5.8	5.9	6.2	6.3	6.6
4.5 ≤ E < 4.7	5.5	5.7	5.9	6.0	6.2	6.4
4.7 ≤ E < 4.9	5.5	5.6	5.8	6.0	6.1	6.4
E ≥ 4.9	5.4	5.6	5.8	5.9	6.0	6.3

Table B2-39 Loading Table for PWR Fuel – 1235 W/Assembly – CE 16x16 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU		
	57< B ≤58	58< B ≤59	59< B ≤60
1.3 ≤ E < 1.5	-	-	-
1.5 ≤ E < 1.7	-	-	-
1.7 ≤ E < 1.9	-	-	-
1.9 ≤ E < 2.1	-	-	-
2.1 ≤ E < 2.3	-	-	-
2.3 ≤ E < 2.5	-	-	-
2.5 ≤ E < 2.7	-	-	-
2.7 ≤ E < 2.9	-	-	-
2.9 ≤ E < 3.1	-	-	-
3.1 ≤ E < 3.3	7.7	8.0	-
3.3 ≤ E < 3.5	7.5	7.8	8.2
3.5 ≤ E < 3.7	7.3	7.6	8.0
3.7 ≤ E < 3.9	7.1	7.5	7.8
3.9 ≤ E < 4.1	7.0	7.3	7.7
4.1 ≤ E < 4.3	6.9	7.2	7.5
4.3 ≤ E < 4.5	6.8	7.0	7.4
4.5 ≤ E < 4.7	6.7	6.9	7.2
4.7 ≤ E < 4.9	6.6	6.9	7.1
E ≥ 4.9	6.5	6.8	7.0

Table B2-40 Loading Table for PWR Fuel – 1710 W/Assembly – CE 16x16 Fuel

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU					
	45< B ≤46	46< B ≤47	47< B ≤48	48< B ≤49	49< B ≤50	50< B ≤51
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-
2.7 ≤ E < 2.9	4.0	4.0	4.0	4.0	-	-
2.9 ≤ E < 3.1	4.0	4.0	4.0	4.0	4.0	4.1
3.1 ≤ E < 3.3	4.0	4.0	4.0	4.0	4.0	4.1
3.3 ≤ E < 3.5	4.0	4.0	4.0	4.0	4.0	4.0
3.5 ≤ E < 3.7	4.0	4.0	4.0	4.0	4.0	4.0
3.7 ≤ E < 3.9	4.0	4.0	4.0	4.0	4.0	4.0
3.9 ≤ E < 4.1	4.0	4.0	4.0	4.0	4.0	4.0
4.1 ≤ E < 4.3	4.0	4.0	4.0	4.0	4.0	4.0
4.3 ≤ E < 4.5	4.0	4.0	4.0	4.0	4.0	4.0
4.5 ≤ E < 4.7	4.0	4.0	4.0	4.0	4.0	4.0
4.7 ≤ E < 4.9	4.0	4.0	4.0	4.0	4.0	4.0
E ≥ 4.9	4.0	4.0	4.0	4.0	4.0	4.0

Table B2-40 Loading Table for PWR Fuel – 1710 W/Assembly – CE 16x16 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU					
	51< B ≤52	52< B ≤53	53< B ≤54	54< B ≤55	55< B ≤56	56< B ≤57
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-
2.9 ≤ E < 3.1	4.2	4.4	4.5	-	-	-
3.1 ≤ E < 3.3	4.2	4.3	4.4	4.5	4.6	4.7
3.3 ≤ E < 3.5	4.1	4.2	4.3	4.4	4.5	4.6
3.5 ≤ E < 3.7	4.0	4.2	4.3	4.4	4.5	4.6
3.7 ≤ E < 3.9	4.0	4.1	4.2	4.3	4.4	4.5
3.9 ≤ E < 4.1	4.0	4.1	4.2	4.3	4.3	4.4
4.1 ≤ E < 4.3	4.0	4.0	4.1	4.2	4.3	4.4
4.3 ≤ E < 4.5	4.0	4.0	4.1	4.2	4.2	4.3
4.5 ≤ E < 4.7	4.0	4.0	4.0	4.1	4.2	4.3
4.7 ≤ E < 4.9	4.0	4.0	4.0	4.0	4.1	4.2
E ≥ 4.9	4.0	4.0	4.0	4.0	4.1	4.2

Table B2-40 Loading Table for PWR Fuel – 1710 W/Assembly – CE 16x16 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU		
	57< B ≤58	58< B ≤59	59< B ≤60
1.3 ≤ E < 1.5	-	-	-
1.5 ≤ E < 1.7	-	-	-
1.7 ≤ E < 1.9	-	-	-
1.9 ≤ E < 2.1	-	-	-
2.1 ≤ E < 2.3	-	-	-
2.3 ≤ E < 2.5	-	-	-
2.5 ≤ E < 2.7	-	-	-
2.7 ≤ E < 2.9	-	-	-
2.9 ≤ E < 3.1	-	-	-
3.1 ≤ E < 3.3	4.9	5.0	-
3.3 ≤ E < 3.5	4.8	4.9	5.0
3.5 ≤ E < 3.7	4.7	4.8	5.0
3.7 ≤ E < 3.9	4.6	4.8	4.9
3.9 ≤ E < 4.1	4.5	4.7	4.8
4.1 ≤ E < 4.3	4.5	4.6	4.7
4.3 ≤ E < 4.5	4.4	4.5	4.7
4.5 ≤ E < 4.7	4.4	4.5	4.6
4.7 ≤ E < 4.9	4.3	4.4	4.5
E ≥ 4.9	4.3	4.4	4.5

Table B2-41 Loading Table for PWR Fuel – 788 W/Assembly – CE 16x16 Fuel

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU					
	45< B ≤46	46< B ≤47	47< B ≤48	48< B ≤49	49< B ≤50	50< B ≤51
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-
2.7 ≤ E < 2.9	10.2	11.0	11.8	12.7	-	-
2.9 ≤ E < 3.1	9.9	10.7	11.5	12.3	13.3	14.2
3.1 ≤ E < 3.3	9.8	10.5	11.2	12.0	12.9	13.9
3.3 ≤ E < 3.5	9.6	10.2	11.0	11.8	12.6	13.6
3.5 ≤ E < 3.7	9.4	10.0	10.8	11.6	12.4	13.3
3.7 ≤ E < 3.9	9.2	9.8	10.6	11.3	12.0	13.0
3.9 ≤ E < 4.1	9.1	9.7	10.4	11.1	11.9	12.8
4.1 ≤ E < 4.3	9.0	9.5	10.2	11.0	11.7	12.5
4.3 ≤ E < 4.5	8.9	9.4	10.0	10.8	11.5	12.3
4.5 ≤ E < 4.7	8.8	9.3	9.9	10.6	11.4	12.1
4.7 ≤ E < 4.9	8.7	9.2	9.8	10.5	11.2	12.0
E ≥ 4.9	8.6	9.1	9.7	10.3	11.1	11.8

Table B2-41 Loading Table for PWR Fuel – 788 W/Assembly – CE 16x16 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU					
	51< B ≤52	52< B ≤53	53< B ≤54	54< B ≤55	55< B ≤56	56< B ≤57
1.3 ≤ E < 1.5	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-
2.1 ≤ E < 2.3	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-
2.5 ≤ E < 2.7	-	-	-	-	-	-
2.7 ≤ E < 2.9	-	-	-	-	-	-
2.9 ≤ E < 3.1	15.2	16.3	17.4	-	-	-
3.1 ≤ E < 3.3	14.9	15.9	17.0	18.0	18.7	19.7
3.3 ≤ E < 3.5	14.6	15.6	16.6	17.7	18.2	19.3
3.5 ≤ E < 3.7	14.2	15.2	16.3	17.3	17.9	19.0
3.7 ≤ E < 3.9	13.9	14.9	15.9	17.0	17.5	18.6
3.9 ≤ E < 4.1	13.7	14.6	15.6	16.7	17.2	18.2
4.1 ≤ E < 4.3	13.4	14.3	15.4	16.4	16.9	18.0
4.3 ≤ E < 4.5	13.2	14.1	15.1	16.1	16.7	17.7
4.5 ≤ E < 4.7	13.0	13.9	14.9	15.8	16.4	17.4
4.7 ≤ E < 4.9	12.8	13.7	14.7	15.7	16.1	17.2
E ≥ 4.9	12.7	13.5	14.5	15.4	16.0	17.0

Table B2-41 Loading Table for PWR Fuel – 788 W/Assembly – CE 16x16 Fuel (Continued)

Minimum Initial Assembly Avg. Enrichment wt % ^{235}U (E)	Assembly Average Burnup (B) GWd/MTU		
	57< B ≤58	58< B ≤59	59< B ≤60
1.3 ≤ E < 1.5	-	-	-
1.5 ≤ E < 1.7	-	-	-
1.7 ≤ E < 1.9	-	-	-
1.9 ≤ E < 2.1	-	-	-
2.1 ≤ E < 2.3	-	-	-
2.3 ≤ E < 2.5	-	-	-
2.5 ≤ E < 2.7	-	-	-
2.7 ≤ E < 2.9	-	-	-
2.9 ≤ E < 3.1	-	-	-
3.1 ≤ E < 3.3	20.8	21.8	-
3.3 ≤ E < 3.5	20.4	21.4	22.5
3.5 ≤ E < 3.7	20.0	21.1	22.1
3.7 ≤ E < 3.9	19.7	20.7	21.7
3.9 ≤ E < 4.1	19	20.3	21.4
4.1 ≤ E < 4.3	19.0	20.0	21.1
4.3 ≤ E < 4.5	18.7	19.7	20.8
4.5 ≤ E < 4.7	18.4	19.5	20.5
4.7 ≤ E < 4.9	18.2	19.2	20.2
E ≥ 4.9	17.9	19.0	20.0

PROPOSED

Table B2-42 Low SNF Assembly Average Burnup Enrichment Limits for CE 16x16 Fuel Loaded via the PMTC

Max. Assembly Avg. Burnup (MWd/MTU)	Min. Assembly Avg. Initial Enrichment (wt% ^{235}U)	Minimum Cool Time (yrs)
10,000	1.3	4.0
15,000	1.5	4.0
20,000	1.7	4.0
25,000	1.9	4.1

Table B2-43 Loading Table for CE 16x16 Fuel Loaded via the PMTC

Minimum Initial Assembly Avg. Enrichment (wt% ^{235}U)	Assembly Average Burnup (GWd/MTU)						
	25 < B ≤ 30	30 < B ≤ 35	35 < B ≤ 40	40 < B ≤ 45	45 < B ≤ 50	50 < B ≤ 55	55 < B ≤ 60
	Minimum Cooling Time (years)						
1.3 ≤ E < 1.5	-	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-	-
2.1 ≤ E < 2.3	4.8	-	-	-	-	-	-
2.3 ≤ E < 2.5	4.7	5.7	-	-	-	-	-
2.5 ≤ E < 2.7	4.7	5.6	6.9	-	-	-	-
2.7 ≤ E < 2.9	4.6	5.5	6.8	8.9	-	-	-
2.9 ≤ E < 3.1	4.6	5.5	6.7	8.8	14.0	-	-
3.1 ≤ E < 3.3	4.5	5.4	6.6	8.6	13.7	19.0	-
3.3 ≤ E < 3.5	4.5	5.3	6.6	8.5	13.4	18.7	23.5
3.5 ≤ E < 3.7	4.5	5.3	6.5	8.3	13.1	18.2	23.1
3.7 ≤ E < 3.9	4.4	5.2	6.4	8.2	12.9	17.9	22.7
3.9 ≤ E < 4.1	4.4	5.2	6.3	8.1	12.6	17.7	22.4
4.1 ≤ E < 4.3	4.4	5.2	6.3	8.0	12.4	17.4	22.1
4.3 ≤ E < 4.5	4.4	5.1	6.2	7.9	12.2	17.1	21.8
4.5 ≤ E < 4.7	4.3	5.1	6.2	7.8	12.0	16.8	21.5
4.7 ≤ E < 4.9	4.3	5.0	6.1	7.8	11.9	16.6	21.3
E ≥ 4.9	4.3	5.0	6.1	7.7	11.8	16.4	21.1

- The minimum cool times for heat loads of 811 W/assy for assembly average burnups less than 45 GWd/MTU and heat loads of 770 W/Assy for burnups greater than 45 GWd/MTU

Enclosure 4 – Supporting Calculations

<u>Enclosure 4</u>

Supporting Calculations:

71160-3155, Rev. 1

71160-3150, Rev. 0

71160-5021, Rev. 0

71160-2029, Rev 0

for

MAGNASTOR® FSAR, Amendment 6

(Docket No. 72-1031)

July 2015

CALCULATIONS WITHHELD IN THEIR ENTIRETY
PER 10 CFR 2.390

Enclosure 5 – FSAR Changed Pages and List of Effective Pages

Enclosure 5

FSAR Changed Pages and LOEP

for

MAGNASTOR® FSAR, Amendment 6

(Docket No. 72-1031)

NAC International

July 2015

July 2015

Revision 15A

MAGNASTOR®

(**M**odular **A**dvanced **G**eneration **N**uclear **A**ll-purpose **STOR**age)

FINAL SAFETY ANALYSIS REPORT

NON-PROPRIETARY VERSION

Docket No. 72-1031

NAC INTERNATIONAL

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List of Effective Pages

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1. General Description

Chapter 1
General Description

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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 (≤ 104°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.

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.

1.2 Introduction

MAGNASTOR is a spent fuel dry storage system consisting of a concrete cask and a welded stainless steel TSC with a welded closure to safely store spent fuel. The TSC is stored in the central cavity of the concrete cask. The concrete cask provides structural protection, radiation shielding, and internal airflow paths that remove the decay heat from the TSC contents by natural air circulation. MAGNASTOR is designed and analyzed for a minimum 50-year service life.

The loaded TSC is moved to and from the concrete cask using the transfer cask. The transfer cask provides radiation shielding during TSC closure and preparation activities. The TSC is transferred into the concrete cask by positioning the transfer cask with the loaded TSC on top of the concrete cask, opening the shield doors, and lowering the TSC into the concrete cask. Figure 1.3-1 depicts the major components of MAGNASTOR in such a configuration.

MAGNASTOR is designed to safely store up to 37 undamaged PWR fuel assemblies in the 37 PWR basket assembly or up to 87 undamaged BWR fuel assemblies in the 87 BWR basket assembly. 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. Each DFC may contain an undamaged PWR fuel assembly, a damaged PWR fuel assembly, or PWR fuel debris equivalent to one PWR fuel assembly. Undamaged PWR fuel assemblies may be placed directly in the DFC locations of a DF Basket Assembly. These capacities, combined with enhanced operational features, ensure that MAGNASTOR reduces the time required and the personnel dose received on a per-assembly basis when placing spent fuel into dry storage. The fuel specifications and parameters that establish the design basis for the PWR and BWR fuel assemblies are presented in Chapter 2. The spent fuel considered in the design includes fuel assemblies that have different overall lengths. The PWR and BWR fuel assembly populations are divided into two groups based on fuel assembly length, and are accommodated by two different lengths of TSCs. There are multiple concrete and transfer casks of different sizes that are used to accommodate the different lengths of TSCs. The designations and corresponding lengths of the TSCs are shown on the License Drawings.

For PWR fuel, the inclusion of nonfuel assembly hardware can increase an assembly's overall length, resulting in the need to use the longer TSC. Fuel assembly spacers may be used in a given TSC to allow loading of fuel assemblies that are significantly shorter than the TSC length. A DFC spacer may be required for damaged fuel cans to ensure the proper design function of the damaged fuel can. A DFC may not contain a fuel assembly that includes core components.

The BWR fuel assembly groups are evaluated for the effects of the zirconium alloy channel that surrounds the fuel assembly in reactor operations. Fuel assembly channel effects are addressed in both the thermal heat transfer and criticality analyses. BWR assembly channels are included in the assembly weight assigned to each basket opening in the structural analysis. The mass associated with the channel is conservatively neglected from the material homogenization in the shielding analysis. Fuel assembly spacers may be used in a given TSC to facilitate the loading of fuel assemblies.

The system design and analyses are in accordance with 10 CFR 72, ANSI/ANS 57.9 [6], the applicable sections of the ASME Boiler and Pressure Vessel Code (ASME Code), and the American Concrete Institute (ACI) code [7]. The analyses demonstrate that MAGNASTOR meets the regulatory requirements of 10 CFR 72 and the guidance of NUREG-1536 [2].

structural strength to protect the TSC and its contents in natural phenomena events such as tornado wind loading and wind-driven missiles and during nonmechanistic tip-over events (refer to Figure 1.3-3). The concrete surfaces remain accessible for inspection and maintenance over the life of the cask, so that any necessary restoration actions may be taken to maintain shielding and structural conditions.

The concrete cask may be supplied in four different configurations designated CC1 through CC4. CC1 is the standard 225.27-in high cylinder. CC2 is also 225.27-in high, but is a segmented design. The CC3 and CC4 configurations are shorter variants at 218.3 inches high. CC1, CC2 and CC4 are equipped with a 1.75-in thick carbon steel liner, while CC3 has a 3-in thick carbon steel liner. CC1, CC2 and CC4 are equipped with standard concrete lids, having a constant thickness, while CC3 lid has a thicker center section for enhanced shielding. Both the CC3 and CC4 cask configurations are equipped with additional shielding at the air inlets.

The concrete cask provides an annular air passage to allow the natural circulation of air around the TSC to remove the decay heat from the contents. The lower air inlets and upper air outlets are steel-lined penetrations in the concrete cask body. Each air inlet/outlet is covered with a screen. The weldment baffle directs the air upward and around the pedestal that supports the TSC. Decay heat is transferred from the fuel assemblies to the TSC wall by conduction, convection, and radiation. Heat is removed by convection and radiation from the TSC shell to the air flowing upward through the annular air passage and to the concrete cask inner liner, respectively. Heat radiated to the liner can be transferred to the air annulus and by conduction through the concrete cask wall. The heated air in the annulus exhausts through the air outlets. The passive cooling system is designed to maintain the peak fuel cladding temperature below acceptable limits during long-term storage [10]. The concrete cask thermal design also maintains the bulk concrete temperature and surface temperatures below the American Concrete Institute (ACI) limits under normal operating conditions. The inner liner of the concrete cask incorporates standoffs that provide lateral support to the TSC in side impact accident events.

A carbon steel and concrete lid is bolted to the top of the concrete cask. (See Table 1.3-4 for the Concrete Cask Lid – Concrete Specification Summary.) The lid reduces skyshine radiation and provides a cover to protect the TSC from the environment and postulated tornado missiles.

Fabrication of the concrete cask requires no unique or unusual forming, concrete placement, or reinforcement operations. The concrete portion of the cask is constructed by placing concrete between a reusable, exterior form and the steel liner. Reinforcing bars are used near the inner and outer concrete surfaces to provide structural integrity. Note: inner rebar cage is optional. The structural steel liner and base are shop fabricated. Refer to Table 1.3-3 for the fabrication specifications for the concrete cask.

Daily visual inspection of the air inlet and outlet screens for blockage assures that airflow through the cask meets licensed requirements. A description of the visual inspection is included

in the Technical Specifications, Chapter 13. As an alternative to daily visual inspections, the loaded concrete cask in storage may include the capability to measure air temperature at the four outlets. Each air outlet may be equipped with a remote temperature detector mounted in the outlet air plenum. The air temperature-monitoring system, designed to provide verification of heat dissipation capabilities, can be designed for remote or local read-out capabilities at the option of the licensee. The temperature-monitoring system can be installed on all or some of the concrete casks at the Independent Spent Fuel Storage Installation (ISFSI) facility.

1.3.1.4 Transfer Cask

The transfer cask is designed, fabricated, and tested to meet the requirements of ANSI N14.6 [11] as a special lifting device. The transfer cask provides biological shielding and structural protection for a loaded TSC, and is used to lift and move the TSC between workstations. The transfer cask is also used to shield the vertical transfer of a TSC into a concrete cask or a transport cask.

The transfer cask is available in two configurations. 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 a shortened stainless steel version (MTC2). The second configuration is the Passive MTC (PMTC) with demineralized water filled shield tank. The PMTC is specifically designed for use in a high ambient temperature environment (≤ 104°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. The principal dimensions and materials of fabrication of the transfer cask are provided in Table 1.3-1.

The transfer cask designs incorporate a retaining ring or three retaining blocks, pin-locked in place, or a bolted retaining ring, to prevent a loaded TSC from being inadvertently lifted through its top opening. The transfer cask has retractable bottom shield doors. During TSC loading and handling operations, the shield doors are closed and secured by lock pins. After placement of the transfer cask on the concrete cask, the lock pins are removed and the doors are retracted using hydraulic cylinders and a hydraulic supply. The TSC is then lowered into a concrete cask for storage. Refer to Figure 1.3-1 for the general arrangement of the transfer cask, TSC, and concrete cask during loading.

The MTC has sixteen penetrations, eight at the top and eight at the bottom, available to provide a water supply to the transfer cask annulus. Penetrations not used for water supply or draining are capped. The transfer cask annulus is isolated using inflatable seals located between the transfer cask inner shell and the TSC near the upper and lower ends of the transfer cask.

The PMTC has eight upper penetrations available to provide a water supply to the transfer cask annulus. The upper PMTC annulus is isolated from the spent fuel pool water by a shield/seal insert ring which inflates against both the PMTC inside diameter and the outside diameter of the

TSC. The large bottom forging inlets are plugged during in-pool operations to essentially isolate the annulus from contaminated spent fuel pool water.

During TSC closure, clean (e.g., filtered) borated or demineralized spent fuel pool water is circulated through these penetrations into the annulus region to minimize component temperatures and improve canister preparation time limits. The annulus circulating water system (ACWS) can be utilized through completion of TSC activities. The ACWS is turned off and disconnected prior to movement of the transfer cask for TSC transfer operations into the concrete cask.

A similar process of clean borated or demineralized spent fuel pool water flow into the annulus is used during in-pool fuel loading to minimize the potential for contamination of the TSC exterior surfaces.

The MTC penetrations can also be used for the introduction of auxiliary forced air or gas to cool the exterior of the TSC. Alternately, if auxiliary cooling is required to lower fuel cladding or TSC component temperatures, the loaded TSC may be returned to the spent fuel pool or shelf for cooling.

The PMTC is specifically designed to provide for convective air cooling of the TSC by providing an oversized PMTC to TSC annulus, by incorporating a water filled neutron shield tank in place of solid neutron shielding material, and by the provision of large inlets in the PMTC bottom forging specifically designed to provide sufficient air flow to maintain the fuel clad temperature lower than allowable temperature for transfer condition.

1.3.1.5 Damaged Fuel Can

The MAGNASTOR Damaged Fuel Can (DFC), shown in License Drawings 71160-601 and 71160-602, is provided to accommodate damaged WE15×15, WE17×17, and B&W 15×15 fuel assemblies in an undamaged condition or fuel debris equivalent to one PWR fuel assembly. Up to four DFCs may be loaded, one into each outer corner, in the MAGNASTOR DF Basket Assembly.

The primary function of the DFC is to confine the fuel material within the can to minimize the potential for dispersal of the fuel material into the TSC cavity. In normal operation, the DFC is in a vertical orientation.

The DFC is fabricated from Type 304 stainless steel and has an 8.7-in square inside dimension. The DFC may be provided in two lengths: an overall length of 166.9 inches with a nominal cavity length of 164.0 inches (WE15×15 or WE17×17 fuel assemblies only), or an overall length of 171.8 inches with a nominal cavity length of 169.0 inches (primarily B&W 15×15 fuel assemblies, but WE15×15 or WE17×17 fuel assemblies may be accommodated with a fuel assembly spacer to limit axial movement). For the shorter DFC, a DFC spacer is used to provide an overall height of DFC and Spacer of 171.5 inches. The side plates that form the upper end of

the DFC are 0.15-in thick and the tube body walls are 0.048-in thick (18-gage sheet). The DFC lid plate and bottom thicknesses total 11/16 (0.688) inch and the lid overall height is 2.32 inches. The DFC bottom plate thickness is 5/8 (0.625) inch. The DFC lid and bottom include screened drain holes.

1.3.2 Operational Features

In storage, MAGNASTOR does not require any active operational systems. The principal MAGNASTOR operational activities are loading, welding, and preparing the TSC for storage and transferring the TSC to the concrete cask. The transfer cask (MTC and PMTC) is designed to meet the requirements of these operations. The transfer cask holds the TSC during fuel loading operations, provides biological shielding during TSC closure and preparation, and positions the TSC for transfer into the concrete cask. The lid design of the TSC assures structural integrity, while reducing the time and dose involved in TSC closure.

The detailed generic step-by-step operating procedures for the loading and transferring of MAGNASTOR are presented in Chapter 9. The following is a list of the major loading activities. This list assumes that the empty TSC is installed in the transfer cask.

- Fill the TSC with water or borated water if required.
- Lift the transfer cask over the pool and start the flow of water to the transfer cask annulus and lower the cask to the bottom of the pool.
- Load the selected spent fuel assemblies and damaged fuel cans (if applicable) into the TSC.
- Install the closure lid assembly.
- Remove the transfer cask from the pool and place it in the cask preparation workstation, or place cask on in-pool shelf or cask loading pit (CLP).
- Decontaminate the transfer cask.
- Lower the TSC water level and weld the closure lid to the TSC shell. Examine the weld.
- Hydrostatically test the TSC.
- Install and weld the closure ring. Examine the weld.
- Drain the remaining pool water from the TSC.
- Vacuum dry the TSC cavity. Verify cavity dryness.
- Establish a helium backfill.
- Install and weld the inner vent and drain port covers. Examine the welds.
- Helium leak test the inner vent and drain port covers.
- Install and weld the outer vent and drain port covers. Examine the welds.
- Engage the retaining blocks or install retaining ring.

- Install the TSC lifting system.
- Install the adapter plate on the concrete cask.
- Lift and place the transfer cask on the transfer adapter.
- Attach the TSC lifting system to the crane hook and raise the TSC off of the shield doors.
- Open the shield doors.
- Lower the TSC into the concrete cask (see Figure 1.3-1).
- Remove the transfer cask, transfer adapter, and TSC lifting systems.
- Install the lid on the concrete cask.
- Move the loaded concrete cask to the storage pad.
- Move the concrete cask to its designated location on the storage pad.

The TSC unloading and spent fuel removal from the TSC are essentially the reverse of these steps, except that weld removal and cooldown of the contents is required. This typical sequence of operations, and individual steps, may be modified by the approved site procedure to accommodate specific site requirements, as long as the requirements of the Technical Specifications and the Certificate of Compliance (CoC) are met.

Figure 1.3-1 Major Component Configuration for Loading the Concrete Cask

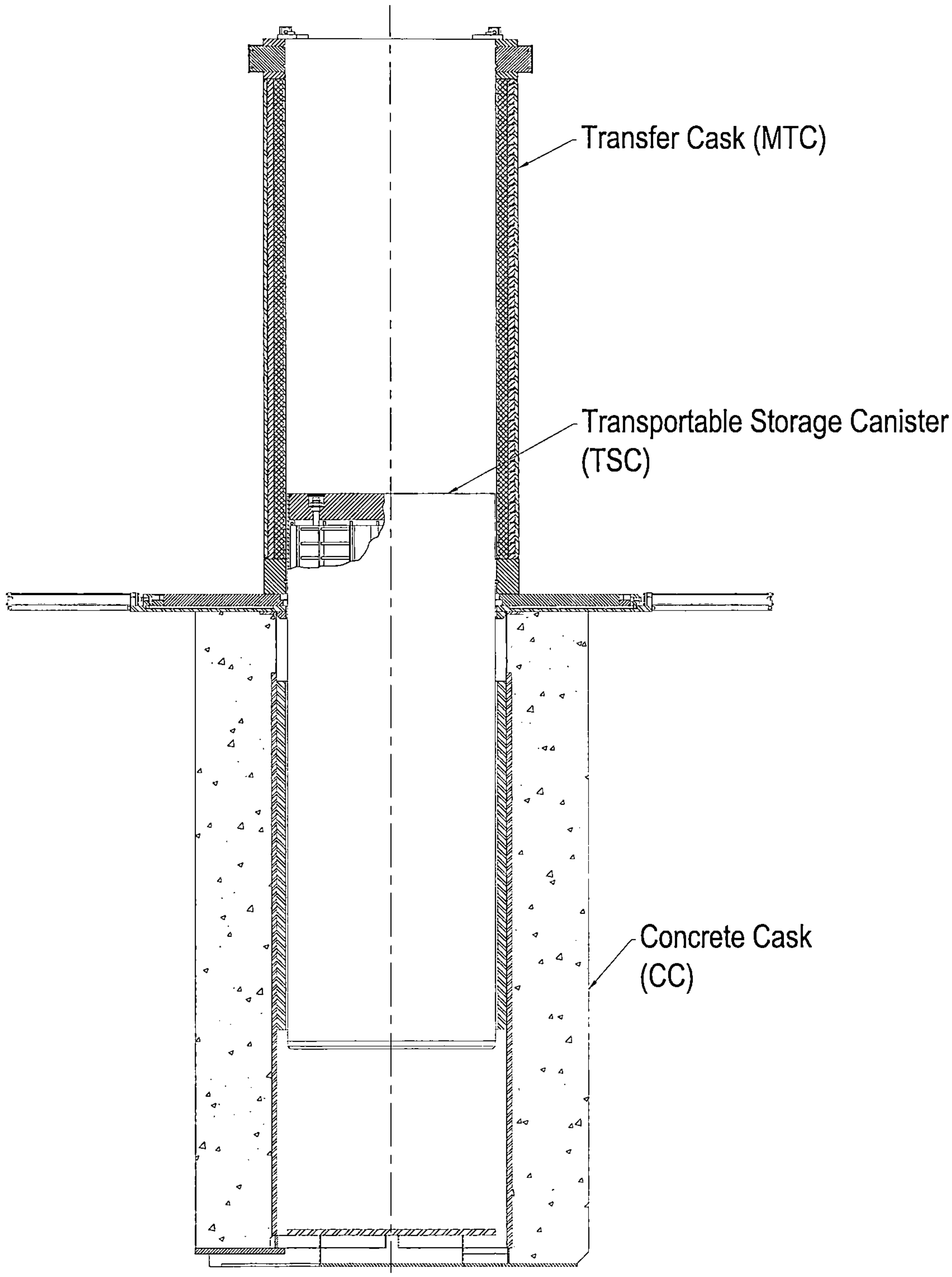
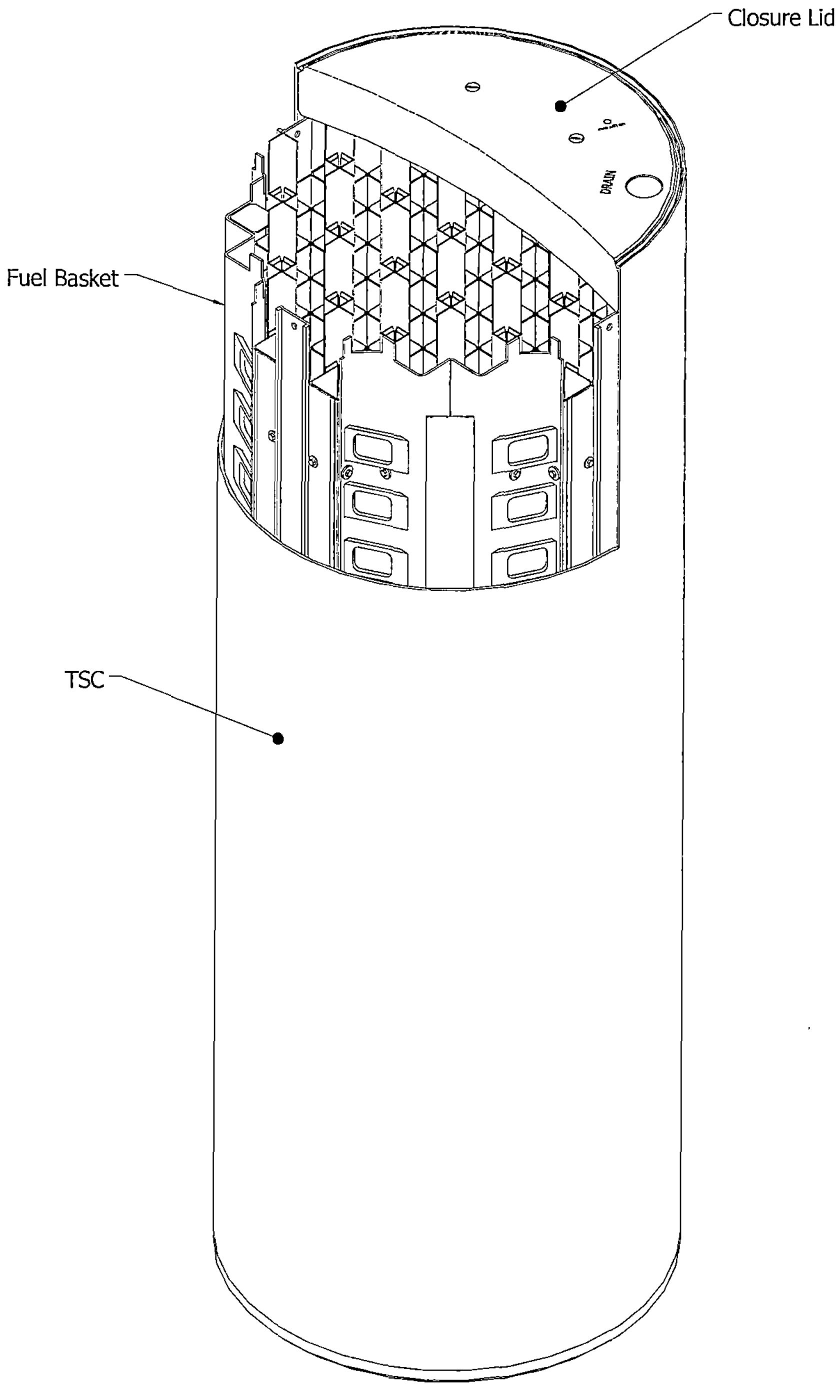
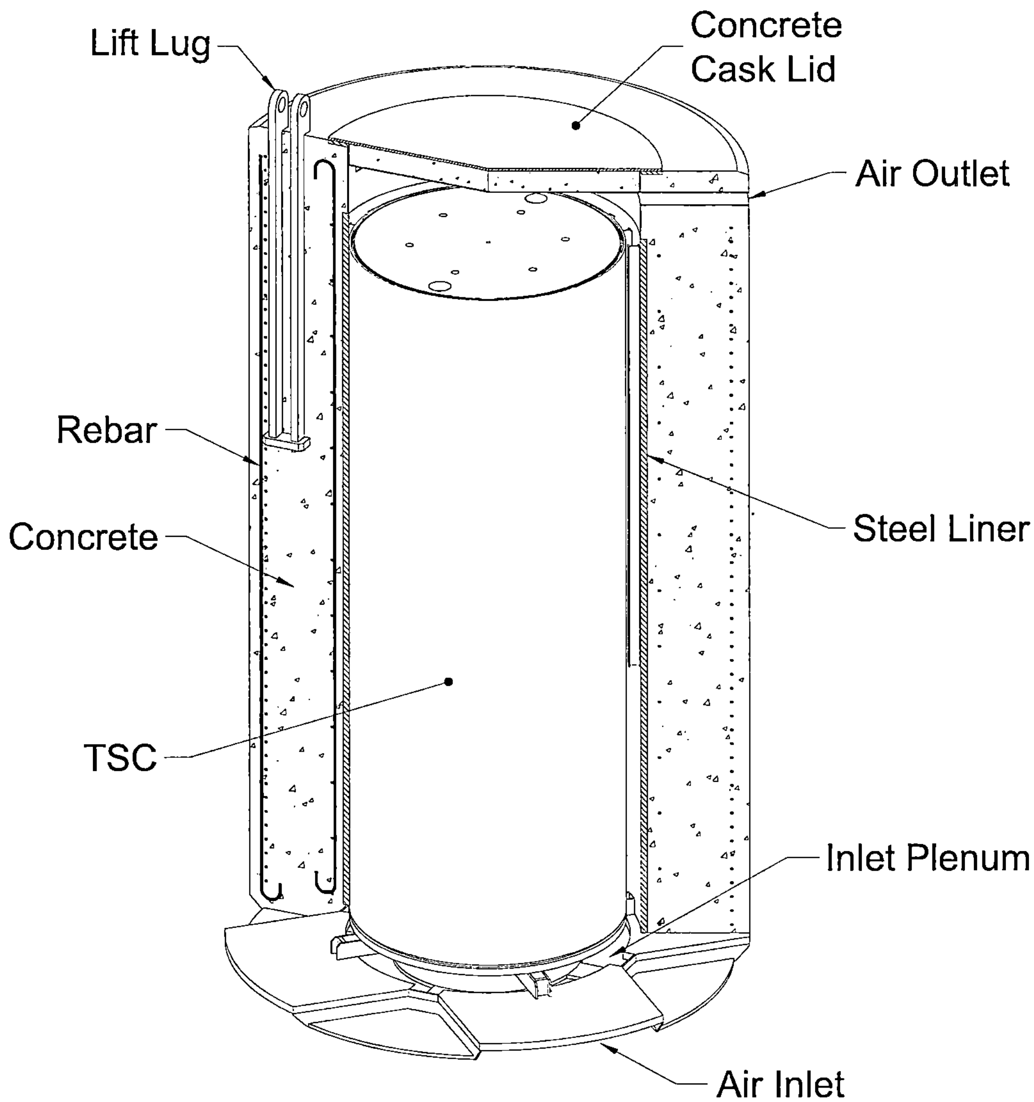


Figure 1.3-2 TSC and Basket



Note: Solid 9-in thick stainless steel closure lid shown.

Figure 1.3-3 Concrete Cask



Note: Inner rebar optional.

Figure 1.3-4 MAGNASTOR Damaged Fuel Can

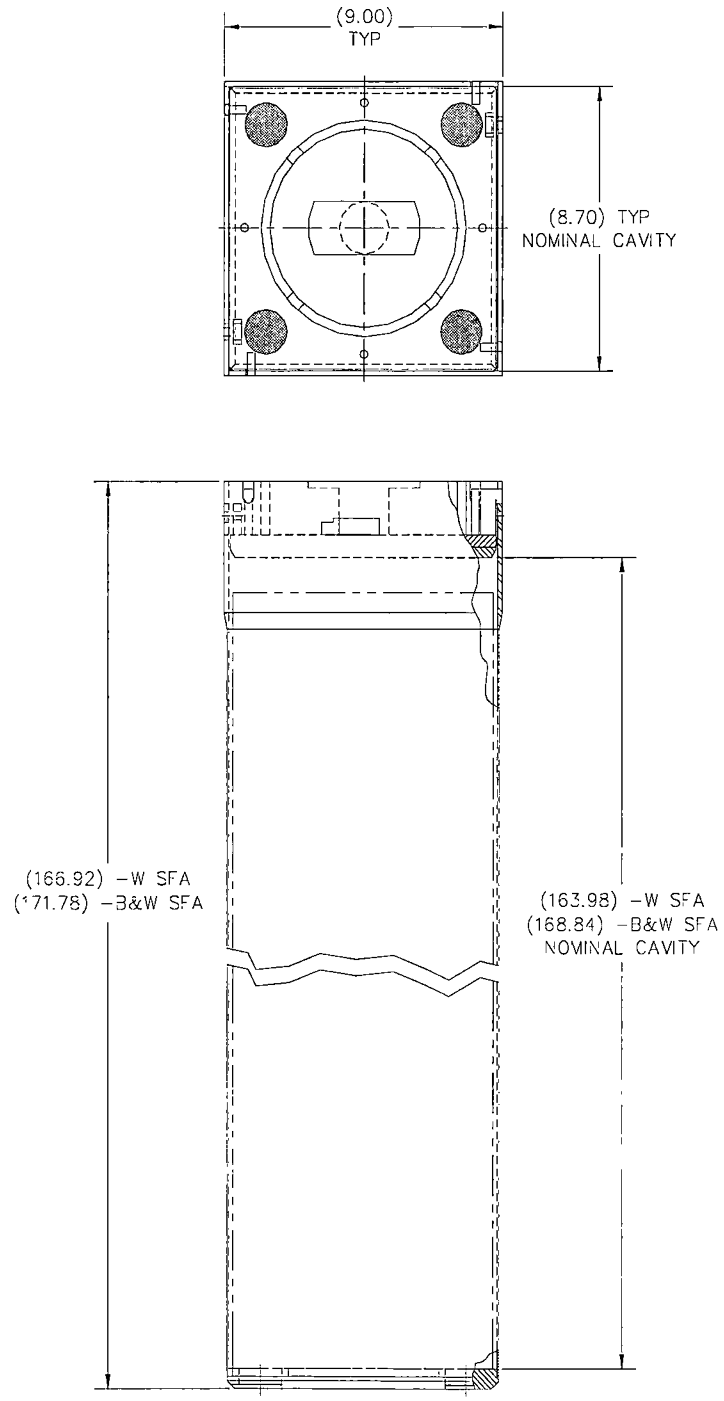


Table 1.3-1 Design Characteristics

	Design Characteristic	Nominal Value (in)[a]	Material
TSC	Shell	0.5 × 72 dia.	Stainless Steel
	Bottom	2.75	Stainless Steel
	Closure Lid Assembly		
	TSC1 & TSC2	9.0-in. thick	Stainless Steel
	TSC3 & TSC4	4.0-in thick/5.0-in thick	Stainless Steel/Carbon Steel
	Closure Ring		
	TSC1 & TSC2	0.75 square	Stainless Steel
	TSC3 & TSC4	0.75 square or 1.5 × 0.75	Stainless Steel
	Length		
	TSC1 & TSC3	191.8	
	TSC2 & TSC4	184.8	
	Capacity (# of fuel assemblies)	37 PWR/87 BWR	
Fuel Basket	PWR Fuel Tube Wall	0.31	Carbon Steel
	BWR Fuel Tube Wall	0.25	Carbon Steel
	Neutron Absorber	0.125 (PWR), 0.1 (BWR)	Metallic Composite/Matrix
	Neutron Absorber Retainer	0.015	Stainless Steel
	Support Plates & Gussets	0.5 to 0.75	Carbon Steel
	Support Bars (PWR)	0.875	Carbon Steel
	Support Plate (BWR)	0.75	Carbon Steel
	Length	172.5 or 179.5	
	Assembly dia.	70.76	
	# of Fuel Tubes/Fuel Loading Positions		
	PWR	21/37	
	BWR	45/87	
	DFC Corner Support Weldment		
	Inner-Formed Plate	1.125	Carbon Steel
	Outer-Formed Plate	0.75	Carbon Steel
	Ridge Gusset	0.75	Carbon Steel
	Damaged Fuel Can Wall		
	Tube Body	0.048	Stainless Steel
	Side Plate	0.15	Stainless Steel
Transfer Cask	MTC1		
	Outer Shell	1.25 × 88 dia.	Low Alloy Steel
	Inner Shell	0.75 × 74.5 dia.	Low Alloy Steel
	Retaining Block	8 × 8.75 × 1.50	Stainless Steel
	Trunnions	9 dia.	Low Alloy Steel
	Bottom Forging	12 × 88 dia.	Low Alloy Steel
	Top Forging	14 × 88 dia.	Low Alloy Steel
	Shield Doors	5.0	Low Alloy Steel
	Door Rails	5.25 × 7.5 × 52.0	Low Alloy Steel
	Gamma Shield	3.25	Lead
	Neutron Shield	2.25	NS-4-FR, Solid Synthetic Polymer
	Length	202.0	

[a] Thickness unless otherwise indicated.

Table 1.3-1 Design Characteristics (continued)

	Design Characteristic	Nominal Value (in) [a]	Material
Transfer Cask (continued)	MTC2		
	Outer Shell	1.25 × 88 dia.	Stainless Steel
	Inner Shell	0.75 × 74.5 dia.	Stainless Steel
	Retaining Ring	1 × 84 dia.	Stainless Steel
	Retaining Block	8 × 8.75 × 1.50	Stainless Steel
	Trunnions	9 dia.	Stainless Steel
	Bottom Forging	12 × 88 dia.	Stainless Steel
	Top Forging	14 × 88 dia.	Stainless Steel
	Shield Doors	5.0	Stainless Steel
	Door Rails	5.25 × 7.5 × 52.0	Stainless Steel
	Gamma Shield	3.25	Lead
	Neutron Shield	2.25	NS-4-FR, Solid Synthetic Polymer
	Length	192.2	
	PMTC		
	Outer Neutron Shield Shell	0.25 × 95 dia.	Stainless Steel
	Expansion Tank Shell	0.25 × 100 dia.	Stainless Steel
	Intermediate Shell	1.25 × 86.5 dia.	Stainless Steel
	Inner Shell	0.75 × 77.5 dia.	Stainless Steel
	Retaining Ring	3 × 88.25 OD x 68.5 ID	Stainless Steel
	Trunnions	10 dia.	Stainless Steel
	Bottom Forging	6 × 95 dia.	Stainless Steel
	Top Forging	16.5 × 95 dia.	Stainless Steel
	Shield Doors	6.0	Stainless Steel
	Door Rails	6.3 × 9 × 57.0	Stainless Steel
	Gamma Shield	3.25	Lead
	Neutron Shield	4.0	Demineralized Water
	Length	207.	
Transfer Adapter	Base Plate	2.0	Carbon Steel
	Guide Ring	2.5 × 79 dia.	Carbon Steel
Concrete Cask	CC1 & CC2		
	Weldment Structures		
	Liner	1.75 × 83 dia	Carbon Steel
	Top Flange	1 × 91.0 dia.	Carbon Steel
	Standoffs (Channels)	3 × 7.5 (s-beam)	Carbon Steel
	Pedestal Plate	2 × 72 dia.	Carbon Steel
	Base Plate	1 × 128 dia.	Carbon Steel
	Inlet Top	2 × 136 dia.	Carbon Steel
	Concrete Cask		Carbon Steel
	Concrete Shell	26.5 × 136 dia.	Type II Portland Cement
	Lid	6.8 × 88 dia.	Carbon Steel Type II Portland Cement
	Rebar	various lengths	Carbon Steel
	Length	225.3	

[a] Thickness unless otherwise indicated.

Table 1.3-1 Design Characteristics (continued)

	Design Characteristic	Nominal Value (in)[a]	Material
Concrete Cask (continued)	CC3		
	Weldment Structures		
	Liner	3 × 83 dia	Carbon Steel
	Top Flange	1 × 93.5 dia.	Carbon Steel
	Standoffs (Channels)	3 × 7.5 (s-beam)	Carbon Steel
	Pedestal Plate	2 × 72 dia.	Carbon Steel
	Base Plate	1 × 128 dia.	Carbon Steel
	Inlet Top	2 × 136 dia.	Carbon Steel
	Concrete Cask		Carbon Steel
	Concrete Shell	25.3 × 136 dia.	Type II Portland Cement
	Lid	12.8 × 91.5 dia.	Carbon Steel Type II Portland Cement
	Rebar	various lengths	Carbon Steel
	Length	218.3	
	CC4		
	Weldment Structures		
	Liner	1.75 × 83 dia	Carbon Steel
	Top Flange	1 × 93.5 dia.	Carbon Steel
	Standoffs (Channels)	3 × 7.5 (s-beam)	Carbon Steel
	Pedestal Plate	2 × 72 dia.	Carbon Steel
	Base Plate	1 × 128 dia.	Carbon Steel
	Inlet Top	2 × 136 dia.	Carbon Steel
	Concrete Cask		Carbon Steel
	Concrete Shell	26.5 × 136 dia.	Type II Portland Cement
	Lid	6.8 × 91.5 dia.	Carbon Steel Type II Portland Cement
	Rebar	various lengths	Carbon Steel
	Length	218.3	

[a] Thickness unless otherwise indicated.

Table 1.3-2 TSC Fabrication Specification Summary

Materials

- All materials shall be governed by the referenced drawings and meet the applicable ASME Code sections.

Welding

- Welds shall be in accordance with the referenced drawings.
- Filler metals shall be appropriate ASME Code materials.
- Welders and welding operators shall be qualified in accordance with ASME Code Section IX [12].
- Welding procedures shall be written and qualified in accordance with ASME Code Section IX.
- Personnel performing weld examinations shall be qualified in accordance with the NAC International Quality Assurance Program and SNT-TC-1A [13].
- Weld inspection and examination requirements and acceptance criteria are specified in Chapter 10.

Fabrication

- Cutting, welding, and forming shall be in accordance with ASME Code, Section III, NB-4000 [8] unless otherwise specified. Code stamping is not required.
- Surfaces shall be cleaned to a surface cleanness classification C, or better, as defined in ANSI N45.2.1 [14], Section 2.
- Fabrication tolerances shall meet the requirements of the referenced drawings after fabrication.

Packaging

- Packaging and shipping shall be in accordance with ANSI N45.2.2 [15].

Quality Assurance

- The TSC shall be fabricated under a quality assurance program that meets 10 CFR 72, Subpart G, and 10 CFR 71, Subpart H.

Table 1.3-3 Concrete Cask Construction Specification Summary

Materials

- Concrete mix shall be in accordance with the requirements of ACI 318 and ASTM C94 [16].
- Type II Portland Cement, ASTM C150 [17].
- Fine aggregate ASTM C33 [18] or C637 [19].
- Coarse aggregate ASTM C33.
- Aggregates that conform to the particle size requirements of a U.S. state's transportation agency, which is in general use in the area, should be considered as having a satisfactory service record with regard to those concrete properties affected by the respective grading requirement.
- Admixtures
  - Water Reducing and Superplasticizing ASTM C494 [20].
  - Pozzolanic Admixture (loss on ignition 6% or less) ASTM C618 [21].
- Compressive strength 4000 psi minimum at 28 days.
- Specified air entrainment per ACI 318.
- All steel components shall be of the material as specified in the referenced drawings.

Construction

- A minimum of two samples for each concrete cask shall be taken in accordance with ASTM C172 [22] and ASTM C31 [23] for the purpose of obtaining concrete slump, density, air entrainment, and 28-day compressive strength values. The two samples shall not be taken from the same batch or truck load.
- Test specimens shall be tested in accordance with ASTM C39 [24].
- Formwork shall be in accordance with ACI 318.
- All sidewall formwork shall remain in place in accordance with the requirements of ACI 318.
- Grade, type, and details of all reinforcing steel shall be in accordance with the referenced drawings.
- Embedded items shall conform to ACI 318 and the referenced drawings.
- The placement of concrete shall be in accordance with ACI 318.
- Surface finish shall be in accordance with ACI 318.
- Welding and inspection requirements and acceptance criteria are specified in Chapter 10.

Quality Assurance

- The concrete cask shall be constructed under a quality assurance program that meets 10 CFR 72, Subpart G.

Table 1.3-4 Concrete Cask Lid – Concrete Specification Summary

Concrete mix shall be in accordance with the following ACI 318 requirements:

- Standard weight concrete density shall be 140 pcf (minimum)
- No strength requirements – commercial grade concrete from a commercial grade supplier

1.5 Identification of Agents and Contractors

The prime contractor for the MAGNASTOR design is NAC. All design, analysis, licensing, and procurement activities are performed by NAC in accordance with its approved Quality Assurance Program, as described in Chapter 14. Fabrication of the steel components will be by qualified vendors. A qualified concrete contractor will perform construction of the concrete cask. All vendors and contractors will be selected and their performance monitored in accordance with the NAC Quality Assurance Program. All MAGNASTOR fabrication and assembly activities will be performed in accordance with quality assurance programs that meet the requirements of 10 CFR 72, Subpart G.

NAC as a contractor, or the licensee, may perform construction of the ISFSI and MAGNASTOR loading operations on site in accordance with the NAC or licensee quality assurance program, as appropriate. The licensee will perform decommissioning of the ISFSI in accordance with the licensee quality assurance program.

NAC was founded as a private corporation in 1968, with the primary focus of tracking, inspecting, handling, storing, and transporting spent nuclear fuel. NAC is a wholly owned subsidiary of USEC, Inc., since completion of its acquisition in November 2004. NAC is recognized in the industry as an expert in all aspects of the design, licensing, and operation of spent fuel handling, inspection, storage, and transport equipment, as well as in the management of spent fuel inventories.

Within the past 15 years, NAC has completed fabrication or has under construction the following transportation and/or storage systems.

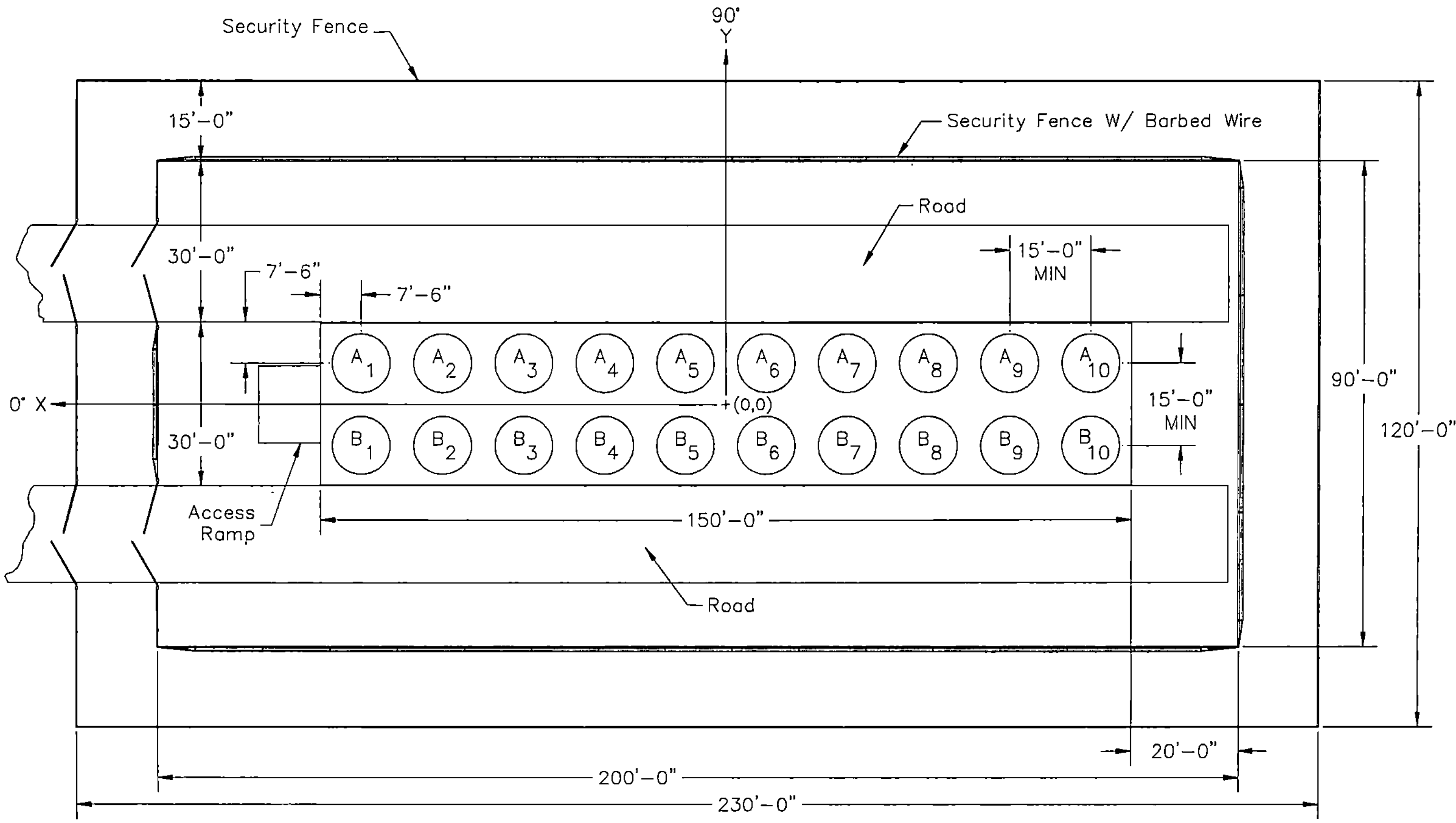
Part 71 (Transport Casks)	Part 72 (Storage System Casks and Components)
8 NAC-LWT	2 NAC-I28 S/T metal casks
16 TRUPACT-II	1 NAC-I26 S/T metal cask
	> 8 UMS®/MPC transfer casks
	4 MAGNASTOR transfer casks
6 RH-TRU 72B	> 324 UMS®/MPC TSCs
2 NAC-STC	> 324 UMS®/MPC concrete casks
	129 MAGNASTOR TSCs
	129 MAGNASTOR concrete casks

1.6 Generic Concrete Cask Arrays

A typical ISFSI storage pad layout for 20 MAGNASTOR systems is provided in Figure 1.6-1. As shown in this figure, roads parallel the sides of the pad to facilitate transfer of the concrete cask from the transporter to the designated storage position on the pad. Alternately, a ramp or low-profile concrete pad may be used to allow access for a self-powered or towed transport frame for concrete cask transfer and placement. Loaded concrete casks are placed in the vertical orientation on the pad in a linear array. Array sizes could accommodate from 1 to more than 200 casks. Figure 1.6-1 shows the minimum concrete cask spacing and representative site dimensions. Actual spacing and facility dimensions are dependent on the general site layout, access roads, site boundaries, and transfer equipment selection.

The reinforced concrete storage pad is capable of sustaining the transient loads from the cask transporter and the general loads of the stored casks. If necessary, the pad can be constructed in phases to specifically meet utility-required expansions.

Figure 1.6-1 Typical ISFSI Storage Pad Layout



1.8 License Drawings

This section presents the list of License Drawings for MAGNASTOR.

Drawing Number	Title	Revision No.
71160-551	Fuel Tube Assembly, MAGNASTOR – 37 PWR	10NP*
71160-556	Assembly, MAGNASTOR Transfer Cask (MTC), Stainless Steel	3
71160-560	Assembly, Standard Transfer Cask, MAGNASTOR	1
71160-561	Structure, Weldment, Concrete Cask, MAGNASTOR	8
71160-562	Reinforcing Bar and Concrete Placement, Concrete Cask, MAGNASTOR	8
71160-571	Details, Neutron Absorber, Retainer, MAGNASTOR – 37 PWR	8
71160-572	Details, Neutron Absorber, Retainer, MAGNASTOR – 87 BWR	8NP*
71160-574	Basket Support Weldments, MAGNASTOR – 37 PWR	6
71160-575	Basket Assembly, MAGNASTOR – 37 PWR	11NP*
71160-581	Shell Weldment, TSC, MAGNASTOR	4
71160-584	Details, TSC, MAGNASTOR	8
71160-585	TSC Assembly, MAGNASTOR	9
71160-590	Loaded Concrete Cask, MAGNASTOR	7
71160-591	Fuel Tube Assembly, MAGNASTOR – 87 BWR	8NP*
71160-598	Basket Support Weldments, MAGNASTOR – 87 BWR	7NP*
71160-599	Basket Assembly, MAGNASTOR – 87 BWR	8NP*
71160-600	Basket Assembly, MAGNASTOR – 82 BWR	5NP*
71160-601	Damaged Fuel Can (DFC), Assembly, MAGNASTOR	0
71160-602	Damaged Fuel Can (DFC), Details, MAGNASTOR	0
71160-656	Cask Body Weldment, Passive Transfer Cask, MAGNASTOR	0NP*
71160-657	Passive Transfer Cask, Assembly, MAGNASTOR	0NP*
71160-671	Details, Neutron Absorber, Retainer, For DF Corner Weldment, MAGNASTOR – 37 PWR	0
71160-673	Damaged Fuel Can (DFC), Spacer, MAGNASTOR	0
71160-674	DF Corner Weldment, MAGNASTOR	3NP*
71160-675	DF Basket Assembly, 37 Assembly PWR, MAGNASTOR	3NP*
71160-681	DF, Shell Weldment, TSC, MAGNASTOR	0
71160-684	Details, DF Closure Lid, MAGNASTOR	2
71160-685	DF, TSC Assembly, MAGNASTOR	3

* Proprietary drawing replaced by nonproprietary version.

L-228368

REV	CHANGE
ONP	INITIAL ISSUE

PROPRIETARY INFORMATION
REMOVED

13. STEEL STAMP/ENGRAVE TEXT "FILL-TO" APPROXIMATELY AS SHOWN AND FILL WITH BLACK WEATHER RESISTANT PAINT.
12. AS A FABRICATION OPTION, LEAD POUR MAY BE USED IN LIEU OF GAMMA SHIELD BRICKS (ITEM 8).
11. FIRST AND FINAL BRICK (ITEM 8) PER ROW MUST BE TRIMMED TO FIT WITH AN OVERLAP PATTERN IN THE CIRCUMFERENTIAL DIRECTION TO ENSURE NO GAPS BETWEEN BRICKS.
10. THREADED HOLES AT USER'S OPTION.
9. ITEMS 18 AND 19 MAY BE MADE UP FROM MULTIPLE SECTIONS.
8. SUBSTITUTION OF 304 ST. STL. ASTM A240 IS ACCEPTABLE.
7. SUBSTITUTION OF ASTM A336 IS ACCEPTABLE.
6. STEEL STAMP/ENGRAVE APPROXIMATELY AS SHOWN AND FILL WITH BLACK WEATHER RESISTANT PAINT.
5. CUT ONE ROW OF BRICKS IN HALF. PLACE A ROW OF FLAT BOTTOM BRICKS IN THE CAVITY FIRST AND A ROW OF BRICKS WITH FLAT TOPS LAST.
4. TYPICAL FOR LONGITUDINAL AND CIRCUMFERENTIAL WELDS, NUMBER AND LOCATION OPTIONAL. SEAM WELDS SHALL BE OFFSET.
3. BACKING BAR MATERIAL SHALL BE COMPATIBLE WITH THE BASE METAL.
2. VISUALLY INSPECT (VT) ALL WELDS. AFTER LOAD TESTING LIQUID PENETRANT INSPECT (PT) ALL ACCESSIBLE LOAD BEARING WELDS WITH ACCEPTANCE CRITERIA PER NF-5350.
1. ALL WELDING PROCEDURES AND QUALIFICATIONS TO BE IN ACCORDANCE WITH AWS D1.1 OR ASME SECTION IX.

NOTES:

	97 ASSY	98 ASSY	99 ASSY	ITEM	NAME	MATERIAL	SPEC	DRAWING No.	DESCRIPTION
			2	36	THREAD INSERT	ST.STL.	COML		
			18	35	THREAD INSERT	ST.STL.	COML		
			8	34	THREAD INSERT	ST.STL.	COML		
	1			33	BAFFLE BASE, SHORT	304 ST. STL.	ASTM A240/A276		PLATE/BAR
	1			32	BAFFLE RIB, SHORT	304 ST. STL.	ASTM A240		PLATE
			10	31	BAFFLE, SHORT			71160-656-97	
			2	30	FILL-TO PORT	304 ST. STL.	ASTM A276		BAR
			2	29	EXPANSION TANK DRAIN PORT	304 ST. STL.	ASTM A276		BAR
			4	28	EXPANSION TANK SIDE PLATE	304 ST. STL.	ASTM A240		PLATE
			2	27	EXPANSION TANK BOTTOM PLATE	304 ST. STL.	ASTM A240		PLATE
			2	26	EXPANSION TANK TOP PLATE	304 ST. STL.	ASTM A240		PLATE
			4	25	EXPANSION TANK SHELL SECTOR-B	304 ST. STL.	ASTM A240		PLATE
			2	24	EXPANSION TANK SHELL SECTOR-A	304 ST. STL.	ASTM A240		PLATE
			2	23	TANK MANIFOLD TUBE	304 ST. STL.	ASTM A269		TUBE
			2	22	TANK MANIFOLD	304 ST. STL.	ASTM A240/A276		PLATE/BAR
			1	21	MAIN TANK DRAIN PORT	304 ST. STL.	ASTM A240/A276		PLATE/BAR
			1	20	MANIFOLD BOSS	304 ST. STL.	ASTM A276		BAR
9			1	19	MANIFOLD PLATE	304 ST. STL.	ASTM A240		PLATE
9			1	18	MANIFOLD RING	304 ST. STL.	ASTM A240		PLATE
		1		17	BAFFLE RIB, LONG	304 ST. STL.	ASTM A240		PLATE
		1		16	BAFFLE BASE, LONG	304 ST. STL.	ASTM A240/A276		PLATE/BAR
			12	15	BAFFLE, LONG			71160-656-98	
			4	14	VENT-B SHIELD, SIDE-B	304 ST. STL.	ASTM A240		PLATE
			4	13	VENT-B SHIELD, SIDE-A	304 ST. STL.	ASTM A240		PLATE
			4	12	VENT-B SHIELD, FRONT	304 ST. STL.	ASTM A240		PLATE
			8	11	VENT-A SHIELD, SIDE	304 ST. STL.	ASTM A240		PLATE
			4	10	VENT-A SHIELD, FRONT	304 ST. STL.	ASTM A240		PLATE
			6	9	STANDOFF	304 ST. STL.	ASTM A276		T-BAR
12, 11, 5			A/R	8	GAMMA SHIELD BRICK	LEAD	ASTM B29		CHEMICAL COPPER GRADE
			2	7	TRUNNION	F304 ST. STL.	ASTM A182		FORGING
8			2	6	DOOR RAIL	F304 ST. STL.	ASTM A182		FORGING
			6	5	OUTER SHELL SECTOR	304 ST. STL.	ASTM A240		PLATE
			1	4	INTERMEDIATE SHELL	304 ST. STL.	ASTM A240		PLATE
			1	3	INNER SHELL	304 ST. STL.	ASTM A240		PLATE
7			1	2	TOP FORGING	F304 ST. STL.	ASTM A182		FORGING
7			1	1	BOTTOM FORGING	F304 ST. STL.	ASTM A182		FORGING

QUANTITY

NAC INTERNATIONAL

UNLESS OTHERWISE STATED
DIMENSIONING AND TOLERANCING SHALL BE PER ASME Y14.5M-94.
ALL THREAD DEPTH CALLOUTS ARE TO BE CONSIDERED AS A MIN. DEPTH OF PERFECT TREADS
ALL DIMENSIONS ARE IN INCHES
MACHINED SURFACES SHALL BE ∇ OR BETTER

GROUP	NAME	DATE
PREPARER	[signature]	2-26-15
CHECKER	[signature]	2-26-15
PROJECT MANAGER	[signature]	3-13-15
ENGINEERING	[signature]	3-9-15
LICENSING	[signature]	4/14/15
QUALITY	[signature]	5/8/15

NEXT ASSEMBLY 71160-657
DRAWING TYPE LICENSE

CASK BODY WELDMENT, PASSIVE TRANSFER CASK, MAGNASTOR

PROJECT 71160 | DRAWING 656 | REV 0NP
SCALE N.T.S. | WEIGHT N/A | SH 1 OF 1 | 11/17/2014

R-228369

REV	CHANGE
ONP	INITIAL ISSUE

PROPRIETARY INFORMATION
REMOVED

Flag	95 ASSY	97 ASSY	98 ASSY	99 ASSY	ITEM	NAME	MATERIAL	SPEC	DRAWING NO.	DESCRIPTION
				A/R	33	SHIELD FLUID	SEE NOTE 6	COML		
				7	32	PLUG	ST. STL.	COML		SAE PLUG
				4	31	PLUG	ST. STL.	COML		SAE PLUG
				3	30	SHIELD/SEAL INSERT BOLT	ST.STL.	COML		HHCS 1 1/2-6 UNC
				18	29	RETAINING RING BOLT	ST. STL.	ASTM A193 Gr.B6		HHCS 1 1/2-6 UNC
				8	28	TRUNNION BOLT	ST. STL.	COML		HHCS 1/2-13 UNC
				1	27	NIPPLE	ST. STL.	COML		QUICK DISCONNECT NIPPLE
				4	26	DOOR LOCK TAB, CASK	304 ST. STL.	ASTM A240/A276		PLATE/BAR
				1	25	NAME PLATE	ST. STL.	COML		11 - 16 GAUGE SHEET
4				A/R	24	THREADED PLUG	ST. STL.	ASTM A276		BAR
				4	23	LOCK PIN	ST. STL.	COML		
				2	22	TRUNNION BUSHING	17-4 PH ST. STL.	ASTM A564, TYPE 630		ROUND BAR
				2	21	TRUNNION CAP	304 ST. STL.	ASTM A240/A276		PLATE/BAR
				1	20	SHIELD/SEAL INSERT RETAINER	304 ST. STL.	ASTM A240		PLATE
				1	19	RETAINING RING	304 ST. STL.	ASTM A240		PLATE
	1				18	INFLATABLE SEAL, OUTER	EPDM	COML		
	1				17	INFLATABLE SEAL, INNER	EPDM	COML		
	1				16	NIPPLE	ST. STL.	COML		QUICK DISCONNECT NIPPLE
	1				15	SHIELD/SEAL INSERT RING	304/F304 ST. STL.	ASTM A240/A182		PLATE/FORGING
	1				14	SHIELD/SEAL INSERT FLANGE	304 ST. STL.	ASTM A240		PLATE
				1	13	SHIELD/SEAL INSERT ASSEMBLY			71160-657-96	
5		1			12	DOOR PLATE-B	F304 ST. STL.	ASTM A182		FORGING
				1	11	DOOR-B			71160-657-97	
		3	3		10	THREADED INSERT	ST. STL.	COML		
		2	2		9	VENT SHIELD-C	304 ST. STL.	ASTM A240		PLATE
		2	2		8	VENT SHIELD-B	304 ST. STL.	ASTM A240		PLATE
		2	2		7	VENT SHIELD-A	304 ST. STL.	ASTM A240		PLATE
		2	2		6	DOOR LOCK TAB, DOOR	304 ST. STL.	ASTM A240/A276		PLATE/BAR
		2	2		5	STANDOFF	304 ST. STL.	ASTM A240/A276		PLATE/BAR
		1	1		4	CONNECTOR	304 ST. STL.	ASTM A240		PLATE
5			1		3	DOOR PLATE-A	F304 ST. STL.	ASTM A182		FORGING
				1	2	DOOR-A			71160-657-98	
				1	1	CASK BODY WELDMENT			71160-656-99	

QUANTITY

7. SHIELD TANK TO BE FILLED WITH SHIELD FLUID (ITEM 33) UNTIL FLUID FLOWS FROM THE FILL-TO PORT LOCATION. INSTALL PORT PLUGS (ITEMS 31 AND 32) TO COMPLETE FILL.
6. SHIELD FLUID (ITEM 33) TO BE DEMINERALIZED WATER.
5. SUBSTITUTION OF 304 ST. STL. ASTM A240 IS ACCEPTABLE.
4. ITEM 24 (THREADED PLUG) AT USER'S OPTION.
3. STENCIL/ENGRAVE APPROXIMATELY AS SHOWN. WHERE "XXXXX-XXX" IS NAC SERIAL NUMBER, "NN" REPRESENTS A UNIQUE NUMBER FOR EACH CASK MANUFACTURED AND "YYY,YYY" IS ACTUAL WEIGHT OF THE CASK. FILL WITH BLACK WEATHER RESISTANT PAINT.
2. VISUALLY INSPECT (VT) ALL WELDS. AFTER LOAD TESTING LIQUID PENETRANT INSPECT (PT) ALL ACCESSIBLE LOAD BEARING WELDS WITH ACCEPTANCE CRITERIA PER NF-5350.
1. ALL WELDING PROCEDURES AND QUALIFICATIONS TO BE IN ACCORDANCE WITH AWS D1.1 OR ASME SECTION IX.

NOTES:

NAC INTERNATIONAL

UNLESS OTHERWISE STATED

DIMENSIONING AND TOLERANCING SHALL BE PER ASME Y14.5M 94.

ALL THREAD DEPTH CALLOUTS ARE TO BE CONSIDERED AS A MIN DEPTH OF PERFECT THREADS

ALL DIMENSIONS ARE IN INCHES

MACHINED SURFACES SHALL BE ∇ OR BETTER

NEXT ASSEMBLY: N/A

DRAWING TYPE: LICENSE

GROUP	NAME	DATE
PREPARER	[illegible]	3-13-15
CHECKER	[illegible]	3-16-15
PROJECT MANAGER	[illegible]	4-13-15
ENGINEERING	[illegible]	4-14-15
LICENSING	[illegible]	4/14/15
QUALITY	[illegible]	5/11/15

PASSIVE TRANSFER CASK ASSEMBLY, MAGNASTOR

PROJECT 71160 | DRAWING 657 | REV 0NP

SCALE N. T. S. | WEIGHT N/A | SH 1 OF 1 | 11/17/2014

2.2 Spent Fuel To Be Stored

MAGNASTOR is designed to safely store up to 37 undamaged PWR fuel assemblies in the 37 PWR basket assembly or up to 87 undamaged BWR fuel assemblies in the 87 BWR basket assembly. 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. Each DFC may contain an undamaged PWR fuel assembly, a damaged PWR fuel assembly, or PWR fuel debris equivalent to one PWR fuel assembly. Undamaged PWR fuel assemblies may be placed directly in the DFC locations of a DF Basket Assembly.

The fuel assemblies are assigned to two groups of PWR and two groups of BWR fuel assemblies on the basis of fuel assembly length. Refer to Chapter 1 for the fuel assembly length groupings.

PWR and BWR fuel assemblies having parameters as shown in Table 2.2-1 and Table 2.2-2, respectively, may be stored in MAGNASTOR. PWR fuel assemblies may be stored with nonfuel hardware. Undamaged or damaged fuel assemblies or PWR fuel debris may be stored in a damaged fuel can. PWR fuel assemblies loaded into a DFC shall not contain nonfuel hardware, with the exception of instrument tube tie components and steel inserts.

The minimum initial enrichment limits are shown in Table 2.2-1 and Table 2.2-2 for PWR and BWR fuel, respectively, and exclude the loading of fuel assemblies enriched to less than 1.3 wt% ^{235}U, including unenriched fuel assemblies. Fuel assemblies with low enriched, unenriched, and/or annular axial end-blankets may be loaded into MAGNASTOR.

2.2.1 PWR Fuel Evaluation

MAGNASTOR evaluations are based on bounding PWR fuel assembly parameters that maximize the source terms for the shielding evaluations, the reactivity for criticality evaluations, the decay heat load for the thermal evaluations, and the fuel weight for the structural evaluations. These bounding parameters are selected from the various spent fuel assemblies that are candidates for storage in MAGNASTOR. The bounding fuel assembly values are established based primarily on how the principal parameters are combined, and on the loading conditions (or restrictions) established for a group of fuel assemblies based on its parameters.

The limiting parameters of the PWR fuel assemblies authorized for loading in MAGNASTOR are shown in Table 2.2-1. The maximum initial enrichments listed are based on a minimum effective neutron absorber sheet areal density of 0.036 ^{10}B g/cm^2 and soluble boron concentration of 2,500 ppm in the spent fuel pool water. Lower absorber sheet areal densities and/or soluble boron concentrations are allowed in the spent fuel pool water for fuel assemblies with lower

maximum enrichments. The maximum initial enrichment authorized represents the peak fuel rod enrichment for variably enriched PWR fuel assemblies. The PWR fuel assembly characteristics are summarized by fuel assembly type in Table 6.4.3-1, with maximum initial enrichment/ minimum soluble boron content as a function of absorber sheet loading listed in Table 6.4.3-2. Table 2.2-1 assembly physical information is limited to the criticality analysis input of fuel mass, array configuration, and number of fuel rods. These analysis values are key inputs to the shielding and criticality evaluations in Chapters 5 and 6. Lattice parameters dictating system reactivity are detailed in Chapter 6. Enrichment limits are set for each fuel type to produce reactivities at the upper subcritical limit (USL).

The maximum TSC decay heat load for the storage of PWR fuel assemblies is 35.5 kW. Uniform and preferential loading patterns are allowed in the PWR basket and in the DF Basket Assembly. The uniform loading pattern permits assemblies with a maximum heat load of 0.96 kW/assembly. The preferential loading pattern permits peak heat loads of 1.20 kW, as indicated in the zone description in Figure 2.2-1. The fuel basket configuration for PWR fuel with damaged fuel cans is shown in Figure 2.2-3. The bounding thermal evaluations are based on the Westinghouse 17×17 fuel assembly. The minimum cool times are determined based on the maximum decay heat load of the contents. The fuel assemblies and source terms that produce the maximum storage and transfer cask dose rates are summarized in Table 5.1.3-3 and Table 5.1.3-6 for MTC1 and MTC2, respectively.

The maximum TSC decay heat load for the PMTC is 30 kW. The PMTC may only be loaded with Combustion Engineering 16×16 base type (PWR) fuel assemblies. The source terms that produce the maximum dose rates for the PMTC are summarized in Table 5.9.3-3.

A bounding weight of 1,680 pounds, as shown in Table 2.2-1, based on a B&W 15×15 fuel assembly with control components inserted, has been structurally evaluated in each location of the PWR fuel basket. A bounding weight of 1,814 pounds is evaluated for each loaded damaged fuel can in the damaged fuel configuration of the PWR DF fuel basket.

As noted in Table 2.2-1, the evaluation of PWR fuel assemblies includes nonfuel hardware. Empty fuel rod positions are filled with a solid filler rod or a solid neutron absorber rod that displaces a volume not less than that of the original fuel rod. PWR fuel assemblies loaded in a DFC shall not contain nonfuel hardware, with the exception of instrument tube tie components and steel inserts.

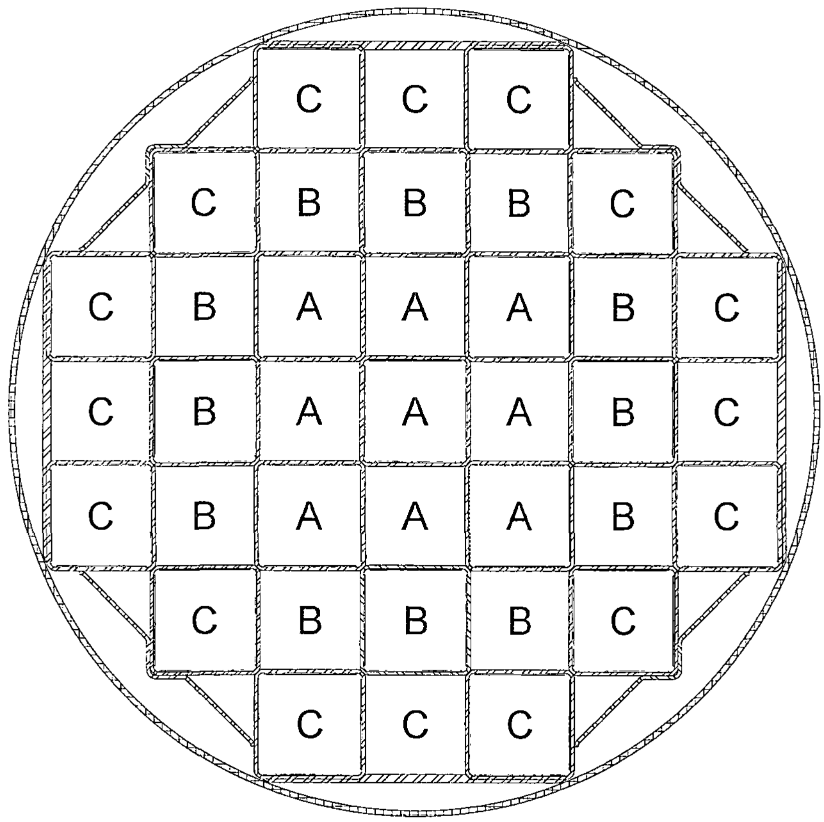
2.2.2 BWR Fuel Evaluation

MAGNASTOR evaluations are based on bounding BWR fuel assembly parameters that maximize the source terms for the shielding evaluations, the reactivity for the criticality evaluations, the decay heat load for the thermal evaluations, and the fuel weight for the structural evaluations. These bounding parameters are selected from the various spent fuel assemblies that are candidates for storage in MAGNASTOR. The bounding fuel assembly values are established based primarily on how the principal parameters are combined, and on the loading conditions or restrictions established for a group of fuel assemblies based on its parameters. Each TSC may contain up to 87 undamaged BWR fuel assemblies. To increase allowed assembly enrichments over those determined for the 87-assembly basket configuration, an optional 82-assembly loading pattern may be used. The required fuel assembly locations in the 82-assembly pattern are shown in Figure 2.2-2.

The limiting parameters of the BWR fuel assemblies authorized for loading in MAGNASTOR are shown in Table 2.2-2. The maximum initial enrichment represents the peak planar-average enrichment. The BWR fuel assembly characteristics are summarized by fuel type in Table 6.4.3-3, with maximum initial enrichment as a function of absorber sheet loading listed in Table 6.4.3-4. Table 2.2-2 assembly physical information is limited to the critical analysis input of fuel mass, array configuration, and number of fuel rods. These analysis values are key inputs to the shielding and criticality evaluations in Chapters 5 and 6. Lattice parameters dictating system reactivity are detailed in Chapter 6. Enrichment limits are set for each fuel type to produce reactivities at the USL. The maximum decay heat load per TSC for the storage of BWR fuel assemblies is 33.0 kW (average of 0.379 kW/assembly). Only uniform loading is permitted for BWR fuel assemblies. The bounding thermal evaluations are based on the GE 10×10 fuel assembly. The minimum cooling times are determined based on the maximum decay heat load of the contents. The fuel assemblies and source terms that produce the maximum storage and transfer cask dose rates are summarized in Table 5.1.3-3 and Table 5.1.3-6 for MTC1 and MTC2, respectively. A bounding weight of 704 pounds, as shown in Table 2.2-2, is based on the maximum weight of GE 7×7 and 8×8 assemblies with channels; this weight has been structurally evaluated in each storage location of the BWR basket.

As noted in Table 2.2-2, the evaluation of BWR fuel envelops unchanneled assemblies and assemblies with channels up to 120 mils thick. Empty fuel rod positions are filled with a solid filler rod or a solid neutron absorber rod that displaces a volume not less than that of the original fuel rod.

Figure 2.2-1 PWR Fuel Preferential Loading Zones



Zone Description	Designator	Heat Load (W/assy)	# Assemblies
Inner Ring	A	922	9
Middle Ring	B	1,200	12
Outer Ring	C	800	16

Table 2.2-1 PWR Fuel Assembly Characteristics

Characteristic	Fuel Class					
	14×14	14×14	15×15	15×15	16×16	17×17
Base Fuel Type[a]	CE, SPC	W, SPC	W, SPC	BW, FCF	CE	BW, SPC, W, FCF
Max Initial Enrichment (wt% ^{235}U)	5.0	5.0	5.0	5.0	5.0	5.0
Min Initial Enrichment (wt% ^{235}U)	1.3	1.3	1.3	1.3	1.3	1.3
Number of Fuel Rods	176	179	204	208	236	264
Max Assembly Average Burnup (MWd/MTU)	60,000	60,000	60,000	60,000	60,000	60,000
Min Cool Time (years)	4	4	4	4	4	4
Max Weight (lb) per Storage Location	1,680	1,680	1,680	1,680	1,680	1,680
Max Decay Heat (Watts) per Preferential Storage Location	1,200	1,200	1,200	1,200	1,200	1,200

- Fuel cladding is a zirconium-based alloy.
- All reported enrichment values are nominal preirradiation fabrication values.
- Weight includes the weight of nonfuel-bearing components.
- Assemblies may contain nonfuel hardware and/or fuel replacement rods (also referred to as filler rods). Filler rods are considered to be a component of spent nuclear fuel assemblies and not nonfuel hardware. Filler rods may be burnable absorber rods, stainless steel rods or zirconium alloy rods.
- Required soluble boron content is fuel type and enrichment specific. Minimum soluble boron content varies between 1,500 and 2,500 ppm. Maximum initial enrichment represents the peak fuel rod enrichment for variably-enriched fuel assemblies.
- Spacers may be used to axially position fuel assemblies to facilitate handling.
- Maximum uniform heat load is 959 watts per storage location.
- Maximum heat load for the PMTC is 811 watts per storage location (CE 16×16 fuel only).

[a] Indicates assembly and/or nuclear steam supply system (NSSS) vendor/type referenced for fuel input data. Fuel acceptability for loading is not restricted to the indicated vendor provided that the fuel assembly meets the limits listed in Table 6.4.3-1. Table 6.2.1-1 contains vendor information by fuel rod array. Abbreviations are as follows: Westinghouse (W), Combustion Engineering (CE), Siemens Power Corporation (SPC), Babcock and Wilcox (BW), and Framatome Cogema Fuels (FCF).

Table 2.2-2 BWR Fuel Assembly Characteristics

Characteristic	Fuel Class			
	7×7	8×8	9×9	10×10
Base Fuel Type[a]	SPC, GE	SPC, GE	SPC, GE	SPC, GE, ABB
Max Initial Enrichment (wt% ^{235}U)	4.5	4.5	4.5	4.5
Number of Fuel Rods	48 49	59 60 61 62 63 64[b]	72 74[c] 76 79 80	91[c] 92[c] 96[c,d] 100[d]
Max Assembly Average Burnup (MWd/MTU)	60,000	60,000	60,000	60,000
Min Cool Time (years)	4	4	4	4
Min Average Enrichment (wt% ^{235}U)	1.3	1.3	1.3	1.3
Max Weight (lb) per Storage Location	704	704	704	704
Max Decay Heat (Watts) per Storage Location	379	379	379	379

- Each BWR fuel assembly may have a zirconium-based alloy channel up to 120 mil thick.
- Assembly weight includes the weight of the channel.
- Maximum initial enrichment is the peak planar-average enrichment.
- Water rods may occupy more than one fuel lattice location. Fuel assembly to contain nominal number of water rods for the specific assembly design.
- All enrichment values are nominal preirradiation fabrication values.
- Spacers may be used to axially position fuel assemblies to facilitate handling.

[a] Indicates assembly vendor/type referenced for fuel input data. Fuel acceptability for loading is not restricted to the indicated vendor/type provided that the fuel assembly meets the limits listed in Table 6.4.3-2. Table 6.2.1-2 contains vendor information by fuel rod array. Abbreviations are as follows: General Electric/Global Nuclear Fuels (GE), Exxon/Advanced Nuclear Fuels/Siemens Power Corporation (SPC), and ASEA Brown Boveri (ABB).

[b] May be composed of four subchannel clusters.

[c] Assemblies may contain partial-length fuel rods.

[d] Composed of four subchannel clusters.

Table 2.4-1 Safety Classification of MAGNASTOR Components

Component Description	Reference Drawings	Safety Function	Safety Classification
TSC Assembly Shell and Base Plate Closure Lid Closure Ring Port Covers	71160-581 71160-584 71160-585	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
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

3. Structural Evaluation

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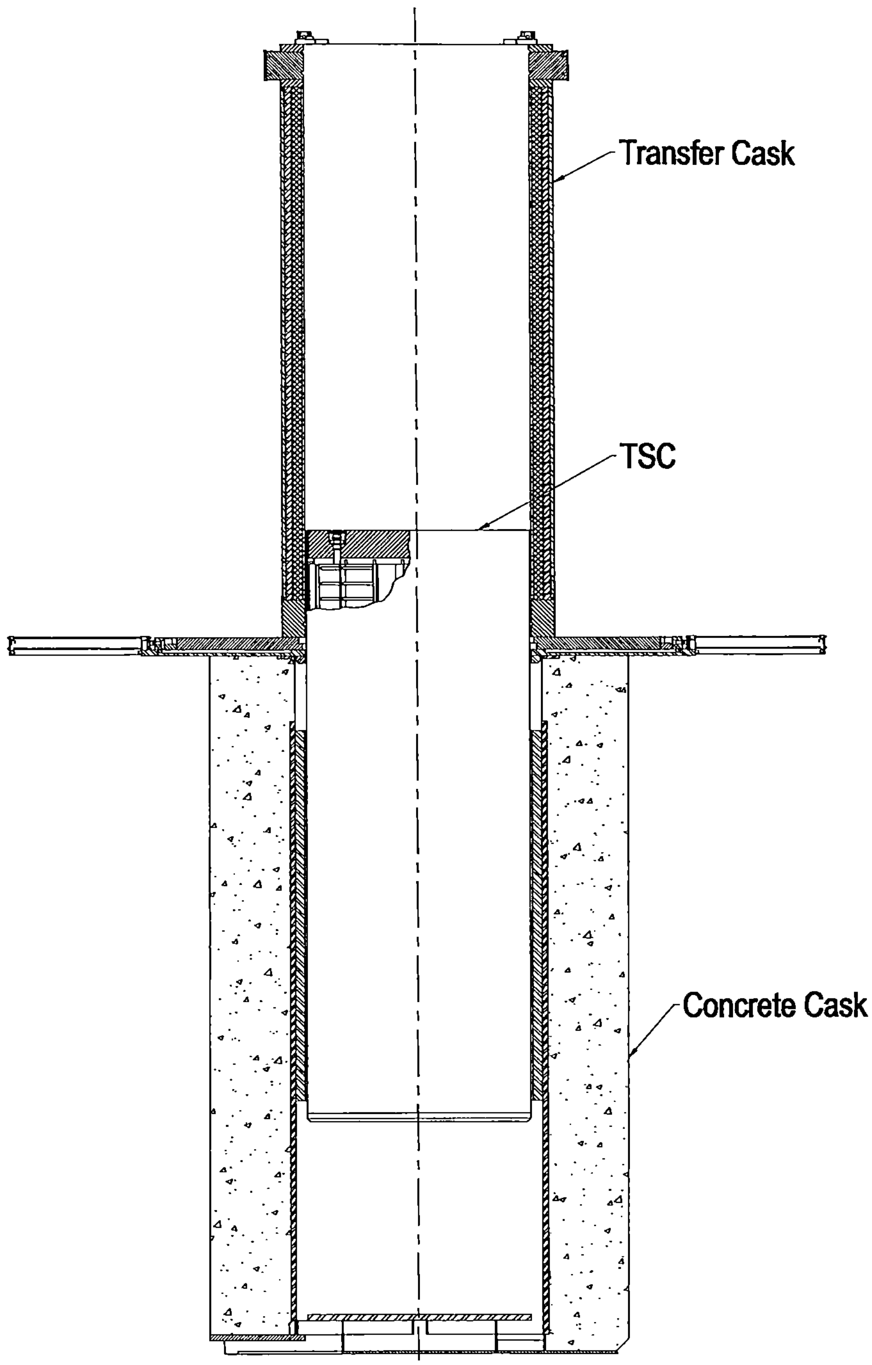
3.1 MAGNASTOR Structural Design

3.1.1 Major Components

The three principal components of MAGNASTOR are the concrete cask, the TSC, and the transfer cask (refer to Figure 3.1.1-1). The following table shows the principal structural components of the three major MAGNASTOR components.

Concrete Cask	TSC	Transfer Cask
Reinforced concrete shell	Closure lid assembly and closure ring	Trunnions
Liner weldment	Shell	Inner and outer steel shells
Bottom weldment	Bottom plate	Shield doors
Lid assembly	Fuel basket assembly (PWR or BWR)	Door support rails
		Lead and NS-4-FR/water shielding

Figure 3.1.1-1 Principal Components of MAGNASTOR



The nominal inner dimension of the PWR fuel tubes is 8.86-inches square. The nominal inner dimension of the BWR fuel tubes is 5.86-inches square.

Transfer Cask

The transfer cask, with its lifting yoke, is primarily a shielded lifting device used to handle the TSC. It provides biological shielding for a loaded TSC. The transfer cask is used for the vertical transfer of the TSC between workstations and the concrete cask, or transport cask. The transfer cask is available in two configurations. 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 a shortened stainless steel version (MTC2). The second configuration is the Passive MTC (PMTC) with demineralized water filled shield tank. The PMTC has a larger cavity diameter (inner diameter of the cask inner shell) than the MTC, resulting in a larger gap between the loaded TSC and the cask inner shell, which allows passive air cooling for the system during the transfer operations. The transfer cask is a heavy lifting device that is designed, fabricated, and load-tested to the requirements of ANSI–N14.6 [2] and NUREG–0612 [3]. All of the transfer cask configurations include TSC retainers that are designed to prevent a loaded TSC from being inadvertently lifted through the top of the transfer cask. The MTC1 TSC retainer consists of three retractable retainer assemblies attached to the top of the transfer cask. The TSC retainer for the MTC2 and PMTC consists of an annular plate that is bolted to the transfer cask top ring. The MTC2 TSC retainer also consists an optional configuration of three retainer assemblies, which is similar to those for the MTC1 cask. The transfer cask has retractable bottom shield doors. During loading operations, the doors are closed and secured by bolts/pins so they cannot inadvertently open. During unloading, the doors are retracted using hydraulic cylinders to allow the TSC to be lowered into the concrete cask or transport cask.

Component Evaluation

The following components are evaluated in this chapter.

- TSC lifting devices
- TSC shell, bottom plate, and closure lid assembly
- Fuel basket assembly
- Transfer cask trunnions, shells, retainer, shield doors, and support rails
- Concrete cask body
- Concrete cask steel components (reinforcement, inner shell, lid assembly, bottom weldment, etc.)

Other MAGNASTOR components shown on the license drawings in Chapter 1 are included as loads in these component evaluations.

The structural evaluations in this chapter demonstrate that MAGNASTOR components meet their respective structural design criteria and are capable of safely storing the design basis PWR or BWR spent fuel assemblies.

3.1.3 Design Criteria Summary

MAGNASTOR structural design criteria are described in Chapter 2. Load combinations for normal, off-normal, and accident loads are evaluated in accordance with ANSI/ANS-57.9 [4] and ACI 349 [5]. The TSC components and welds that form the confinement boundary are evaluated in accordance with ASME Code, Section III, Subsection NB for Class 1 components [6]. The shield plate and its attachment bolts for the TSC3 and TSC4 composite lids are analyzed in accordance with ASME Code, Section III, Subsection NF [31]. The basket is evaluated in accordance with ASME Code, Section III Subsection NG [7] and ASME Code, Section III, Appendix F [8]. The buckling evaluation of the fuel basket is performed in accordance with NUREG/CR-6322 [9]. The transfer cask and lifting yoke are lifting devices that are designed to NUREG-0612 [3] and ANSI N14.6 [2].

3.2 Weights and Centers of Gravity

3.2.1 Calculated Maximum Weights and Centers of Gravity

The maximum calculated weights and centers of gravity (CGs) for MAGNASTOR PWR, PWR with Damaged Fuel Cans, and BWR configurations are presented in Table 3.2.1-1. The weights and CGs presented in this section are calculated based on nominal design dimensions.

The stainless steel TSC assembly holds the fuel basket structure and confines the contents. TSCs are provided in four configurations designated TSC1 through TSC4. The TSC configurations are distinguished by their length and closure lid assembly design, as detailed on the drawings. TSC1 and TSC3 are 191.8 inches long; TSC2 and TSC4 are 184.4 inches long. TSC1 and TSC2 include a 9-in thick solid stainless steel closure lid assembly. TSC3 and TSC4 include a composite closure lid assembly consisting of a 4-in thick stainless steel closure lid and a 5-in thick carbon steel shield plate. The solid stainless steel standard closure lid assembly is heavier than the composite closure lid assembly. Therefore, the bounding weight of the standard closure lid assembly is used for all weight and CG calculations.

The concrete cask is a reinforced concrete structure with a structural steel inner liner and base. The concrete cask may be supplied in four different configurations designated CC1 through CC4. CC1 is the standard 225.27-in high cylinder. CC2 is also 225.27-in high, but is a segmented design. CC1, CC2 and CC4 are equipped with a 1.75-in thick carbon steel liner. CC3 is a 218.3-in high standard design cylinder equipped with a 3-in thick carbon steel liner and additional shielding at the air inlets. CC4 is a 218.3-in high standard design cylinder with inlet shield bars. The shorter length of CC3 and CC4 limit their use to the shorter canisters, i.e., TSC2 and TSC4, while the longer CC1 and CC2 can be used with all canister designs. The top of the concrete cask is closed by a lid assembly. The lid assembly is composed of a carbon steel top plate and a cylindrical concrete plug that is encased in ¼-in thick carbon steel plate. The lid assembly used with the CC1 and CC2 configurations has an overall thickness of 6.8 inches and an overall diameter of 88.0 inches. The CC3 lid assembly has a slightly larger overall diameter (91.5 inches) and also includes an additional 6.0 inches of concrete (over a 60.0-in diameter) for enhanced radiation shielding. The CC4 lid assembly has the same overall diameter as the CC3 lid configuration and the same thickness of the CC1 and CC2 lid configuration.

There are three MAGNASTOR Transfer Casks (MTCs) considered in this calculation, i.e., MTC1, MTC2 and PMTC, as described in Section 3.1.2.

Table 3.2.1-1 MAGNASTOR Storage Weight and Center of Gravity Summary

Description	CC1 & CC2 / MTC1 & PMTC[1]						CC3 & CC4 / MTC2 [2]			
	PWR		BWR		DF - PWR		PWR		DF - PWR	
	Weight (lb)[3]	C.G. (in)[4]	Weight (lb)[3]	C.G. (in)[4]	Weight (lb)[3]	C.G. (in)[4]	Weight (lb)[3]	C.G. (in)[4]	Weight (lb)[3]	C.G. (in)[4]
Maximum Contents[17]	62,160	-	61,248	-	61,184	-	62,160	-	61,184	-
Basket	20,500	-	22,000	-	24,000	-	19,500	-	24,000	-
TSC w/o Lid	9,500	-	9,500	-	9,500	-	9,500	-	9,500	-
Closure Lid	10,500	-	10,500	-	10,500	-	10,500	-	10,500	-
Loaded TSC (TSC, Lid, Basket, Contents)	102,000	100	103,000	99	104,500	96	101,000	96	104,500	96
Water in TSC and Annulus (lifted)	17,500[15]	-	16,500[15]	-	16,500[15]	-	17,000	-	16,500	-
	17,000[16]	-	16,000[16]		15,500[16]					
Transfer Cask[5] (does not include Lifting Yoke or Transfer Adapter)	108,500[15]	-	108,500[15]	-	108,500[15]	-	106,000	-	106,000	-
	130,500[16]	-	130,500[16]	-	130,500[16]	-				
Lifting Yoke[6]	5,500	-	5,500	-	5,500	-	5,500	-	5,500	-
Concrete Cask [7, 8] (does not include Concrete Cask Lid)	214,500	-	214,500	-	214,500	-	225,500[12]	-	225,500[12]	-
							210,000[13]	-	210,000[13]	-
Concrete Cask Lid[8]	4,500	-	4,500	-	4,500	-	6,000[12]	-	6,000[12]	-
							4,500[13]	-	4,500[13]	-
Storage Cask Loaded (Concrete Cask w/ Lid, TSC w/ Lid, Basket, Contents)	320,500	113	321,500	-	323,500	112	332,000[12]	108[12]	335,500[12]	108[12]
							315,000[13]	109[13]	318,500[13]	109[13]
Storage Cask Empty System Weight (Concrete Cask w/ Lid, TSC w/ lid, Basket)	258,500	-	260,500	-	262,000	-	270,000[12]	-	274,500[12]	-
							252,500[13]	-	257,500[13]	-
Transfer Cask, TSC w/o Lid, Basket, Lifting Yoke - Empty	143,500[15]	-	145,500[15]	-	147,000[15]	-	140,000	-	144,500	-
	165,500[16]	-	167,000[16]	-	169,000[16]	-				
Loaded Transfer Cask Wet Weight[9]	228,000[15]	-	228,000[15]	-	229,500[15]	-	223,500	-	226,500	-
	249,000[16]	-	249,000[16]	-	250,500[16]	-				

Table 3.2.1-1 MAGNASTOR Storage Weight and Center of Gravity Summary (continued)

Description	CC1 & CC2 / MTC1 & PMTC[1]						CC3 & CC4 / MTC2 [2]			
	PWR		BWR		DF - PWR		PWR		DF - PWR	
	Weight (lb)[3]	C.G. (in)[4]	Weight (lb)[3]	C.G. (in)[4]	Weight (lb)[3]	C.G. (in)[4]	Weight (lb)[3]	C.G. (in)[4]	Weight (lb)[3]	C.G. (in)[4]
Under Hook Wet Weight[10]	233,500[15]	-	233,500[15]	-	235,000[15]	-	229,000	-	232,000	-
	254,500[16]	-	254,500[16]	-	256,000[16]	-				
Under Hook Dry Weight[11]	216,000[15]	-	217,000[15]	-	218,500[15]	-	212,000	-	216,000	-
	238,000[16]	-	238,500[16]	-	240,500[16]	-				

Notes:
1. Bounding weights and centers of gravity for CC1 and CC2 concrete casks, and MTC1 and PMTC transfer casks with all TSC configurations.
2. Bounding weights and centers of gravity for CC3 and CC4 concrete casks, and MTC2 transfer cask with TSC2 or TSC4 configurations.
3. Weights and CGs are maximum calculated values based on nominal component dimensions. All weights rounded to the nearest 500 pounds, except for the maximum contents. Component weights are rounded individually, so total assembly weights may not equal the sum of the component weights.
4. CG is measured from the bottom of each component and CG of TSC contents is assumed to equal the mid-length of the TSC cavity.
5. The MTC1 and MTC2 transfer casks can be used with all three concrete cask configurations (i.e., CC1, CC2, CC3 and CC4). The MTC2 transfer cask can only be used for a short TSC configuration (i.e., TSC2 and TSC4), while MTC1 can be used with any TSC configuration.
6. Transfer cask lifting yoke weight for specific sites may vary from listed weight. The site-specific yoke weight should be used for site-specific applications.
7. Bounding weight with inner rebar cage, which bounds the weight of construction aids used with the no inner rebar cage configuration.
8. Average concrete density is considered to be 148 pcf for conservative weight calculation.
9. Loaded Transfer Cask Wet Weight (transfer cask, TSC, basket, closure lid, contents, water in TSC and transfer cask annulus).
10. Under Hook Wet Weight (transfer cask, TSC, basket, lifting yoke, closure lid, contents, water in TSC and transfer cask annulus).
11. Under Hook Dry Weight (transfer cask, TSC, basket, lifting yoke, closure lid, contents).
12. Value for the CC3 concrete cask configuration
13. Value for the CC4 concrete cask configuration
14. An additional 15 lb. was added to the weight prior to rounding.
15. Weight corresponds to the MTC1 transfer cask configuration.
16. Weight corresponds to the passive transfer cask (PMTC) configuration. Note that annulus water is not lifted for the PMTC.
17. Fuel, DFC and/or spacers (if used).

Yield:

$$FS_y = \frac{\text{yield strength}}{\text{maximum stress intensity}} = \frac{18{,}000 \text{ psi}}{3{,}919 \text{ psi}} = 4.59 > 3$$

Ultimate:

$$FS_u = \frac{\text{ultimate strength}}{\text{maximum stress intensity}} = \frac{63{,}400 \text{ psi}}{3{,}919 \text{ psi}} = 16.2 > 5$$

The criteria of NUREG-0612 and ANSI N14.6 for redundant systems are met. Thus, the TSC shell and closure lid are adequate.

3.4.3.3 Transfer Cask Lift

The MAGNASTOR transfer casks are analyzed for loads associated with the heavy lift requirements specified in ANSI N14.6 [2] and NUREG–0612 [3]. All load path components of the casks are evaluated for structural adequacy. The transfer casks are analyzed for loads associated with the vertical lift of the transfer casks. The transfer cask is not designed for redundant lifting; therefore, factors of safety of six on material yield strength and ten on material ultimate strength are required for the lifting trunnions.

The analysis of the fully loaded transfer cask consists of a finite element analysis using the ANSYS program to calculate the stress in the transfer cask forgings, shells, and the trunnion region for the operational vertical lift condition. Additionally, the ANSYS program was used to evaluate stress in the retaining ring of the MTC2 and PMTC casks for the inadvertent lift condition. Details of the ANSYS finite element models are presented in Section 3.10.5. The structural evaluations of the rail, the shield door, and the rail welds are performed using standard engineering equations. The analysis of the carbon steel transfer cask, MTC1, is presented in Section 3.4.3.3.1, while the stainless steel transfer casks, MTC2 and PMTC, analysis is presented in Section 3.4.3.3.2 and Section 3.4.3.3.3, respectively.

3.4.3.3.1 Transfer Cask Lift: MTC1

The MTC1 transfer cask is analyzed in the following section. The design weight of the transfer cask is 230,000 pounds. A bounding weight of the transfer cask of 240,000 lb is considered in the evaluation. A conservative load of 264,000 lb (240,000 × 1.1 dynamic load factor) is used in the finite element analysis.

Transfer Cask Body

Table 3.4.3-1 provides the summaries of the stress intensities for the seven cross-sectional locations of the trunnion and top ring. Table 3.4.3-2 provides the stress summaries for the inner and outer shells and bottom ring. The maximum primary membrane stress intensity, P_m, and the maximum primary membrane plus bending stress intensity, $P_m + P_b$, is compared with the allowable stress criteria.

The cross-section of the trunnion is circular. Two cross-sectional areas are examined as shown in Figure 3.4.3-1. The maximum bending stress occurs at the cross-section (x = 43.9 inches) at the intersection of the trunnions with the outer diameter of the top forging ring. The maximum stress occurs at the trunnion surface. The maximum stress in the trunnion is 3.8 ksi. Comparing the stress to the material (A350 Grade LF 2) allowable yield and ultimate strength, the factors of safety are 8.1 (>6) for material yield strength and 18.5 (>10) for material ultimate strength.

For the top ring, the five cross-sectional areas selected for stress examination are shown in Figure 3.4.3-1. The maximum bending plus membrane stress occurs at the radial cross-section (topring-A1) above the trunnion. The bending stress through this cross-sectional area is 4.9 ksi. Comparing the stress to the material (A516 Gr 70) allowable yield and ultimate strength, the factors of safety are 6.6 (>6) and 14.2 (>10) for yield and ultimate material strengths, respectively.

For the inner shell, the maximum stress intensity occurs at the location of "θ = 10°, z = -7.0 inches", which is outside the intersection just below the trunnion. The maximum bending plus membrane stress through the shell is 2.3 ksi. Comparing the stress to the material (A588) allowable yield and ultimate strengths, the factors of safety are 18.6 (>6) and 30.2 (>10), respectively.

For the outer shell, the maximum stress intensity occurs at the location of "θ = 10°, z = -7.0 inches", which is outside the intersection just below the trunnion. The maximum bending plus membrane stress in the shell thickness is 3.5 ksi. Comparing the stress to the material (A588) allowable yield and ultimate strengths, the factors of safety are12.3 (>6) and 20 (>10), respectively.

For the bottom ring the maximum stress intensity occurs at the nodal location of "θ = 90°, z = -173.5 inches", which is just below the inner and outer shells. The maximum membrane plus bending stress in the ring thickness is 0.7 ksi. Comparing this stress to the material (A588) allowable yield and ultimate strengths, the factors of safety are 58 (>6) and 94 (>10) for yield and ultimate strength, respectively.

3.4.3.3.3 Transfer Cask Lift: PMTC

The PMTC transfer cask is analyzed in the following section. Three structural analyses are performed: vertical lift of the PMTC, inadvertent lift of the TSC, and hydrostatic load on the outer shell of the PMTC.

Vertical Lift of the PMTC

As described in Section 3.10.5.4, a quarter-symmetry finite element model is used for evaluation of the vertical lift of the PMTC. A bounding weight of the transfer cask of 257,000 lb. with a DLF of 1.1 (282,700 lb.) is considered in the evaluation.

Transfer Cask Body

Figure 3.4.3-3 identifies the locations of the maximum stress sections for the trunnion and top forging.

The average shear stress in the trunnion (at Section L1) is calculated [32]

$$\tau = \frac{4V}{3A} = \frac{4 \times 141.4}{3 \times 78.54} = 2.40 \text{ ksi}$$

where:

V = W×DLF/2 = (257×1.1)/2 = 141.4 kip.----shear force per trunnion
A = $\pi D^2/4 = \pi(10)^2/4 = 78.54 \text{ in}^2$---------------shear area per trunnion

The maximum bending stress in the trunnion (at Section L1) is calculated:

$$\sigma_b = \frac{M \times c}{I} = 3.42 \text{ ksi}$$

where:

M = F × L = 141.4×2.375 = 336 kip-in --------Maximum moment
L = 4.75/2 = 2.375 in --------------------------Half of the trunnion length outside the top forging
c = 5 in ---Radius of the trunnion
I = $\pi D^4/64 = \pi(10)^4/64 = 490.9 \text{ in}^4$ -----------Moment of inertia of the trunnion

The shear (τ), bending (σ_b), and combined stresses (σ_{comb}) may be expressed as a function of Z, the vertical distance from the centerline (neutral axis) of the trunnion [32]:

$\tau(z) = \frac{4V}{3A}\left(1 - \frac{Z^2}{R^2}\right)$ $\sigma_b(z) = \frac{M \times Z}{I}$ $\sigma_{comb}(z) = \sqrt{[\sigma_b(z)]^2 + 3[\tau(z)]^2}$

The shear, bending, and combined stresses (at Section L1) are listed in the following table as a function of Z, the vertical distance from the centerline (neutral axis) of the trunnion.

z (in)	τ(z) (ksi)	σ_b(z) (ksi)	σ_{comb}(z) (ksi)	Yield Strength (ksi)	FS on Yield Strength	Ultimate Strength (ksi)	FS on Ultimate Strength
0.0	2.40	0.00	4.16	25	6.01	66.3	15.9
0.5	2.38	0.34	4.13	25	6.05	66.3	16.1
1.0	2.30	0.68	4.05	25	6.17	66.3	16.4
1.5	2.18	1.03	3.92	25	6.38	66.3	16.9
2.0	2.02	1.37	3.75	25	6.67	66.3	17.7
2.5	1.80	1.71	3.56	25	7.02	66.3	18.6
3.0	1.54	2.05	3.36	25	7.44	66.3	19.7
3.5	1.22	2.40	3.20	25	7.81	66.3	20.7
4.0	0.86	2.74	3.12	25	8.01	66.3	21.3
4.5	0.46	3.08	3.18	25	7.86	66.3	20.8
5.0	0.00	3.42	3.42	25	7.31	66.3	19.4

As shown in the table above, the maximum combined stress is 4.16 ksi, which occurs at the center of the trunnion (at Z=0).

The factor of safety (FS) for the trunnion based on the yield strength is as follows.

$$FS = \frac{S_y}{\sigma_{comb}} = \frac{25}{4.16} = 6.01 > 6$$

where:

S_y = 25 ksi -------------------------- yield strength of SA182 Type F304 at 200°F

The factor of safety (FS) for the trunnion based on the ultimate strength is as follows.

$$FS = \frac{S_u}{\sigma_{comb}} = \frac{66.3}{4.16} = 15.9 > 10$$

where:

S_u = 66.3 ksi ----------------------- ultimate strength of SA182 Type F304 at 200°F

In the top forging, the maximum sectional stress occurs at the radial cross-section through the centerline of the trunnion hole (see Figure 3.4.3-3, areas A1 and A2). The linearized maximum stresses in cross-sectional areas A1 and A2 is 1.88 ksi and 2.45 ksi, respectively.

The factor of safety for the top forging based on the yield strength is as follows.

$$FS = \frac{S_y}{\sigma_{max}} = \frac{25}{2.45} = 10.2 > 6$$

where:

S_y = 25 ksi -------------------------- yield strength of SA182 F304 at 200°F

The factor of safety for the top forging based on the ultimate strength is as follows.

$$FS = \frac{S_u}{\sigma_{max}} = \frac{66.3}{2.45} = 27.1 > 10$$

where:

S_u = 66.3 ksi ----------------------- ultimate strength of SA182 F304 at 200°F

Stresses in Cask Shells and Bottom Forging

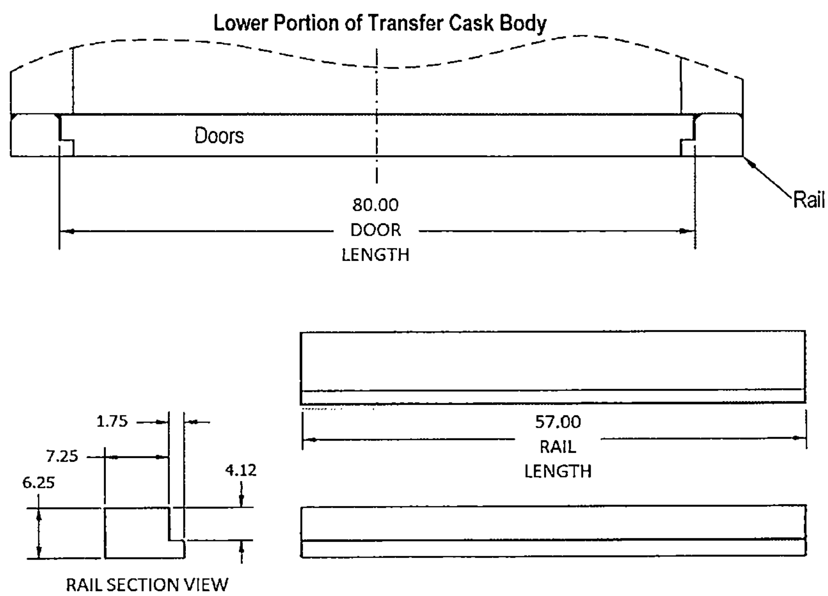
The maximum stress intensities for the primary membrane and primary bending ($P_m + P_b$) stresses and the factors of safety (F.S.) for the inner shell, outer shell, intermediate shell and the bottom-forging ring are summarized in the following table. The stress results are obtained from the quarter-symmetry finite element model for the PMTC.

Component	Position Coordinates*	$P_m + P_b$ (ksi)	Material	Yield Strength (ksi)	Ultimate Strength (ksi)	F.S. for Yield Strength	F.S. for Ultimate Strength
Inner Shell	θ = 0°, z= -31.25 in.	1.3	A240 304	25.0	71.0	Large	Large
Outer Shell	θ = 6.7°, z= -6.25 in.	3.5	A240 304	25.0	71.0	7.1	Large
Intermediate Shell	θ = 8.3°, z= -6.25 in.	4.0	A240 304	25.0	71.0	6.3	Large
Bottom Forging	θ = 0°, z= -187.25 in.	0.36	A182 or A336 F304	25.0	66.0	Large	Large

* The positions correspond to the coordinate system shown in Figure 3.10.5-3 (θ is circumferential angle measured from the positive X axis)

Shield Doors and Rails

The evaluation conservatively considers a bounding weight of 124.5 kips for the fully loaded TSC (with water in the TSC and annulus) and 13.7 kips for the self-weight of the doors and rails. With a 10% dynamic load factor (DLF), the total load used in the evaluation of the doors and rails is 1512 kips (138.2×1.1). The doors and the door rails are constructed of SA182 Type F304 or SA240 Type 304 stainless steel. Allowable stresses for the material are taken at 200°F, which bounds the maximum temperature of the transfer cask for the lift conditions.



Doors

The shield doors are 6 inches thick across the span and step down to a minimum of 3.94 inches thick at the outer edges, where they rest on the rails. Each door supports half of the total weight. The engagement length of each door with the rail is half of the 57-inch length of the rails. The average shear stress at the edges of each door (where it is supported by the rails) is as follows.

$$\tau = \frac{F}{A_S} = \frac{151.4/4}{112.3} = 0.33 \text{ ksi}$$

where:

A_s = $t_d \times L/2 = 114 \text{ in}^2$ ---------------------------the shear area of one door

t_d = $6.0 - 2.0 = 4.0$ in ---------------------------minimum thickness of the door at edge

L = 57.0 in ---------------------------------------length of engagement at rail

The maximum bending stress, σ_b, at the center of the doors is as follows.

$$\sigma_b = \frac{Mc}{I} = \frac{760 \times 3}{778.5} = 2.93 \text{ ksi}$$

where:

$M = \frac{Wl}{8} = \frac{76 \times 80}{8} = 760$ kip-in ------------------bending moment

$W = 152/2 = 76$ kips ----------------------------half of the total weight

$L = 80$ in--span length (conservative)

$h = 6$ in --height (thickness) of the door

$c = \frac{h}{2} = 3$ in

$I = \frac{bh^3}{12} = 778.5 \text{ in}^4$----------------------------moment of inertia

$b = 43.25$ in ------------------------------------width in the middle of the door

The maximum bending stress of the door occurs at the middle of the span, while the maximum shear stress occurs at the door edge. Using the maximum door stress of 2.93 ksi, the factors of safety for the door are calculated as follows.

The factor of safety based on the yield strength is as follows.

$$FS = \frac{S_y}{\sigma_b} = \frac{25}{2.93} = 8.53 > 6$$

where:

$S_y = 25$ ksi ------------------------- yield strength of SA182 F304 at 200°F

The factor of safety based on the ultimate strength is as follows.

$$FS = \frac{S_u}{\sigma_b} = \frac{66.3}{2.93} = 22.6 > 10$$

where:

$S_u = 66.3$ ksi ---------------------- ultimate strength of SA182 F304 at 200°F

Doors Rails

Due to symmetry, each of the two rails is considered to carry half of the 152 kips load.

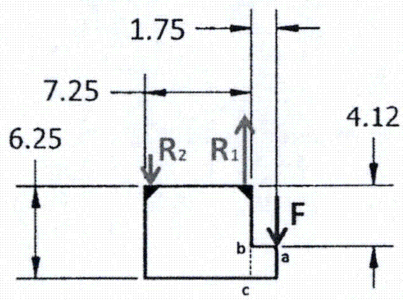
The average shear stress in each door rail (Section b-c in the following sketch) due to the applied load is

$$\tau = \frac{F}{A} = \frac{76}{121.4} = 0.63 \text{ ksi}$$

where:

$F = W / 2 = 152 / 2 = 76$ kips ------------------half of the total load

$A = (6.25 - 4.12) \times 57 = 121.4 \text{ in}^2$ ------------shear area of Section b-c



The bending stress in each rail bottom (Section b-c) due to the applied force, F, is calculated:

$$\sigma_b = \frac{6M}{Lt_{b\text{-}c}^{2}} = 3.09 \text{ ksi}$$

where:

$M = F \times L_{a\text{-}b} = 76 \times 1.75 = 133$ kip-in ---------moment about point "b"

$L_{a\text{-}b} = 1.75$ in --------------------------------------applied load moment arm

$L = 57$ in --length of the rail

$t_{b\text{-}c} = 2.13$ in --------------------------------------thickness at Section b-c

The maximum stress intensity in the bottom section of the rail is calculated:

$$\sigma = \sqrt{(\sigma_b)^2 + 4\tau^2} = \sqrt{(3.09)^2 + 4 \times (0.63)^2} = 3.34 \text{ ksi}$$

The factor of safety for the door rail based on the yield strength is as follows.

$$FS = \frac{S_y}{\sigma} = \frac{25}{3.34} = 7.49 > 6$$

where:

S_y = 25 ksi -------------------------- yield strength of SA182 Type F304 at 200°F

The factor of safety for the door rail based on the ultimate strength is as follows.

$$FS = \frac{S_u}{\sigma} = \frac{66.3}{3.34} = 19.9 > 10$$

where:

S_u = 66.3 ksi ----------------------- ultimate strength of SA182 Type F304 at 200°F

Door Rail Weld

The door rails are attached to the bottom of the transfer cask by ¾-inch partial penetration bevel groove welds. The sketch above shows a free body diagram of the force and reactions acting on the door rail. The maximum load on the door rail welds is indicated by R1. The reaction forces are calculated as follows.

$\Sigma F_y=0$: $R_1 = F + R_2$

$\Sigma M_1=0$: $R_2 = F \times x_1/x_2 = 25$ kips

where:

$F = 152/2 = 76$ kips ------------------ Force on one rail (half of the load on both rails)

$x_1 = 1.75 + 0.75/2 = 2.125$ in -------- Distance between F and R_1

$x_2 = 7.25 - 0.75 = 6.5$ in ------------- Distance between R_1 and R_2

Thus: $R_1 = 76 + 25 = 101$ kips

The maximum linearized stress in the door rail welds, due to the reaction force, R_1, is calculated:

$$\sigma_{weld} = \frac{R_1}{A_{weld}} = 3.07 \text{ ksi}$$

where:

A_{weld} = 32.85 in^2 ------------------------------------Area of the weld at R_1

The factor of safety based on the yield strength is as follows.

$$FS = \frac{S_y}{\sigma_{weld}} = \frac{25}{3.06} = 8.14 > 6$$

where:

S_y = 25 ksi -------------------------- yield strength of SA182 Type F304 at 200°F

The factor of safety based on the ultimate strength is as follows.

$$FS = \frac{S_u}{\sigma_{weld}} = \frac{66.3}{3.06} = 21.6 > 10$$

where:

S_u = 66.3 ksi ----------------------- ultimate strength of SA182 Type F304 at 200°F

Trunnion Bearing Stress

For vertical lifting, the transfer cask is lifted by two trunnions. Using a bounding weight of 257 kips, and dynamic load factor, DLF = 1.1, the bearing load, W_{VL}, on each trunnion is calculated as follows.

$$W_{VL} = \frac{257 \times 1.1}{2} = 141.4 \text{ kips}$$

The trunnion bearing engagement depth is 9.5 inches, but only 50% is used in this evaluation. The diameter of the trunnion is 10 inches. The trunnion bearing stress is calculated as follows.

$$\sigma_{br} = \frac{141.4}{0.5 \times 9.5 \times 10} = 2.98 \text{ ksi}$$

The factor of safety for trunnion bearing stress based on yield strength is as follows.

$$FS = \frac{S_y}{\sigma_{br}} = \frac{25}{2.98} = 8.4 > 1$$

where:

S_y = 25.0 ksi ----------------------- yield strength of SA182 Type F304 at 200°F

Inadvertent Lift of Transfer Cask by TSC

The inadvertent lift of the transfer cask by the TSC is considered an off-normal event. The stresses associated with this condition are required to satisfy allowable stress limits for ASME Boiler and Pressure Vessel Code, Service Level C condition. In the event the transfer cask is lifted by the TSC during handling operations instead of by the transfer cask trunnions, the weight of the transfer cask is supported by a retaining ring mounted to the top of the PMTC transfer cask top ring.

Retaining Ring

As described in Section 3.10.5.5, a finite element model is used for the evaluation of the stresses in the components of the retaining ring. The temperature of the cask at the top is conservatively assumed to be 200°F. The retaining ring is mounted to the transfer cask top ring using eighteen 1½-6 UNC bolts made of SA-193 Grade B6 material. In the inadvertent lift condition, the retaining ring and mounting bolts must have sufficient strength to support the weight of the transfer cask. A bounding weight of the empty transfer cask of 130 kips is considered in the evaluation. A conservative load of 143 kips (130 × 1.1 dynamic load factor) is used in the finite element analysis. Additionally, the retaining ring evaluation considers a bounding bolt preload of 2 kips, which corresponds to a torque of 42.5 ft-lb. (the required bolt torque is 40 ft-lb).

A summary of the stress intensities for the retaining ring is shown in the table below. The maximum stress intensity occurs at the inner radius of the bolt hole as shown in Figure 3.4.3-4.

Stress	Stress Intensity (ksi)	Allowable Stress (ksi)	Factor of Safety
P_m	6.21	30.0	4.83
P_m+P_b	16.53	45.0	2.72

The maximum primary membrane stress intensity, P_m, and the maximum primary membrane plus bending stress intensity, $P_m + P_b$, are compared with the allowable stress. The allowable membrane stress for the retaining ring is

$$S_{allow} = 1.5S_m = 1.5(20) = 30 \text{ ksi}$$

and the allowable membrane plus bending stress for the retaining ring is

$$S_{allow} = 1.5(1.5)S_m = 2.25(20) = 45 \text{ ksi}$$

where:

S_y = 20.0 ksi ------------------------------design stress intensity for SA-240, Type 304, at 200°F

<u>Bolt Head Bearing Stress</u>

The bearing area of the bolt head on the ring is calculated:

$$A_b = \frac{\pi}{4}\left(D^2 - d^2\right) = \frac{\pi}{4}\left((2.25)^2 - (1.63)^2\right) = 1.89 \text{ in}^2$$

Where,

D is the diameter of the bolt head
d is the diameter of the bolt hole

The bearing force of the bolt on the ring is 30.8 kips, obtained from the finite element model.

The bearing stress is calculated:

$$\sigma_b = \frac{F}{A} = \frac{30.8}{1.89} = 16.3 \text{ kip.}$$

The bearing stress factor of safety is calculated:

$$FS = \frac{S_y}{\sigma_b} = \frac{25}{16.3} = 1.53 > 1.0$$

where:

S_y = 25 ksi -------------------------- yield strength of SA240 Type 304 at 200°F

Bolt Tensile Stress

The tensile area of the bolt is calculated:

$$A_t = \frac{\pi}{4}\left(D - \frac{0.9743}{n}\right)^2 = \frac{\pi}{4}\left(1.5 - \frac{0.9743}{6}\right)^2 = 1.405\ \text{in}^2$$

where:

D = Diameter of bolt (nominal) = 1.5 in.
n = Number of threads per inch = 6

The moment of inertia of the threaded portion of the bolt is calculated:

$$I_t = \frac{\pi}{64}\left(D - \frac{0.9743}{n}\right)^4 = \frac{\pi}{64}\left(1.5 - \frac{0.9743}{6}\right)^4 = 0.157\ \text{in}^4$$

where:

D = Diameter of bolt (nominal) = 1.5 in.
n = Number of threads per inch = 6

The maximum tensile stress is calculated:

$$\sigma_{\max} = \frac{F_z}{A_t} + \frac{M_y c}{I_t} = \frac{30.8}{1.406} + \frac{2.3 \times 0.67}{0.157} = 31.7\ \text{ksi}$$

where:

F_z = 30.8 kips (bolt tension)
M_y = 2.3 kip-in (bolt moment)
c = (1.5 – 0.9743/6) / 2 = 0.67 in.

The factor of safety is calculated based on the allowable stress per ASME Section III, Subsection NF3324.6:

$$FS = \frac{1.25 S_u / 3.33}{\sigma_{\max}} = \frac{1.25(104.9)/3.33}{31.7} = 1.24 > 1$$

where:

S_u = 104.9 kips --------------------- Ultimate strength of SA-193 Grade B6 at 200°F

Thread Shear Stress

Since the SA-193 Grade B6 bolts have a significantly higher strength than the SA-182 Type F304 top-forging ring, the shear stress in the internal threads of the top-forging ring is evaluated.

The shear area for the internal threads of the 1½ – 6 UNC (Class 2A) threads, A_n, is calculated as follows.

$$A_n = \pi n L_e D_s \min\left[\frac{1}{2n} + 0.57735\left(D_s \min - E_n \max\right)\right] = 7.134 \text{in}^2$$

where:

n = 6, the number of bolt threads per inch
$D_s min$ = 1.4794 in., the minimum major diameter of the bolt's external threads
$E_n max$ = 1.4022 in., the maximum pitch diameter of the top forging's internal threads
L_e = 2.0 in., thread engagement

The shear stress (τ_n) in the internal threads is:

$$\tau_n = \frac{F}{A_n} = \frac{30.8 \text{ kips}}{7.134 \text{ in}^2} = 4.32 \text{ ksi.}$$

where the total tension, F, is the output bolt load of 30.8 kips.

The shear allowable is:

$$\tau_{allowable} = 1.5 \times 0.6 \times S_m = 1.5 \times 0.6 \times 20.0 = 18.0 \text{ ksi}$$

where:

S_m = 20.0 ksi design stress intensity of SA182 Type F304 at 200°F

The factor of safety is:

$$FS = \frac{\tau_{allowable}}{\tau_n} = \frac{18.0}{4.32} = 4.17 > 1$$

Hydrostatic Load on the Outer Shell of the PMTC

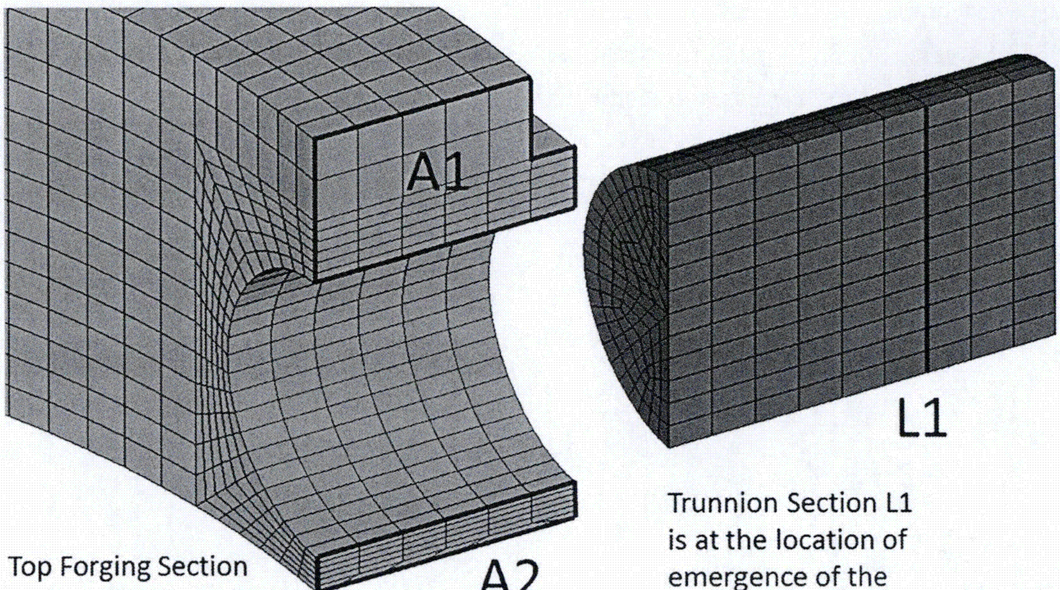
As described in Section 3.10.5.6, a finite element model is used for the evaluation of the hydrostatic load on the outer shell of the PMTC transfer cask. The outer shell stress intensity for the Primary Membrane plus Primary Bending ($P_m + P_b$) stresses resulting from the hydrostatic pressure load ranges from 5679 psi at the top to a maximum 8915 psi at the base. Using allowable stress for the P_m+P_b stress, the factor of safety is calculated as follows.

$$FS = \frac{1.5S_m}{\sigma_{\max}} = \frac{30}{8.92} = 3.36 > 1.0$$

where:

S_m = 20.0 ksi ----------------------- design stress intensity of SA182 Type 304 at 200°F

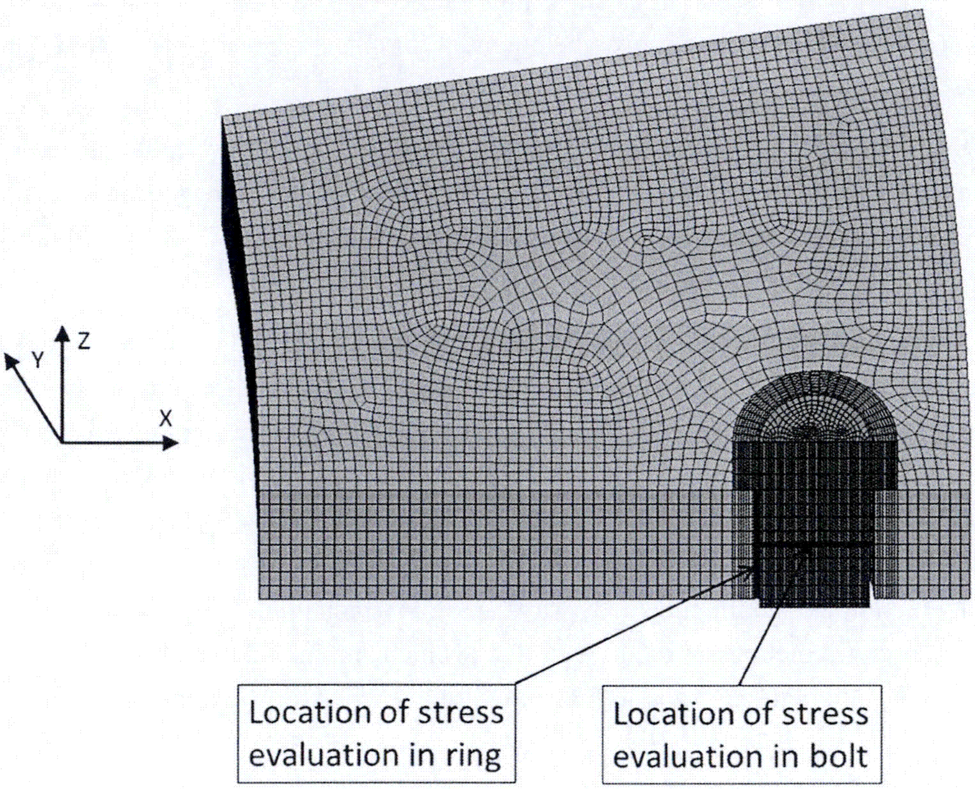
Figure 3.4.3-3 PMTC Model – Top Forging and Trunnion Section Cuts



Top Forging Section Areas A1 and A2 are on a radial plane through the center of the hole.

Trunnion Section L1 is at the location of emergence of the trunnion from the top forging hole.

Figure 3.4.3-4 PMTC Model - Retaining Ring Section Cut



3.4.3.4 Damaged Fuel Can Lift

The MAGNASTOR Damaged Fuel Can (DFC), shown in License Drawings 71160-601 and 71160-602, is provided to accommodate damaged fuel, including damaged WE15×15, WE17×17 and B&W15×15 fuel assemblies. The primary function of the DFC is to confine the fuel material within the can to minimize the potential for dispersal of the fuel material into the TSC cavity.

The DFC may also contain the WE15×15, WE17×17 and B&W15×15 fuel assemblies in an undamaged condition, or damaged fuel, such as undamaged or damaged fuel rods, or fuel debris. Four DFCs may be loaded into the outer corners of the MAGNASTOR 37-assembly PWR, DF Basket Assembly.

The DFC is fabricated from SA-240, Type 304 stainless steel and has an 8.7-inch square inside dimension. The DFC may be provided in two lengths: an overall length of 166.9 inches with a nominal cavity length of 164.0 inches (WE15×15 or WE17×17 fuel assemblies only), or an overall length of 171.8 inches with a nominal cavity length of 169.0 inches (primarily B&W15×15 fuel assemblies, but WE15×15 or WE17×17 fuel assemblies may be accommodated with a DFC spacer to limit axial movement). The side plates that form the upper end of the DFC are 0.15-inch thick and the tube body walls are 0.048-inch thick (18-gage sheet). The DFC lid plate and bottom thicknesses total 11/16 (0.688) inch and the lid overall height is 2.32 inches. The DFC bottom plate thickness is 5/8 (0.625) inch. The DFC lid and bottom include screened drain holes.

In the normal condition of storage, the DFC is in a vertical orientation. The weight of the contents in the can is transferred directly through the bottom plate of the can to the TSC bottom plate, and the DFC is subjected to its self-weight only. For the lift of the DFC, the evaluation considers the weight of the DFC itself and its contents.

The MAGNASTOR DFC is evaluated for dead weight and handling loads for normal conditions of storage. Classical hand calculations are used to evaluate the stresses in the DFC. The DFC lifting components are designed with a safety factor of 3.0 on material yield strength at a temperature of 300°F.

3.4.3.4.1 Dead Weight and Handling Loading Evaluation

The weight of the MAGNASTOR DFC is conservatively assumed to be 150 pounds. The maximum compressive stress acting in the tube of the DFC is due to its own weight in addition to that of the top assembly. A 10% dynamic load factor is applied to the DFC weight for an applied load of 165 pounds to account for loads due to handling. The yield strength (S_y) for

SA-240, Type 304 stainless steel is 22,400 psi at 300°F. Based on the minimum cross-sectional area of the DFC, 1.68 in^2, the factor of safety at 300°F is:

$$FS = 22{,}400/(165/1.68)$$
$$FS = \text{Large}$$

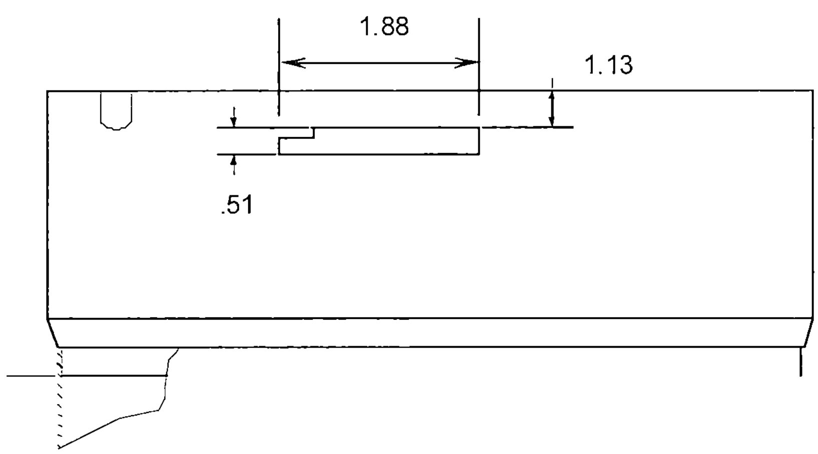
3.4.3.4.2 Lifting Evaluation

Based on the loaded weight of the DFC, the lift evaluation does not require the use of the design criteria of ANSI N14.6 or NUREG-0612. However, for purposes of conservatism and good engineering practice, a factor of safety of 3.0 on material yield strength is used for the stress evaluations for the lift condition. Since a combined stress state results from the loading and the calculated stresses are compared to material yield strength, the Von Mises stress is computed.

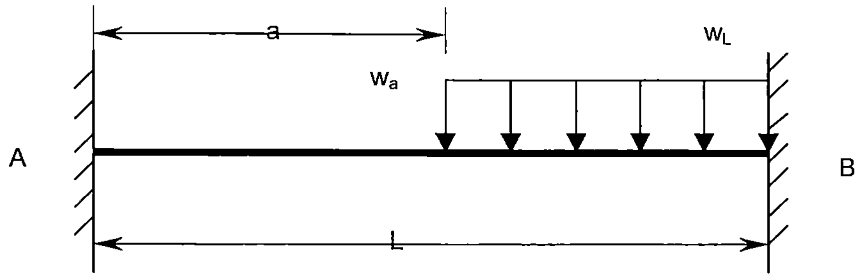
Side Plates

The side plates will be subjected to bending, shear and bearing stresses because of interaction with the lifting tool during handling operations. The lifting tool engages the 1.88-inches × 0.38-inch lifting slots with lugs that are 1 inch wide and lock into the ends of the four lifting slots.

For this evaluation, the handling load is conservatively assumed to be 2,100 lbs (actual fuel assembly weight is less than 1,600 lbs), plus the MAGNASTOR DFC weight (150 lbs), amplified by a dynamic load factor of 10 percent.



The stress in the side plate above the slot is determined by analyzing the section above the slot as a 0.15-inch thick × 1.88-inches long × 1.13-inches deep beam that is fixed at both ends. The lifting tool lug is 1-inch wide and engages the last 1 inch of the slot. The following figure represents the configuration to be evaluated:



where:

a = 0.88 inch

L = 1.88 inches

$w_a = w_L = \frac{P}{4b_t}(1.1) = 620$ lbs/inch

P = 2,250 lbs ---------------------------------- Bounding weight of the loaded DFC

b_t = 1 inch ------------------------------------- Lifting tool lug width

Reactions and moments at the fixed ends of the beam are calculated per Roark's Formula, Table 3, Case 2d.

The reaction at the left end of the beam (R_A) is:

$$R_A = \frac{w_a}{2L^3}(L-a)^3(L+a)$$

$$= \frac{620}{2(1.88)^3}(1.88-0.88)^3(1.88+0.88) = 128.8 \text{ lbs}$$

The moment at the left end of the beam (M_A) is:

$$M_A = \frac{-w_a}{12L^2}(L-a)^3(L+3a)$$

$$= \frac{-620}{12(1.88)^2}(1.88-0.88)^3(1.88+3(0.88)) = -66.1 \text{ lbs}\cdot\text{inch}$$

The reaction at the right end of the beam (R_B) is:

$$R_B = w_a(L-a) - R_A = 620(1.88-0.88) - 128.8 = 491.2 \text{ lbs}$$

The moment at the right end of the beam (M_B) is:

$$M_B = R_A L + M_A - \frac{w_a}{2}(L-a)^2$$
$$= 128.8(1.88) + (-66.1) - \frac{620}{2}(1.88-0.88)^2 = -134 \text{ lbs}\cdot\text{inch}$$

The maximum bending stress (σ_b) in the side plate is:

$$\sigma_b = \frac{Mc}{I} = \frac{134(0.565)}{0.0180} = 4{,}206 \text{ psi}$$

The maximum shear stress (τ) occurs at the right end of the slot:

$$\tau = \frac{R_B}{A} = \frac{491.2}{1.13(0.15)} = 2{,}898 \text{ psi}$$

The Von Mises stress (σ_{max}) is:

$$\sigma_{max} = \sqrt{\sigma_b^2 + 3\tau^2} = \sqrt{4{,}206^2 + 3(2{,}898)^2} = 6{,}549 \text{ psi}$$

The yield strength (S_y) for SA-240, Type 304 stainless steel is 22,400 psi at 300°F. The factor of safety is calculated as:

FS = 22,400/6,549 = 3.4 >3

The design condition requiring a safety factor of 3 on material yield strength is satisfied.

Tensile Stress

The tube body will be subjected to tensile loads during lifting operations. The load (P) includes the DFC contents (2,100 lbs design weight), the tube body weight, and the bottom assembly weight. Conservatively using 150 lbs for the tube body and bottom assembly weight, a total load of 2,250 lbs, with a 10% dynamic load factor, is used for the analysis.

The tensile stress (σ_t) is then:

$$\sigma_t = \frac{1.1P}{A} = \frac{1.1(2{,}250)}{1.680} = 1{,}473 \text{ psi}$$

where:

A = 1.680 inch^2---------------------------------- Tube cross-section area

The factor of safety (FS) based on the yield strength at 300°F (22,400 psi) is:

$$FS = \frac{22{,}400 \text{ psi}}{1{,}473} = 15.2 > 3$$

Weld Evaluation

The welds joining the tube body to the bottom weldment and to the side plates are full-penetration welds (Type III, paragraph NG-3352.3). In accordance with NG-3352-1, the weld quality factor (n) for a Type III weld with visual surface inspection is 0.5.

The weld stress (σ_W) is:

$$\sigma_w = \frac{1.1(P)}{A} = \frac{1.1(2{,}250)}{1.680} = 1{,}473 \text{ psi}$$

where:

P = 2,250 lbs ------------------------------------ Bounding weight of the loaded DFC
A = 1.680 inch^2 --------------------------------- Tube cross-section area

The factor of safety (FS) is:

$$FS = \frac{n \cdot S_y}{\sigma_w} = \frac{0.5(22{,}400 \text{ psi})}{1{,}473 \text{ psi}} = 7.6 > 3$$

Bottom Plate

The bottom plate is analyzed as an 8.80-in square plate, 0.625-in thick, simply supported at the edges. The distributed handling load (q) is the weight of the DFC contents (2,100 lbs design weight) plus the weight of the bottom plate (15 lbs) times a dynamic load factor of 1.1.

Using Roark's "Formulas for Stress and Strain," [13] Table 26, Case 1a for a uniformly loaded rectangular plate, simply supported at the edges, the maximum stress (S_{max}) is found by the relation:

$$S_{max} = (ßqb^2)/t^2 = (0.2874)(30)(8.80)^2/(0.625)^2 = 1{,}710 \text{ psi}$$

where:

$q = ((2{,}100+15) \times 1.1)/(8.80)^2 = 30$ lb/in.^{2}
ß = 0.2874

a = b = 8.80 inches ------------------------- Plate length and width

t = 0.625 inch -------------------------------- Plate thickness

Because of the safety factor, FS = S_y/S_{max} = 17,600/1,710 = 10.3 > 3 at a temperature of 700°F, the design conditions that lifting stresses have a load factor of 3 on the basis of yield strength is satisfied.

Conclusion

The MAGNASTOR DFC is structurally adequate for lifting conditions.

32. Volterra, Enrico and Gaines, J. H., *Advanced Strength of Materials*, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1971.

3.10.5.4 PMTC Transfer Cask Vertical Lift

As shown in Figure 3.10.5-3, a three-dimensional finite element model is used to evaluate the lifting of the fully loaded PMTC. Due to symmetry, only one-quarter of the transfer cask is modeled. The trunnion, top forging, inner shell, intermediate shell, outer shells, the bottom forging and the lead are included in the model. ANSYS SOLID45 elements are used to construct the model. Note that the water and the baffle ribs are not explicitly modeled but their weights are accounted for. CONTAC52 elements are used to represent the interface between the trunnion and the top forging. The groove weld attaching the trunnion to the top-forging at the inner surface of the cask is modeled by coupled nodes between the two components, while the small groove weld attaching the trunnion to the outer surface of the top forging is conservatively neglected.

The total weight of the loaded PMTC transfer cask is less than 257 kips. A bounding load of 257 kips, with a 10% dynamic load factor (DLF), is used in the model. The load used in the quarter-symmetry model is 70.7 kips (257×1.1/4), applied upward at the trunnion as a surface pressure load, as shown in Figure 3.10.5-3. Symmetry boundary conditions are applied to the two planes of symmetry. The bottom of the model is restrained in the vertical direction.

3.10.5.5 PMTC Transfer Cask Retaining Ring Model for Inadvertent Lift

A finite element model is used to calculate the stresses in the retaining ring assembly for the inadvertent lift condition. Since the circular retaining ring has 18 equally spaced bolts, a 1/36th portion (a 10° periodic section) is modeled, as shown in Figure 3.10.5-4. The model is constructed using ANSYS SOLID45 brick elements for the retaining ring and retaining bolt. CONTAC52 elements are used to model the interface between the bolt head and the retaining ring. CONTAC52 elements are also used at the bottom side of the retaining ring representing the interface between the ring and the top forging of the transfer cask. The bottom of the bolt is constrained. Symmetry boundary condition is defined at the planes of symmetry. An initial bolt preload of 2 kips is established by assigning a temperature differential of 10°F to the ring and bolt. The retaining ring is loaded by the weight of the transfer cask. The inadvertent lift load applied to the model is calculated as follows:

$$F_{FEM} = \frac{W_{MTC} \times DLF}{C_{TSC}} L_{FEM} = 3.97 \text{ kips}$$

Where W_{MTC} = Weight of the empty PMTC = 130 kips

DLF = Dynamic Load Factor = 1.1

C_{TSC} = Circumference of the canister = π D_{TSC} = 226.2 in.

D_{TSC} = Diameter of the canister = 72 in.

L_{FEM} = Arc length of FEM at the radius of the canister = $C_{TSC}/36$ = 6.28 in.

The model is loaded by applying a pressure force to the bottom side of the retaining ring equal to the required load divided by the area of the elements which are loaded.

3.10.5.6 PMTC Outer Shell Model for Hydrostatic Load

A finite element model is used to evaluate the stress in the outer shell resulting from the hydrostatic pressure. Due to symmetry, the three-dimensional model represents $1/24^{th}$ portion (15° angle) of the outer shell, as shown in Figure 3.10.5-5. ANSYS SHELL63 elements are used to construct the model. A pressure load is applied to the inner surface of the outer shell. This pressure increases linearly from 30 psi at the top to 36.3 psi at the base. The pressure load is the sum of a bounding 30 psi pressure due to thermal expansion of the water, plus the hydrostatic pressure, which increases linearly from 0 psi at the top to 6.3 psi ($\rho \times h = 62.5\ lb/ft^3 \times 14.5\ ft / 144\ in^2/ft^2 = 6.3$ psi) at the base.

Figure 3.10.5-1 Finite Element Model for the Transfer Cask

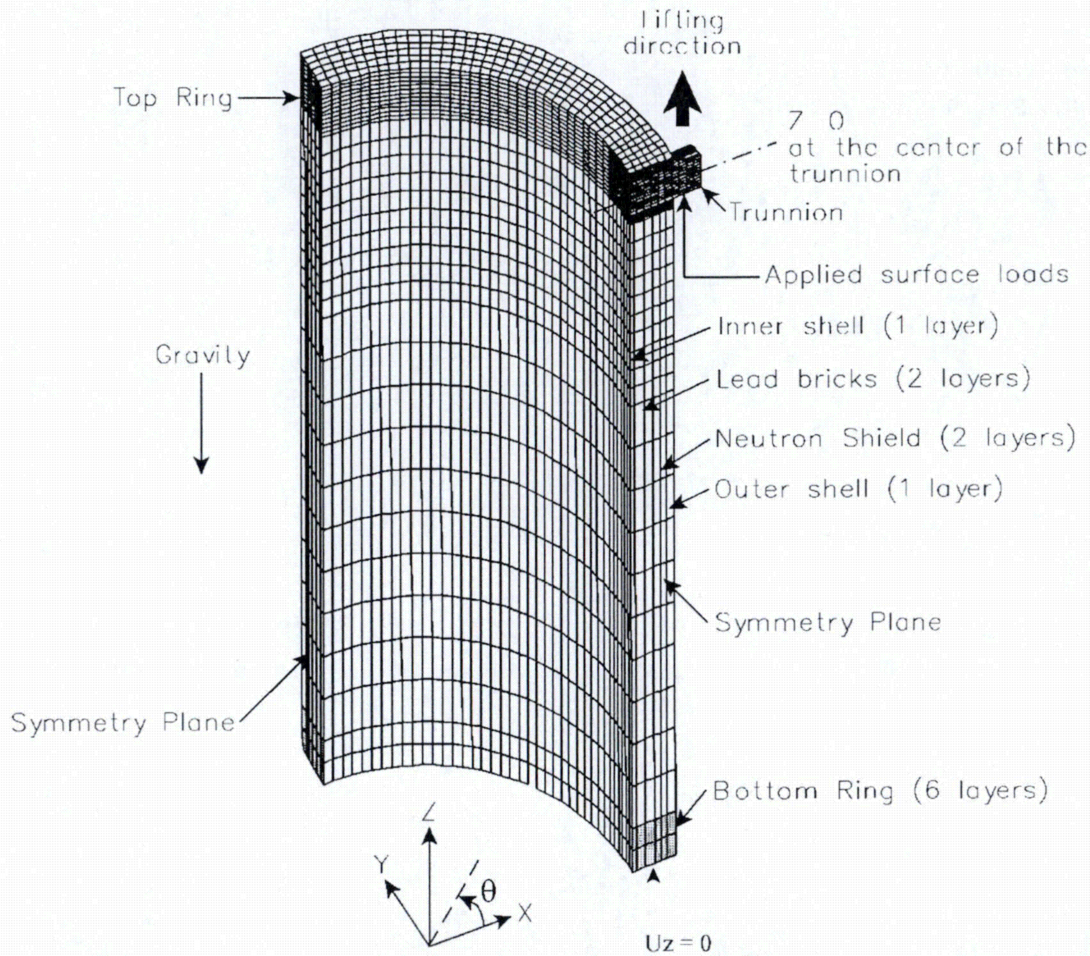


Figure 3.10.5-2 Finite Element Model for the MTC2 Transfer Cask Retaining Ring

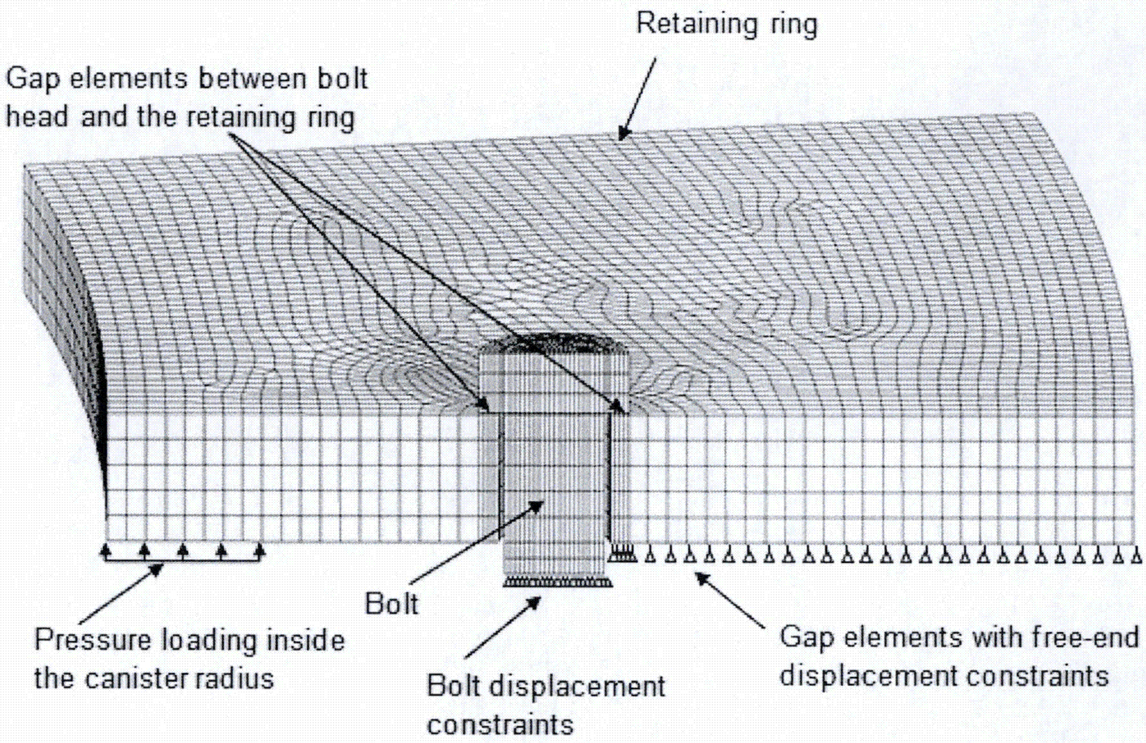


Figure 3.10.5-3 Finite Element Model for the PMTC Transfer Cask

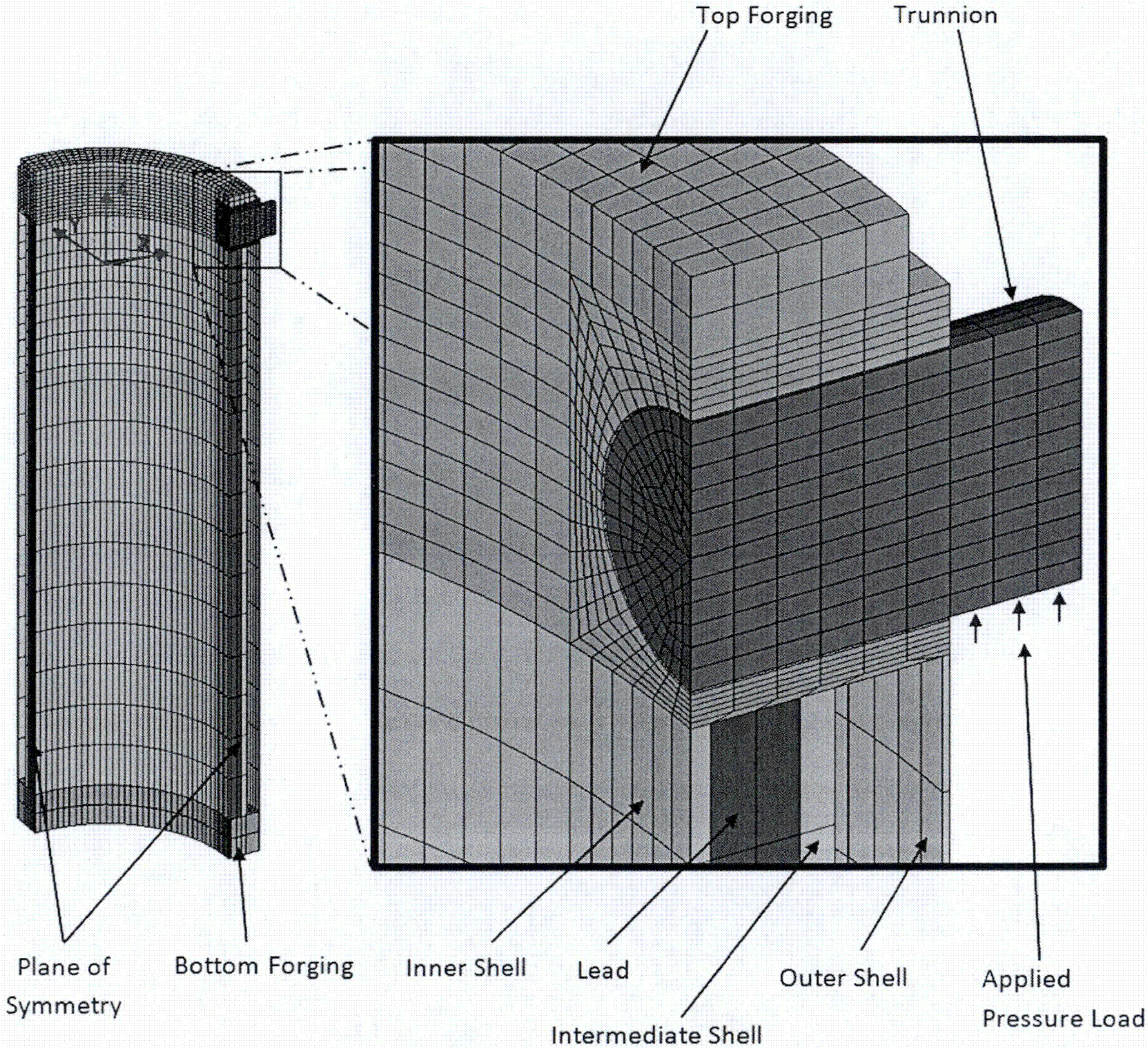


Figure 3.10.5-4 Finite Element Model for the PMTC Restraining Ring

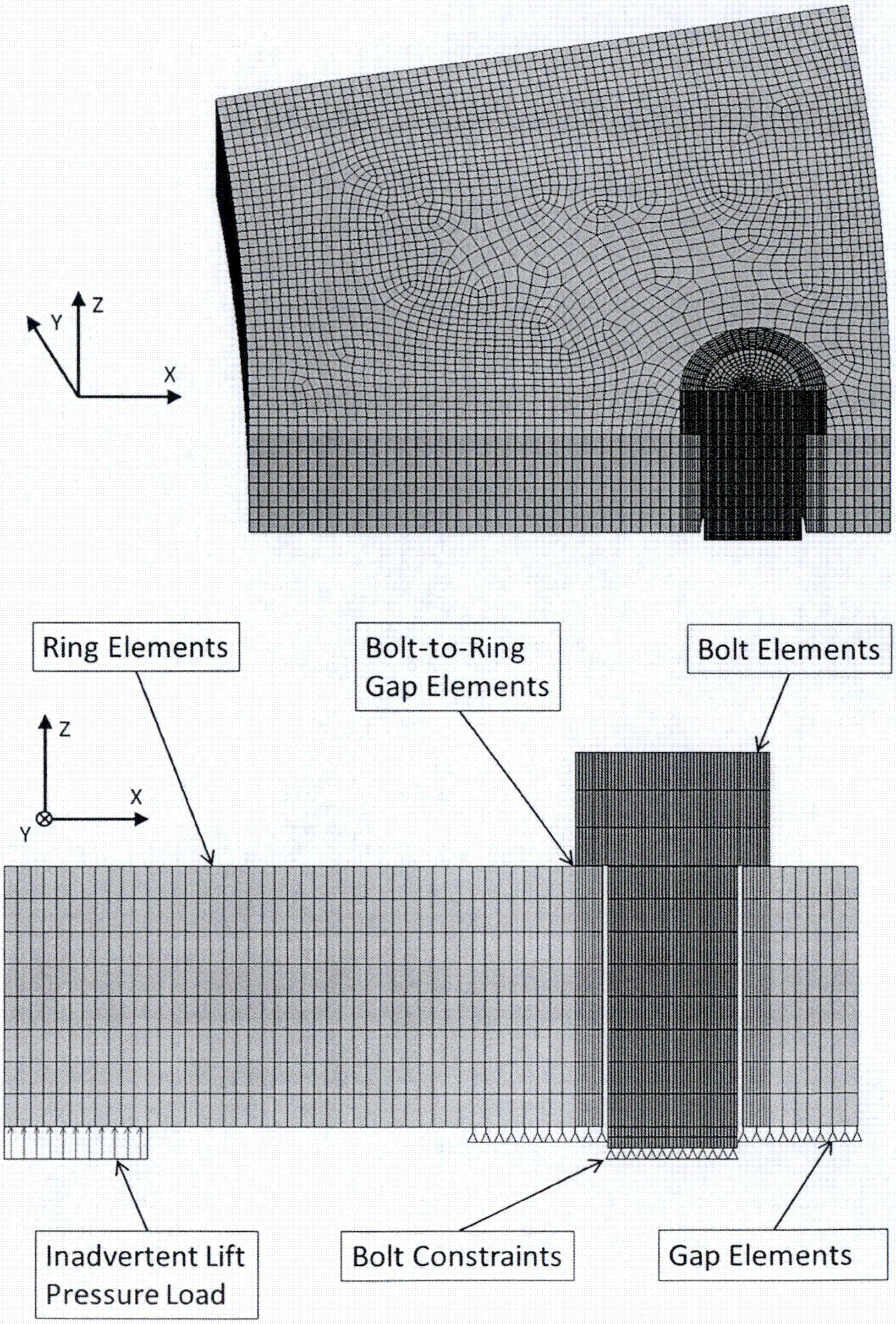
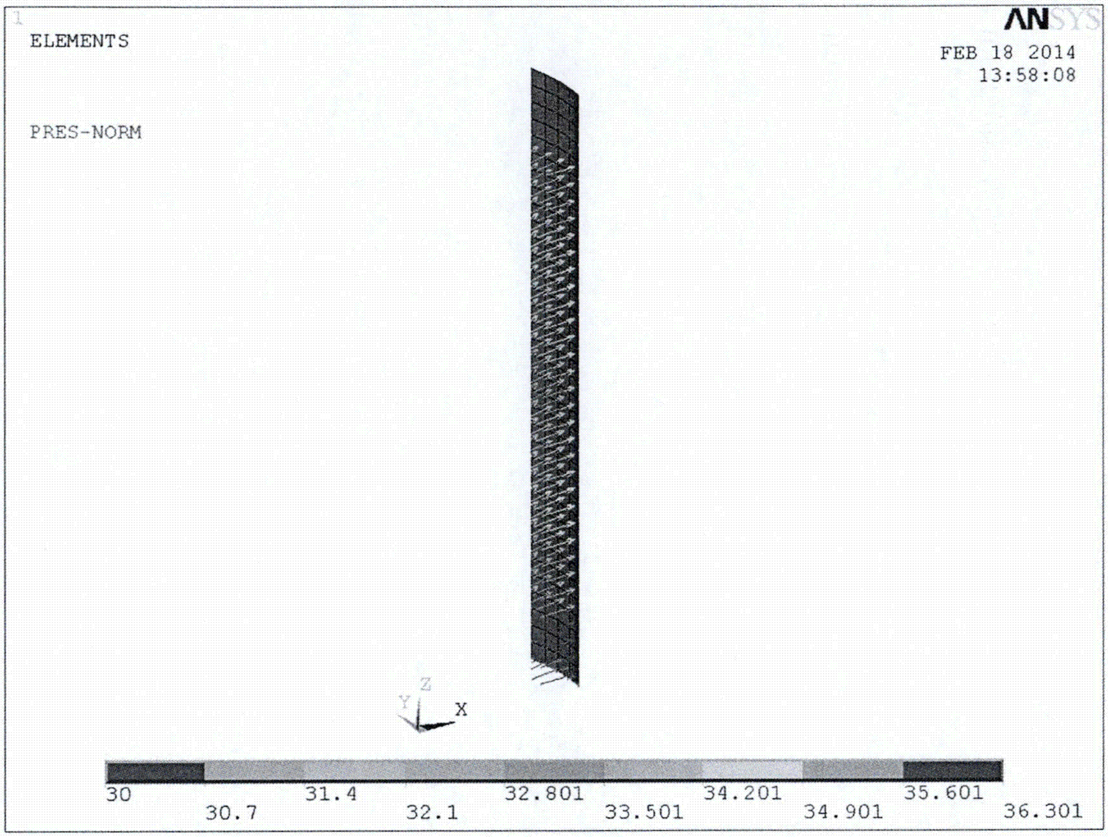


Figure 3.10.5-5 Finite Element Model for the PMTC Outer Shell for Hydrostatic Pressure (Unit: psig)



4. Thermal Evaluation

Chapter 4
Thermal Evaluation

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4.1 Discussion

MAGNASTOR consists of a TSC, concrete cask, and a transfer cask. In long-term storage, the fuel, including fuel contained in damaged fuel cans, is loaded in a basket structure positioned within the TSC. The TSC is placed in the concrete cask, which provides passive radiation shielding, structural protection and natural convection cooling. The transfer cask is used to handle the TSC. The thermal performance of the concrete cask containing a loaded TSC with design basis fuel, and the performance of the transfer cask containing a loaded TSC with design basis fuel are evaluated in this chapter.

The thermal evaluation considers normal conditions and off-normal and accident events of storage. Each of these conditions can be described in terms of the environmental temperature, use of solar insolation, and the condition of the air inlets as shown in Table 4.1-1. The evaluation of the different phases of the transfer operation is accomplished by altering the properties of the medium in the canister to correspond to water or helium.

In order for the heat from the stored spent fuel assemblies, including fuel contained in damaged fuel cans, to be rejected to the ambient environment via the concrete cask or the transfer cask, the decay heat from the contents is transferred to the TSC surface. The MAGNASTOR baskets for the PWR and the BWR fuel assemblies use all three heat transfer modes—radiation, conduction and convection—to transfer the heat to the TSC surface. The basket design enhances convection heat transfer. Helium is used as the backfill gas in the TSC because its thermal conductivity is better than other allowable backfill gases. The basket is comprised of full-length carbon steel tubes that provide a significant path for conduction heat transfer. Radiation is a significant mode of heat transfer in the fuel region and between the outer surface of the basket and the TSC shell.

The significant thermal design feature of the concrete cask is the passive convective airflow around the outside of the TSC. Cool (ambient) air enters at the bottom of the concrete cask through four air inlets. Heated air exits through the four air outlets in the upper concrete cask body. Radiant heat transfer occurs from the TSC shell to the concrete cask liner, which then transmits heat to the annular airflow. Conduction through the concrete cask, although not significant, is included in the analytical model. Natural circulation of air through the concrete cask annulus, in conjunction with radiation from the TSC surface, maintains the fuel cladding temperature and all component temperatures below their design limits.

The transfer cask is available in two configurations. The first is the standard MAGNASTOR Transfer Cask (MTC) with solid neutron shielding. The second configuration is the Passive MTC (PMTC) with demineralized water filled shield tank. The PMTC is specifically designed

for use in a high ambient temperature environment and to passively cool the loaded TSC during transfer operations by convective air cooling similar to that provided by the concrete cask

The MAGNASTOR design basis heat load is 35.5 kW for PWR fuel. The fuel loading may be in the 37 PWR Basket Assembly, i.e., up to 37 undamaged PWR fuel assemblies, or in the DF Basket Assembly, which has a capacity of up to 37 undamaged fuel assemblies including four DFC locations. Damaged fuel cans may be located in the DFC locations at the four outer corners of the DF basket assembly (Figure 2.2-3 and License Drawing 71160-675). Both the PWR fuel basket and the DF basket assembly can accommodate a uniform heat load of 959 W per assembly, or a preferential loading pattern as shown in Figure 4.1-1. The preferential loading pattern identified in Figure 4.1-1 defines three values of heat generation that place the fuel assemblies with the maximum heat generation rate in an intermediate region of fuel storage locations. Analyses are performed using the two-dimensional axisymmetric model with the same fluid resistances and material properties for both the preferential and uniform loading patterns. The calculated maximum fuel temperature is essentially the same for both loading configurations. The maximum temperatures at the radial location of the center of a preferential loaded fuel assembly with the 1.2 kW heat load is determined to be 689°F. At this same radial location, the calculated temperature for the uniform heat load is 684°F. This small increase is a localized bounding temperature response due to the localized increased heat generation for the preferential loading configuration. As shown in Sections 4.4.1.6 and 4.4.3 and as concluded in Sections 4.5 and 4.6, the maximum fuel temperature for the DF basket assembly configuration is bounded by that for the standard PWR basket configuration.

The identical maximum fuel cladding temperature calculated for both loading configurations, resulting from identical total heat and small differences in inner region heat (4%), demonstrates efficiencies in the alternate PWR preferential loading configuration. Placement of the highest heat load for the preferential loading configuration in an intermediate radial location balances system performance. The thermal loading basis for the PWR analyses in this chapter uses the preferential loading since it represents the system loading with maximum heat concentration. The BWR fuel basket can accommodate 87 fuel assemblies with a uniform design basis total heat load of 33 kW, or 379 watts, per assembly.

The thermal evaluation applied different component temperature limits and allowable stress limits for long-term conditions versus short-term conditions. Normal storage operation is considered to be a long-term condition. Off-normal and accident events are considered to be short-term conditions. Thermal evaluations are performed for the design basis PWR and BWR

fuels for all design conditions. The maximum allowable material temperatures for long-term and short-term conditions are provided in Table 4.1-2.

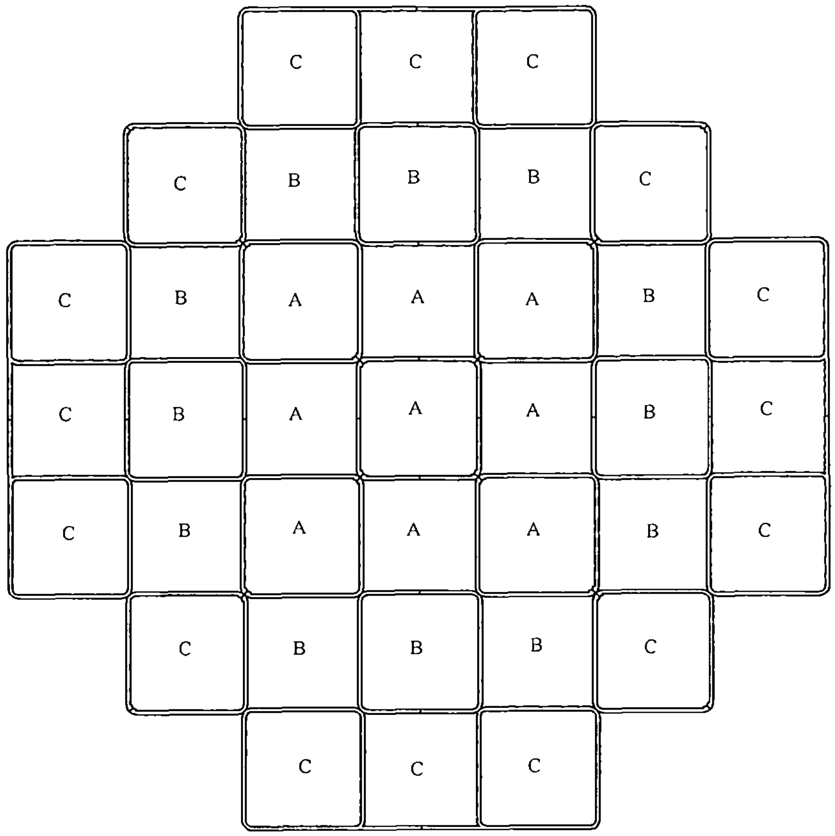
During normal conditions of storage and off-normal and accident events, the concrete cask must reject the decay heat from the TSC to the environment without exceeding the system components temperature limits. In addition, to ensure fuel rod integrity for normal conditions of storage, the spent fuel must be maintained at a sufficiently low temperature in an inert atmosphere to preclude thermally induced fuel rod cladding deterioration. To preclude fuel degradation, the maximum cladding temperature under normal conditions of storage and canister transfer operations is limited to 752°F (400°C) per ISG-11 [2]. The maximum cladding temperature for off-normal and accident events is limited to 1,058°F (570°C). For the structural components of the storage system, the thermally induced stresses, in combination with pressure and mechanical load stresses, are limited to the material allowable stress levels.

Thermal evaluations for normal conditions of storage and canister transfer operations using the standard transfer cask (MTC) are presented in Section 4.4. Thermal evaluations for the transfer operations using the passive transfer cask (PMTC) are presented in Section 4.10. The finite element method is used to compute the effective properties for the basket, neutron absorber and fuel region. The thermal solutions for the concrete cask and transfer cask are obtained using finite element and finite volume methodologies. Thermal models used in the evaluation of normal and transfer conditions using MTC are described in Section 4.4.1. Thermal models used in the evaluation of transfer condition using PMTC are described in Section 4.10.1.

A summary of the thermal evaluation results for normal conditions of storage is provided in Table 4.4-3 for the PWR and the BWR cases. Table 4.4-5 through Table 4.4-14 contain the maximum fuel cladding temperatures for the different phases of the transfer operations using MTC for the PWR and BWR cases. Thermal evaluation results for off-normal and accident events are presented in Sections 4.5 and 4.6, respectively. Thermal evaluation results for the transfer condition using PMTC are presented in Section 4.10.2. Comparison of the evaluation results shows that the standard PWR basket evaluation bounds that of the DF basket assembly. The results demonstrate that the calculated temperatures are less than the allowable fuel cladding and component temperatures for all normal (long-term) storage conditions and for short-term events. As shown in Chapter 3, the thermally induced stresses, combined with pressure and mechanical load stresses, are also within allowable limits.

As discussed in Section 4.4.1, for TSC that is less than fully loaded, empty fuel storage locations shall begin at the center of the basket and continue outward, as required in an approximately symmetric pattern.

Figure 4.1-1 Definition of the Preferential Loading Pattern for the PWR Basket Assembly



Zone Identification	A	B	C
Maximum Heat Load per Assembly (kW)	0.922	1.20	0.80
Total Number of Fuel Assemblies	9	12	16

vacuum drying is administratively controlled for the PWR basket with heat loads greater than 25 kW, and for the BWR basket with heat loads greater than 29 kW, to ensure the maximum fuel cladding temperature is less than the allowable temperature. For high heat loads greater than 25 kW for the PWR basket and greater than 29 kW for the BWR basket, the 24-hour helium-backfilled phase is needed for both systems. The maximum time allowed for loading the helium-backfilled TSC into the concrete cask without operating the transfer cask annulus circulating water cooling system is determined by transient analyses. During the operational sequence of TSC loading, an Annulus Circulating Water cooling System (ACWS) may be used to flow water through the annulus to cool and maintain a specified temperature for the TSC external shell. Alternative cooling methods, such as reverse ACWS, or any other equivalent site-approved annulus cooling system or by fully submerging the TSC with the lid removed or the transfer cask annulus seals deflated, may also be used. The annulus cooling methods, when used, are designed to accommodate design basis heat loads without additional heat rejection from the transfer cask to the environment. The annulus cooling methods, i.e., ACWS and reverse ACWS, may be generically referred to as "ACWS" for discussion purposes.

Note that the standard MAGNASTOR transfer cask (MTC) is provided in two configurations, MTC1 and MTC2. The main difference between these two configurations is the material used for the cask shells and shield door (carbon steel for MTC1 and stainless steel for MTC2). The thermal models described in the following sections consider carbon steel properties for the cask shells and shield door. Since the radial conductance of the cask body is governed by the NS-4-FR material, and the water or air in the annulus between the canister and the cask shells carries out the majority of the heat, the cask shell material has an insignificant effect on the TSC and its contents. Therefore, the thermal models are applicable to both the MTC1 and MTC2 configurations.

Evaluation of the Water Phase With Annulus Circulating Water Cooling System

The model that includes water in the TSC treats the entire cavity as though it is filled with water. Since it is necessary to remove some water from the TSC during the closure lid welding operation, the water level in the TSC may be below the top of the fuel basket. The fuel tubes are designed with holes in the sides to permit the water to flow from the center of the TSC to the downcomer region of the TSC. The two-dimensional axisymmetric transfer cask and TSC models are used to evaluate the transfer operation for PWR fuels and BWR fuels. The components comprising the transfer cask and TSC model are shown in Figure 4.4-13 for the PWR configuration. The BWR model is identical to the PWR model except for a slight difference in the dimensions. The TSC portion of the model is identical to the model employed in Section 4.4.1.1, with the exception that one of the conditions in the transfer operations uses

water in the TSC instead of helium. The model for the TSC, described in Section 4.4.1.1, uses effective properties for the fuel basket region. For the water condition, the methodology described in Sections 4.4.1.2, 4.4.1.3, and 4.4.1.4 is used to determine the effective properties for the fuel basket region. For the condition of water in the TSC, no contribution due to radiation was considered; only conduction was taken into account for the effective properties. The porous media constants for the fuel basket region need not be recomputed since they are dependent on the fuel assembly and fuel basket geometry only. However, during the analytical evaluation of the water phase, the pressure drop in the fuel basket region due to the water requires the use of the viscosity, which is input as a material property. Since the maximum water temperature in the TSC is significantly below 212°F, the water is expected to remain in the liquid state, and the use of properties for the liquid state is acceptable. The transfer cask and the water annulus between the transfer cask and the TSC are also included in the model. The transfer cask is represented by effective properties. The transfer cask wall is comprised of four different materials: 1) a carbon steel inner shell; 2) a lead gamma shield layer; 3) an NS-4-FR neutron absorber layer; and 4) a carbon steel outer shell. Effective thermal conductivity for the transfer cask in the radial direction treats the four different cask wall materials as being in series. The effective thermal conductivity for the transfer cask wall in the axial direction treats the four different cask wall materials as being in parallel. The model also contains the shield doors of the transfer cask. While the inlets to the transfer cask are tubes in the side walls of the transfer cask, they are included in the model as straight sections parallel to the annulus. The following conditions are applied to the model for the steady-state evaluation of the water phase with the annulus circulating water cooling system.

- The outer surfaces of the transfer cask are considered to be adiabatic and without the application of solar insolance.
- The inlet water temperature for the annulus between the TSC and the transfer cask is specified to be 100°F.
- The driving force for the water flow in the annulus between the TSC and the transfer cask is natural convection. Water is supplied to the annulus inlets by an annulus circulating water cooling system.
- The heat generation internal to the TSC is modeled as 15, 20, 25, 30 and 35.5 kW for PWR fuels. The heat loads in Zones A, B and C, as defined in Figure 4.1-1, are factored based on the heat load for heat loads other than 35.5 kW. For the heat load of 35.5kW, the heat loads in Zones A, B and C are 0.922 kW, 1.20 kW and 0.80 kW, respectively. The heat generation internal to the TSC is modeled as 15, 20, 25, 30 and 33 kW for BWR fuels with a uniform heat distribution.
- The flow in the TSC and in the annulus region is treated as being laminar for both the water and helium conditions of the TSC.
- Radiation heat transfer is removed from the solution.

Evaluation of TSC Loaded with DF Basket Assembly

The flow resistance for a single zone DF basket assembly is slightly lower than the flow resistance for the standard PWR basket. The thicker side plates forming the basket corner slots for the damaged fuel can enhance the basket assembly conductance in the basket axial direction. Therefore, the thermal analysis results for the standard PWR basket bound the results for the DF basket assembly, as demonstrated by three representative analyses performed for the DF basket assembly for the transfer condition. Maximum fuel temperatures for all three analyses for the DF basket assembly are lower than those for the standard PWR basket. The three analyses are: 1) For the water phase, the 35.5 kW steady-state case (FLUENT CFD analysis) with helium inside the canister and water in the annulus between the canister and the transfer cask inner shell; 2) For the drying phase, the 25 kW steady-state case (ANSYS analysis) with helium inside the canister and water in the annulus between the canister and the transfer cask inner shell; 3) For the drying phase, the 35.5 kW transient case (ANSYS analysis) with helium inside the canister and water in the annulus between the canister and the transfer cask inner shell. Cases with helium inside the canister are selected because they yield higher fuel temperatures than cases with water inside the canister.

4.4.2 Test Model

MAGNASTOR is conservatively designed by analysis. Therefore, no physical model is employed for thermal analysis. The benchmark provided in Section 4.8.1 provides confirmation that the analysis methodology employed for the MAGNASTOR design is conservative.

4.4.3 Maximum Temperatures for PWR and BWR Fuel Configurations

Normal Conditions of Storage

The temperature distributions and maximum component temperatures for MAGNASTOR for normal conditions of storage are provided in this section. System components of the CC1/CC2 concrete cask containing a PWR and BWR TSC and the CC3 concrete cask containing a PWR TSC are addressed separately. The temperature distributions in the CC1/CC2 concrete cask containing the BWR TSC are similar to those of the same system with the PWR TSC and are, therefore, not presented.

The temperature distribution in the CC1/CC2 concrete cask and the TSC containing the PWR design basis fuel (uniform heat load) for normal conditions of storage is shown in Figure 4.4-14. The air velocity distribution in the annulus between the TSC and the concrete cask liner for the normal conditions of storage for PWR fuel for the CC1/CC2 configuration is shown in Figure 4.4-15. The maximum component temperatures for the normal conditions of storage are

summarized in Table 4.4-3. Note that the bounding temperatures from CC1/CC2 and CC3 analyses are conservatively used as the maximum component temperatures for the CC4 configuration. It is noted that these system thermal performance results are based on an average annual ambient temperature of 76°F at sea level pressure and standard air density properties. Site-specific conditions are to be evaluated to assure thermal margins are maintained for steady-state storage conditions at the intended MAGNASTOR ISFSI site.

As shown in Figure 4.4-14, the peak fuel temperature for the normal storage condition occurs near the top of the fuel basket and, based on the uniform spacing of the isotherms at the centerline of the TSC, the temperature varies monotonically from the TSC bottom to the peak near the top of the fuel basket. This is indicative that the dominant mode of heat rejection from the fuel is by convection due to the helium flow circulating within the TSC.

The calculated temperatures at the TSC surface for the normal storage condition are higher than the concrete liner or surface, indicating that radiation heat transfer occurs across the concrete cask to TSC annulus.

To confirm that the concrete cask heat removal system is operable, one of the following two surveillance options with a frequency of 24 hours is required: (1) Visually verify all concrete cask air inlet and outlet screens are free of blockage; (2) Verify the difference between the concrete cask air outlet average temperature and the ambient temperature is less than 119°F, 130°F, 134°F and 119°F for the concrete cask configuration CC1/CC2-PWR, CC1/CC2-BWR, CC3-PWR and CC4-PWR, respectively. A minimum of two outlet air temperatures must be measured to provide an average outlet temperature to comply with Technical Specifications SURVEILLANCE REQUIREMENT 3.1.2.1. The allowable temperature differences are determined based on the maximum calculated temperature difference between air outlet and ambient and the calculated minimum temperature margin for concrete and fuel temperatures for all normal and off-normal conditions.

Normal Conditions of Storage – PWR Configuration with DF Basket Assembly

The thermal evaluation for the concrete cask loaded with a TSC containing a DF basket assembly in storage conditions is performed based on configuration CC3 using the two-dimensional axisymmetric FLUENT CFD models described in Section 4.4.1.1. Three cases are considered:

Case 1: The active fuel region is modeled as a single porous zone with a single lumped resistance coefficient. The uniform loading heat generation rate (based on a total heat load of 35.5 kW) is applied to the active fuel region. The calculated maximum fuel temperature is 704°F.

Case 2: The active fuel region is modeled as two parallel porous zones radially, with a resistance coefficient for the outer zone of 16 basket slots (which include the four damaged fuel can slots)

Off- Normal Event TSC Internal Pressures

Off-normal event TSC internal pressures are evaluated using the method and inputs documented in the normal condition pressure evaluations (Section 4.4.4). The off-normal event TSC internal pressure analysis considers a 10% rod failure fraction and a TSC backfill temperature at 495°F and a pressure of 106 psig. The higher backfill temperature, and associated pressure, is the result of the "severe heat" off-normal thermal evaluation. The maximum TSC internal pressures calculated for off-normal events are 118 psig for the PWR system, 119 psig for the damaged fuel PWR system, and 112 psig for the BWR system.

4.5.2 Off-Normal Transfer Phase Events for PWR Fuel in a Standard MAGNASTOR Transfer Cask (MTC)

Crane Failure During Transfer Cask Movements

While maneuvering the transfer cask in preparation for transfer operations, a mechanical or electrical malfunction could temporarily disable the crane and inhibit movement of the transfer cask and TSC. Such an occurrence would eliminate the option of submerging the transfer cask and TSC in the spent fuel pool for cooling and might make it difficult to establish an annulus cooling system flow. If operability of the crane can be restored within the normal transfer time limits, the transfer operation may be completed and no special actions are required. However, if the crane cannot be repaired in a timely manner it may not be possible to complete or abort the transfer operation within the normal limits. This condition is considered an off-normal event.

The two dimensional FLUENT model of the TSC and transfer cask with reduced annulus inlet, described in the transfer phase evaluation in Section 4.4.1.5, is used to perform steady state evaluations to determine the maximum heat load at which steady state fuel temperatures are below the off-normal allowable temperature limits. [redacted]

Crane/Hoist System Failure During TSC Transfer to VCC

With the transfer cask in place on top of the VCC, the TSC is lifted, the transfer cask doors are opened, and the TSC is lowered into the VCC. A mechanical or electrical malfunction of the crane could strand the TSC in the transfer cask/VCC cavity. Such an occurrence would eliminate the option of submerging the transfer cask and TSC in the spent fuel pool for cooling, and might make it difficult to establish an annulus cooling water flow. If operability of the crane can be restored within the normal transfer time limits, transfer of the TSC into the VCC may be completed, and no special actions are required. However, if the crane cannot be repaired in a timely manner it may not be possible to complete or abort the transfer operation within the normal limits. This condition is considered an off-normal event.

Since the transfer cask doors are open, the air flow through the annulus region is greater than that in the off-normal event discussed in the preceding section (if the doors cannot be opened then the results of the preceding section apply). The two dimensional FLUENT model used in the preceding evaluation, configured with the full annulus inlet, is used to perform steady state evaluations to determine the maximum heat load at which steady state fuel temperatures are below the off-normal allowable temperature limits. [redacted]

Retrieving a TSC from a VCC for Unloading

If a TSC must be returned to the spent fuel pool for wet unloading, an off-normal event, it will be lifted out of the VCC into the transfer cask. Considering the initial conditions to be the steady state condition in the VCC, the transient results from the transfer phase evaluation in Section 4.4.1.5 for the design basis heat load are used to determine that the normal allowable temperature limits for the TSC and its PWR contents are reached 3 hours after the TSC is removed from the VCC and off-normal allowable temperature limits for the TSC and its PWR contents are reached 11 hours after the TSC is removed from the VCC. Annulus cooling flow, or an equivalent cooling method, must be established within this time limit to maintain the TSC and its contents below the off-normal allowable temperature limits.

4.7 References

1. 10 CFR 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High Level Radioactive Waste and Reactor-Related Greater than Class C Waste," Code of Federal Regulations, US Government, Washington, DC.
2. ISG-11, Revision 3 – "Cladding Considerations for the Transportation and Storage of Spent Fuel," US Nuclear Regulatory Commission, Washington, DC, November 17, 2003.
3. 10 CFR 71, "Packaging and Transportation of Radioactive Material," Code of Federal Regulations, US Government, Washington, DC.
4. ACI-349-85, "Code Requirement for Nuclear Safety Related Concrete Structures and Commentary," American Concrete Institute, Farmington Hills, MI.
5. PNL-4835, Johnson, A.B., and Gilbert, E.R., "Technical Basis for Storage of Zirconium-based alloy-Clad Fuel in Inert Gases," 1985.
6. "NS-4-FR Fire Resistant Neutron and/or Gamma Shielding Material" - Product Technical Data, The Japan Atomic Power Company, Tokyo, Japan.
7. Standard Handbook for Mechanical Engineers, Baumeister T. and Mark, L.S., 7th Edition, New York, McGraw-Hill Book Co., 1967.
8. ASME Boiler and Pressure Vessel Code, Section II, Part D, "Properties," American Society of Mechanical Engineers, New York, NY, 2001 Edition with 2003 Addenda.
9. ARMCO Product Data Bulletin No. S-22, "17-4PH, Precipitation Hardening Stainless Steel," ARMCO, Inc., 1988.
10. ASME Code Case N-71-17, "ASME Boiler and Pressure Vessel Code, Code Cases - Boilers and Pressure Vessels," American Society of Mechanical Engineers, New York, NY, 1996.
11. ANSYS, Revision 6.0, ANSYS INC, Canonsburg, PA
12. FLUENT, Revision 6.1, Fluent Inc., Lebanon, NH
13. "Principles of Heat Transfer," Krieth F., Bohn M.S., Fifth Edition, West Publishing Company.
14. "Fundamentals of Heat and Mass Transfer," F.P. Incropera and D.P. DeWitt, 1981.
15. "A Method for Determining the Spent-Fuel Contribution to Transport Cask Containment Requirements," TTC-1019, UC-820, Sandia 90-2406, Sanders, T. L., et al., November 1992.
16. EPRI NP-5128, "The TN-24P PWR Spent-Fuel Storage Cask: Testing and Analyses," Pacific Northwest Laboratory, Virginia Power Company and EG&G, Idaho National Engineering Laboratory, April 1987.
17. "A Physical Introduction to Fluid Mechanics," 1st Edition, Alexander J. Smits, 2000.
18. "Fluid Mechanics," 2nd Edition, Frank M. White, 1979.

19. "Annual Books for ASTM Standards," Section 1, Volume 01.04, American Society for Testing and Materials, West Conshohocken, PA.
20. "NUREG-1567, Standard Review Plan for Spent Fuel Dry Storage Facilities," US Nuclear Regulatory Commission, Washington, DC, March 2000.
21. EPRI TR-100305, "Performance Testing and Analyses of the VSC-17 Ventilated Concrete Cask," Pacific Northwest Laboratory, Virginia Power Company and EG&G, Idaho National Engineering Laboratory, May 1992.
22. "NUREG-1536, Standard Review Plan for Dry Cask Storage Systems", US Nuclear Regulatory Commission, Washington, DC January, 1997.
23. DOE/ET/47912-3, NAC-C-8129, "Domestic Light Water Reactor Fuel Design Evaluation," Volume III, September 1981.
24. DOE/RW-0184, Office of Civilian Radioactive Waste Management, "Characteristics of Spent Fuel, High-Level Waste, and Other Radioactive Wastes Which May Require Long-Term Isolation," Volume 3, December 1987.
25. ASHRAE Handbook, "Fundamentals," American Society of Heating, Refrigeration, and Air Conditioning Engineers, Atlanta, GA, 1993.
26. ASME Boiler and Pressure Vessel Code, Case N-707, "Use of SA-537, Class A Plate for Spent-Fuel Containment Internals in Non-pressure Retaining Applications Above 700°F (370°C)", Section III, Division 3.
27. "The Properties of Gases and Liquids," Bruce E. Poling, etc., 5th Edition, McGraw Hill, 2001.
28. NAC Calculation No. 71160-3050, "MAGNASTOR Passive Cooling Transfer Cask Thermal Evaluation", Atlanta, Georgia.

4.9 Thermal Contingency Events During PWR TSC Preparation and Transfer Operations with TSC in a Standard MAGNASTOR Transfer Cask (MTC)

This section has been prepared to present the analyses performed to evaluate the postulated thermal contingency events, and operational corrective actions to be taken to resolve these events. These events have been analyzed to ensure that the MAGNASTOR System for PWR spent fuel assemblies can be safely loaded by Licensees. Operational requirements for identification of the contingency events and the actions to be taken to resolve are documented in the MAGNASTOR System Operations Manual, Document No. 71160-P-02, or site-specific Operations Manuals prepared for specific utility users.

4.10 Thermal Evaluation for PWR Fuel in the Passive MAGNASTOR Transfer Cask (PMTC)

This section presents the thermal analyses of Passive Cooling MAGNASTOR® Transfer Cask (PMTC) containing a loaded PWR TSC with a maximum heat load of 30 kW for the following conditions:

- The water phase when the lid is being welded to the TSC
- The vacuum drying phase to remove moisture from the TSC
- The helium backfilled phase (24-hours) when second or subsequent vacuum drying phase is required
- The operation of transferring the helium backfilled TSC into the concrete cask with air in the TSC/transfer cask annulus

All the conditions above, except the transfer operation of the TSC into the concrete cask, are analyzed considering the R-ACWS (reverse flow Annulus Circulating Water System) in operation. Cooling water is provided from the eight ports at the top of the PMTC with a minimum flow rate of 100 gpm and at a water inlet temperature of ≤ 125°F. The ambient temperature of the PMTC is considered to the 104°F. For vacuum drying operations, the vacuum drying time is administratively controlled per LCO 3.1.1. The 24-hour helium-backfilled phase is required only if a second or subsequent vacuum drying is needed for PMTC with TSC having a decay heat load > 20 kW. No time limit is required for loading the helium backfilled TSC into the concrete cask as the decay heat is rejected via the air flow in the annulus of the TSC and PMTC.

Results of the analyses demonstrate that the loaded PMTC meets the thermal performance requirements.

4.10.1 Thermal Models for the PMTC Thermal Evaluation

Five thermal models are used for the thermal evaluation for the PMTC, as shown below.

Model No.	Condition	Analysis Type
1	Two-dimensional FLUENT models for transfer condition with air in the annulus and helium inside the canister	Steady State
2	Two-dimensional FLUENT model for water phase with water inside the canister and R-ACWS in operation	Steady State
3	Two-dimensional FLUENT model for vacuum phase with vacuum inside canister and R-ACWS. This model is used to determine the temperature boundary condition for Model No. 5.	Steady State
4	Two-dimensional FLUENT model for the helium cool-down condition with helium inside the canister and R-ACWS in operation	Transient
5	Three-dimensional ANSYS model for vacuum drying condition. Vacuum inside the canister and R-ACWS in operation	Transient and Steady State

Heat generation rate is defined at the active fuel region of the models based on the axial power profile for the PWR fuel as shown in Figure 4.1-1. Heat load distribution in the radial direction in the models is based on the preferential loading pattern as presented in Figure 4.4-3.

4.10.1.1 Two-Dimensional Axisymmetric FLUENT Model for the Transfer Condition (Model No. 1)

The two-dimensional axisymmetric FLUENT model is used to perform a steady state analysis for the transfer condition of the TSC inside the PMTC. The model is shown in Figure 4.10.1. The TSC is backfilled with helium with air flow in the annulus.

The passive cooling transfer cask body has five layers: inner shell, lead, outer shell, water inside the water tank (main tank), and the intermediate shell. The retaining ring at the top of the upper forging and above the canister lid is modeled. The baffles in the water tank are not modeled since they are located along the cask axial direction and have an insignificant impact on water flow. The equivalent area of the air inlet at cask bottom is computed based on the total inlet area and the radius where the inlet is located. The annulus between the cask and TSC shell is filled with air. The standoff in the annulus is not modeled since it has an insignificant impact on the air flow. A dead air gap is modeled below the canister bottom plate and the PMTC door. The air above the passive cooling transfer cask and the canister is modeled so that flow of annulus air above the TSC lid can be simulated.

Since water flow inside the water tank is considered, this model is solved by separating the full geometry into two separate models, and iterating between the two models (see Reference 28 for more details). The air in the annulus and the water in the PMTC water tank are meshed for near-wall turbulence modeling with relatively high mesh density near walls to capture wall gradients and boundary layers. Identical to the PWR model described in Section 4.4.1.1, the loaded TSC is backfilled with helium. The ambient temperature is considered to be 104°F.

4.10.1.2 Two-Dimensional Axisymmetry FLUENT Model for Water Phase (Model No. 2)

The two-dimensional axisymmetric FLUENT model is used to perform a steady state analysis for PMTC containing the loaded TSC with water inside the TSC and cooling water running in the annulus using R-ACWS.

The model is identical the thermal model as described in Section 4.10.1.1, except that 1) the water is in the TSC; 2) the water inside the water tank of the cask body is modeled as solid; 3) The annulus between the cask and the TSC is filled with water to the height corresponding to the inlet location; 4) Since there is water flow in TSC, the mesh in the non-porous zones of the TSC is modified by increasing mesh density near walls to model water flow in the TSC.

The cooling water in the annulus flows downwards with the following boundary conditions:

1. On the top annulus fluid boundary, a constant down-ward velocity is specified, which corresponds a water flow rate of 100 GPM going into the annulus.
2. Pressure is set to zero on the bottom open boundary of the annulus.
3. Water temperature is set to 125°F at top boundaries of the annulus.
4. Relatively low turbulence levels are set on the annulus water boundaries for the k-omega turbulence model.
5. All outer solid boundaries are conservatively modeled as adiabatic.

4.10.1.3 Two-Dimensional Axisymmetry FLUENT Model for Vacuum Drying Condition (Model No. 3)

The two-dimensional axisymmetric FLUENT model is used to perform a steady state analysis to provide boundary conditions for the vacuum drying condition. The model is identical to the model described in Section 4.10.1.2 (Model No. 2), except that the canister is in vacuum condition. The boundary conditions for this model are also identical to those for Model No.2.

4.10.1.4 Two-Dimensional Axisymmetry FLUENT Model for Helium Cool Down Condition (Model No. 4)

The two-dimensional axisymmetric FLUENT model is used to perform a transient analysis for the helium cool down condition, i.e. the TSC is backfilled with helium and water cooling in the annulus.

This model is identical to the Model No.2 except for the canister contains helium with a pressure of 76 psig.

Initial conditions for the transient cooling simulation using this model are:

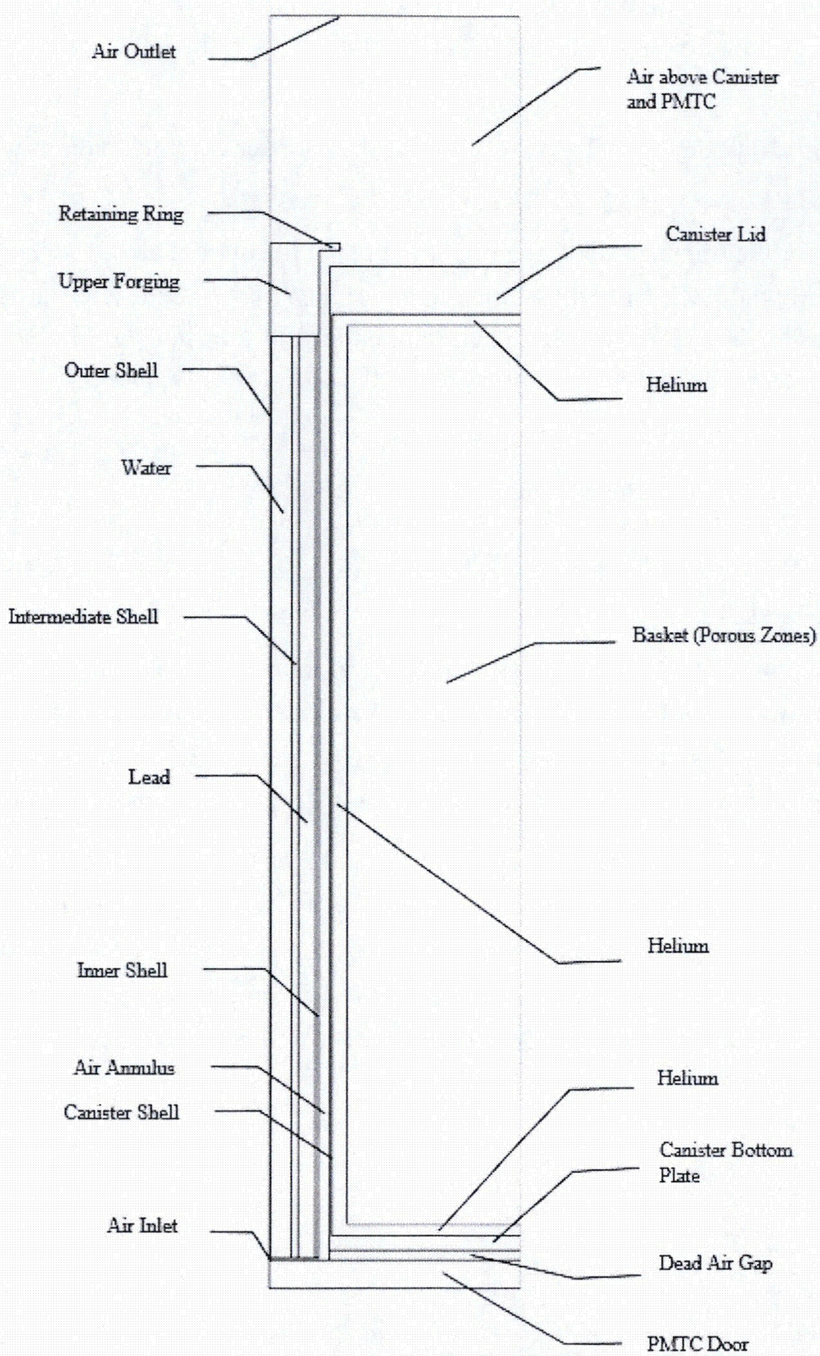
1. Temperature field with a peak temperature of 665 °F is used since at the end of the vacuum drying of 30kW case the peak temperature of the fuel (663°F, from the analysis using ANSYS model described in section 4.10-1.5) is lower than 665 °F.
2. Zero water velocity in the annulus.
3. Zero helium velocity in the canister.

4.10.1.5 Three-Dimensional ANSYS Model for Vacuum Drying Condition (Model No. 5)

The three-dimensional ANSYS model is used to perform transient and steady state analyses for loaded PMTC with water cooling condition in the annulus and vacuum inside the canister. The loaded TSC in this model is identical to the loaded TSC model described in Section 4.4.1.5 (Figure 4.4-16), except the heat load, boundary conditions, and the initial condition.

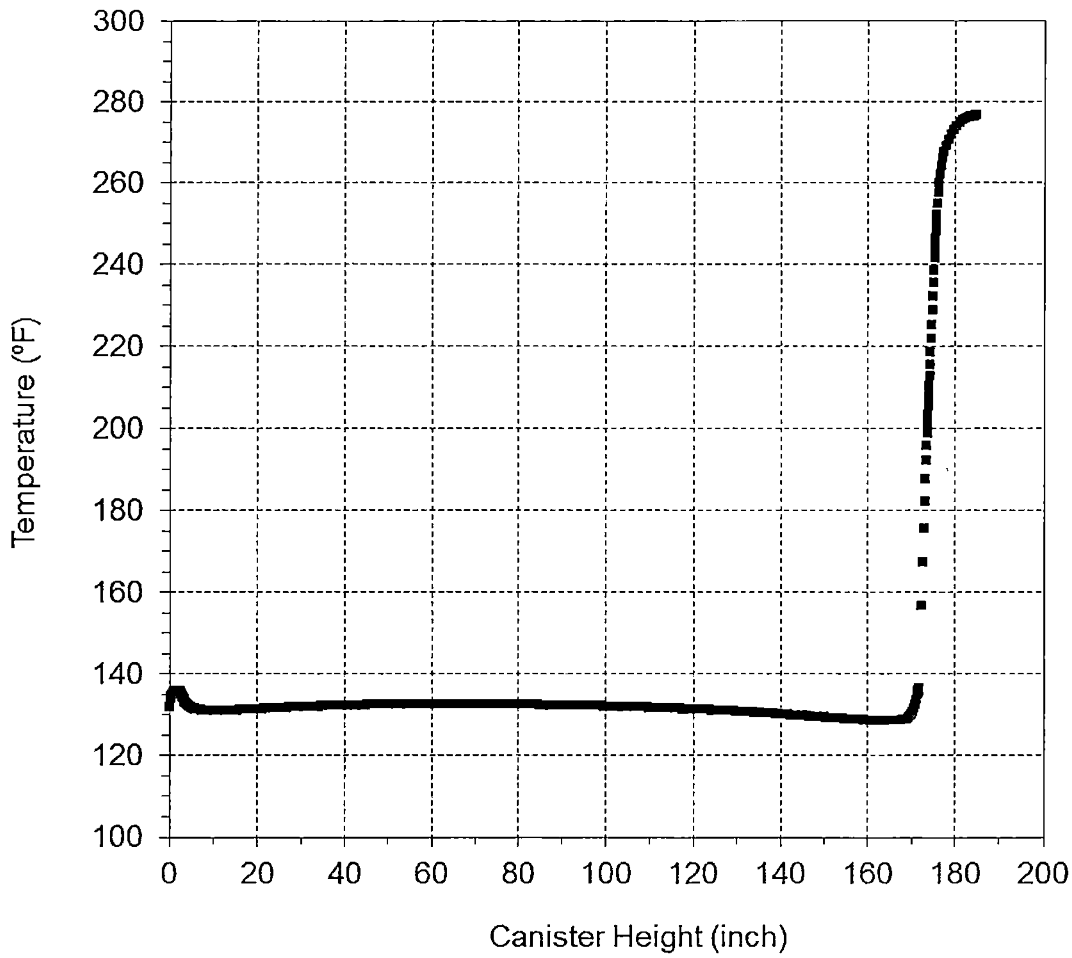
Three heat load cases are considered: 30 kW, 25 kW, and 20 kW. The temperature profile at the TSC outer surface from the analysis using Model No.3 (see Figure 4.10-2) is used as the boundary condition of this model. The outer surfaces of canister top and bottom plate are both conservatively assumed to be adiabatic. The maximum fuel temperature of 143°F from steady state analysis using Model No. 2 is conservatively applied to the entire model as initial temperature condition.

Figure 4.10-1 Two-Dimensional FLUENT Axisymmetric Model for Transfer Condition



(For clarity, mesh is not shown)

Figure 4.10-2 Temperature Distribution of the Canister Outer Surface (°F) – Vacuum Drying Condition



4.10.2 Evaluation of Transfer Operations Using PMTC

Thermal evaluation is performed for the Transfer Cask (PMTC) containing the TSC with PWR fuels for the water, vacuum drying, helium and transfer conditions.

4.10.2.1 Evaluation of the Water Phase

The two-dimensional axisymmetric FLUENT model as described in Section 4.10.1.2 (Model No.2) is used to evaluate the transfer operation when the TSC is filled with water and cooling water running in the annulus between the TSC shell and the inner shell of the PMTC. A steady state analysis is performed using a heat load of 30 kW. The maximum fuel temperature is computed to be 143°F.

4.10.2.2 Evaluation of the Vacuum Drying Phase

A vacuum drying system is used to evacuate and dry the TSC cavity by vaporization and removal of the water vapor and other gases from the cavity through the vent and drain port openings. Thermal analysis for the vacuum drying phase is performed using the three-dimensional ANSYS model as described in Section 4.10.1.5.

Three (3) heat load cases are considered: 20 kW, 25 kW and 30 kW. The initial condition is based on the analysis results for the water phase described in Section 4.10.2.1 (conservative for the 20 kW and 25 kW cases). A bounding boundary condition (TSC shell OD temperature profile) is obtained by a steady state analysis using the two dimensional axisymmetric FLUENT model described in Section 4.10.1.3 (Model No. 3) which corresponds to the heat load of 30 kW.

A transient analysis is performed for 32 hours and 54 hours for the heat load case of 30 kW and 25 kW respectively. A steady state analysis is performed for the 20 kW case. A summary of the maximum temperature for the fuel cladding and the basket is provided in the following table. The maximum fuel temperature as a function of time for the vacuum drying for the 30 kW case is shown in Figure 4.10-3.

Heat Load (kW)	Vacuum Duration (hours)	T_{max} at the End of the Duration (°F)	
		Fuel	Basket
30	32	663	635
25	54	686	658
20	No Limit	648	621

Note that, after completion of vacuum drying and helium backfill, the shield/seal insert shall be removed in 4 hours for TSC with heat load greater than 20 kW and 7 hours for TSC with heat load less or equal to 20 kW. To determine the system thermal performance during this period, the boundary condition of the three-dimensional ANSYS model is conservatively changed to adiabatic and the transient analysis for the vacuum drying phase is continued for another 4 hours for the 25 kW and 30 kW cases. Similarly, a transient analysis is performed for 7 hours for the 20 kW case after the steady state analysis. Note that these analyses are conservative since the TSC has been backfilled with helium with the required helium mass per Table 3A-1 of LCO 3.1.1, while vacuum condition is considered in the thermal model. The maximum fuel temperature is calculated to be 694°F, 697°F and 650°F for the heat load case of 30 kW, 25 kW and 20 kW, respectively. Since these temperatures are below the maximum fuel temperature of 715°F for the steady state transfer condition (See Section 4.10.2.4), the TSC can be transferred to the concrete cask after the shield/seal insert are removed.

If the dryness verification is not met within the first vacuum drying cycle time limits, for TSC's having a decay heat of > 20 kW, the TSC shall be backfilled with helium to 84 (-0, +10) psig and cooled by R-ACWS for a minimum of 24 hours. As presented in Section 4.10.2.3, a bounding transient analysis for the 24 hours cooling period is performed for the 30 kW heat load case. As shown in Figure 4.10-4, the maximum fuel temperature decreased from 665°F to 446°F in 24 hours. By using the temperature history for the first vacuum drying cycle and the effect of the 24-hour cooling with TSC backfilled with helium, the time limit for the second (or subsequent) vacuum drying after the cooling period, is determined to be 17 hours and 34 hours for heat load of 30 kW and 25 kW, respectively, as shown in the following table.

Heat Load (kW)	Helium Backfill Duration (hours)	T_{max} of Fuel at the End of the Helium Backfill (°F)	Second Vacuum Duration (hours)	T_{max} of Fuel at the End of the Second Vacuum (°F)
30	24	444	17	663
25	24	467	34	686

4.10.2.3 Evaluation of the Helium Backfill Phase (24 Hours Cooling)

As discussed in Section 4.10.2.2, if the dryness verification is not met within the first vacuum drying cycle time limits, for TSC's having a decay heat of > 20 kW, the TSC shall be backfilled with helium to 84 (-0,+10) psig and cooled by R-ACWS for a minimum of 24 hours. This section presents a bounding transient analysis for the 24 hours cooling period for the 30 kW heat load case. The two-dimensional FLUENT model described in Section 4.10.1.4 is used for the

analysis. The analysis considers an initial condition with a maximum fuel cladding temperature of 665°F. The maximum fuel temperature history for the 24 hours period is shown in Figure 4.10-4. After 24 hours of cooling, the maximum fuel temperature is 446°F. Note that this analysis is considered to be bounding for TSC with heat load less than 30 kW.

4.10.2.4 Evaluation of Transfer Condtion (Moving the TSC into the Concrete Cask)

A steady state analysis is performed for the PMTC containing the loaded TSC for the 30 kW case. The three-dimensional ANSYS model described in Section 4.10.1.1 is used for the analysis. The decay heat is rejected by the air flow in the annulus. The air temperature at the inlet is considered to be 104°F. There is no time limit for this operation since the maximum fuel temperature for the steady state for this condition is 715°F, which is lower than the allowable temperature of 752°F for fuel cladding.

Figure 4.10-3 Maximum Fuel Temperature vs. Time for Vacuum Drying – 30 kW Case

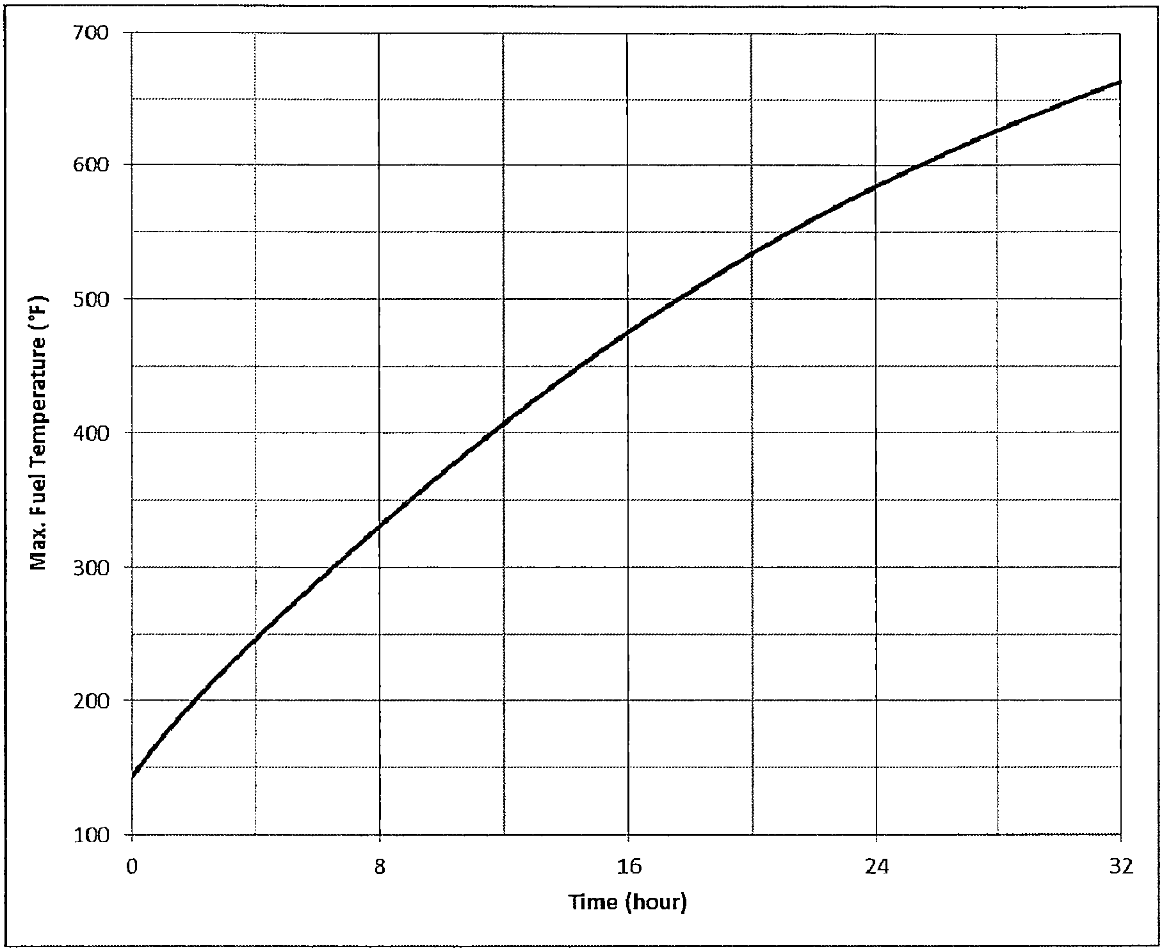
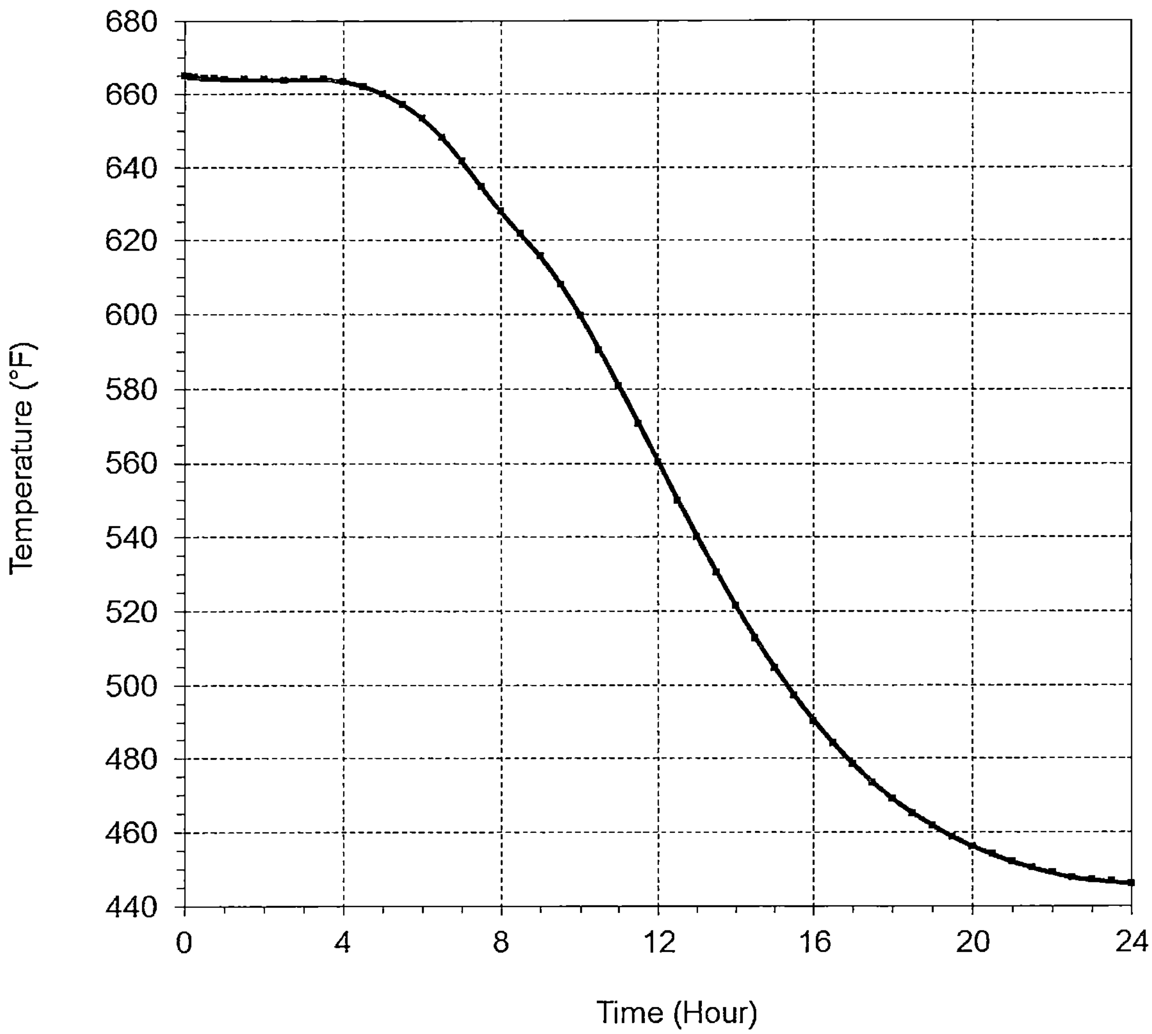


Figure 4.10-4 Maximum Fuel Temperature vs. Time for Cool-down Condition – 30 kW Case



5. Shielding Evaluation

Chapter 5
Shielding Evaluation

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5 SHIELDING EVALUATION

Specific dose rate limits for individual casks in a storage array are not established by 10 CFR 72 [1]. Annual dose limit criteria for the ISFSI-controlled area boundary are established by 10 CFR 72.104 and 10 CFR 72.106 for normal operating conditions and for design basis accident conditions, respectively. These regulations require that, for an array of casks in an ISFSI, the annual dose to an individual outside the controlled area boundary must not exceed 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ during normal operations. For a design basis accident, the dose to an individual outside the controlled area boundary must not exceed 5 rem to the whole body. In addition, the occupational dose limits and radiation dose limits established in 10 CFR Part 20 (Subparts C and D) [2] for individual members of the public must be met.

This chapter describes the shielding design and the analysis used to establish bounding radiological dose rates for the safe storage of up to 37 undamaged PWR fuel assemblies in the 37 PWR basket assembly or up to 87 undamaged BWR fuel assemblies in the 87 BWR basket assembly. 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. Each DFC may contain an undamaged PWR fuel assembly or damaged fuel, which may be a damaged PWR fuel assembly or PWR fuel debris equivalent to one PWR fuel assembly. Undamaged PWR fuel assemblies may be placed directly in the DFC locations of a DF Basket Assembly.

PWR fuel assemblies may contain nonfuel hardware – i.e., reactor control components (RCCs), burnable poison rod assemblies (BPRAs), guide tube plug devices (GTPDs), neutron sources/neutron source assemblies (NSAs), hafnium absorber assemblies (HFRAs), instrument tube tie components, in-core instrument thimbles, and steel rod inserts (used to displace water from the lower section of guide tubes), and components of these devices, such as individual rods. The analysis shows that for the design basis fuel, the system meets the requirements of 10 CFR 72.104 and 10 CFR 72.106 and complies with the requirements of 10 CFR 20 with regard to annual and occupational doses at the owner-controlled area boundary.

The system is designed with three transfer cask and four concrete cask configurations. Transfer casks are designed with either carbon steel shells for PWR and BWR systems (MTC1) or stainless steel shells for the PWR system (MTC2). The passive transfer cask (PMTC) is detailed in Section 5.9. Concrete casks are designed in:

- A standard shielding configuration (one piece – CC1 and segmented – CC2) with a 1.75-inch liner thickness (PWR and BWR systems);
- An augmented shielding configuration (CC3) with a 3-inch liner thickness, an increased lid thickness and additional shielding at the air inlets (PWR system);
- And a short, standard shielding configuration cask (CC4) with a 1.75-inch liner thickness and additional shielding at the air inlets (PWR system).

Canisters may be sealed with either an all stainless steel closure lid (PWR and BWR systems) or a composite carbon steel and stainless steel lid assembly (PWR system). BWR evaluations are performed with the all stainless steel closure lid and PWR evaluations are performed with the composite closure lid assembly. The composite lid assembly bounds the all stainless steel lid in shielding evaluations due to the lower density of carbon steel.

Minimum cool times prior to fuel transfer and storage are specified as a function of minimum assembly average fuel enrichment and maximum assembly average burnup (MWd/MTU). To minimize the number of loading tables, PWR and BWR fuel assemblies are grouped by bounding fuel and hardware mass. Key characteristics of each assembly grouping are shown in Section 5.2. Refer to Section 5.8.9 for detailed loading tables meeting the system heat load limits.

Source terms for the various vendor-supplied fuel types are generated using the SCALE 4.4 sequence as discussed in Section 5.2. Three-dimensional MCNP [3] shielding evaluations provide dose rates for transfer and concrete casks at distances up to four meters. NAC-CASC, a modified version of the SKYSHINE-III code [4], calculates site boundary dose rates for either a single cask or cask array. See Section 5.6 for more detail on the shielding codes.

27. EPA Federal Guidance Report No. 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," US Environmental Protection Agency, Washington, DC, 1998.
28. EPA Federal Guidance Report No. 12, "External Exposure to Radionuclides in Air, Water, and Soil," US Environmental Protection Agency, Washington, DC, 1993.
29. NUREG-1400, "Air Sampling in the Workplace," US Nuclear Regulatory Commission, Washington, DC, September 1993.
30. DOE/RW-0184, "Characteristics of Spent Fuel High-Level Waste and Other Radioactive Wastes Which May Require Long-Term Isolation," U.S. Department of Energy, Washington, DC, December 1987.
31. ORNL/TM-12667, "Validation of the SCALE System for PWR Spent Fuel Isotopic Composition Analyses," Oak Ridge National Laboratory, March 1995.
32. ORNL/TM-13317, "An Extension of the Validation of SCALE (SAS2H) Isotopic Prediction for PWR Spent Fuel," Oak Ridge National Laboratory, September 1996.
33. NUREG/CR-6798, "Isotopic Analysis of High Burnup PWR Spent Fuel Samples from the Takahama-3 Reactor," US Nuclear Regulatory Commission, January 2003.
34. ORNL/TM-13315, "Validation of SCALE (SAS2H) Isotopic Predictions for BWR Spent Fuel," Oak Ridge National Laboratory, September 1998.
35. ORNL/TM-13687, "Prediction of the Isotopic Composition of UO_2 Fuel from a BWR: Analysis of the DU1 Sample from the Dodewaard Reactor," Oak Ridge National Laboratory, October 1998.
36. NUREG/CR-6701, "Review of Technical Issues Related to Predicting Composition and Source Terms for High-Burnup LWR Fuel," US Nuclear Regulatory Commission, January 2001.
37. ORNL/TM-2005/39, Version 6.1, Section M8, "Standard Composition Library," Petrie, L.M., *et al.*, Oak Ridge National Laboratory, June 2011.

5.9 Passive Transfer Cask (PMTC) Shielding Evaluation Detail

This section contains the evaluation of the passive transfer cask (PMTC).

5.9.1 Shielding Discussion and Dose Results

The TSC is loaded and sealed inside the PMTC and then moved into a concrete cask for placement on the ISFSI pad. Dose evaluations are performed for the PMTC. Only CE 16×16 PWR fuel assemblies are evaluated. Therefore, they are the only acceptable payload for the PMTC.

The dose results are presented based on bounding heat loads and corresponding source terms for a 30 kW cask heat load. Cool time tables for the thermally restricting payloads are listed in Section 5.9.7. Based on the code validation discussion in Section 5.2, a 5% uncertainty is applied to the heat loads for fuel burnups above 45 GWd/MTU. All dose rates calculated at higher cask heat loads are bounding for the reduced heat load.

Dose rates (detector tallies) in this chapter are calculated using Monte Carlo methods and, therefore, contain a result and statistical uncertainty of the result. The statistical uncertainty is expressed as a percentage and referred to as fractional standard deviation (FSD) or relative uncertainty.

The PMTC radial shield is comprised of stainless steel inner, intermediate, and outer shells connected by solid steel top and bottom forgings. The inner and intermediate shells enclose a lead gamma shield. The space between intermediate and outer shells contain demineralized water, which serves as the neutron shield. The TSC shell and the basket internal structure provide additional radial shielding. The transfer operation bottom shielding is provided by the TSC bottom plate and solid steel PMTC doors. The TSC closure lid provides radiation shielding at the top of the TSC.

The annulus between the TSC and PMTC inner shell is widened from that in the MTC1 and MTC2 configurations to enable passive cooling during the transfer operation. Vents are added at the bottom of the PMTC to serve as the air inlet. Vent shields and increased bottom forging material provides shielding at the vent locations. At the top of the PMTC, the shield/seal insert assembly and retaining ring provide shielding of streaming through the annulus. The shield/seal insert assembly is utilized during TSC closure operations. The retaining ring is utilized during the transfer operations.

As no shielding changes are made for the PMTC over the bulk of the TSC closure lid, dose rates at the top of the cask are focused on the streaming paths above and around the TSC to PMTC annulus. Both TSC closure operations and transfer operations are considered. Radial and bottom dose rate evaluations are retained. Dose rates at the vent shields and bottom forging are also determined.

The three-dimensional PMTC shielding analysis provides a complete, non-homogenized representation of the PMTC and TSC structure. The model assumes the following TSC/PMTC configuration for all dose rate evaluations.

- Dry canister cavity and TSC to PMTC annulus:
  The majority of the TSC operations, in particular closure lid welding, are performed with the TSC cavity and TSC to PMTC annulus filled with water. Evaluating a dry cask is conservative. Transfer cask dose rates from a wet canister, while containing an increased neutron source due to a higher subcritical multiplication resulting from a higher k_{eff}, are lower than those of the dry system due to the additional radiation shielding provided by the water within and surrounding the source region. PWR and BWR confirmatory calculations comparing dry, wet and partially flooded canister configurations are included in Section 5.8.11. Water in the TSC to PMTC annulus would serve as shielding material while having negligible impact on subcritical neutron multiplication.
- Homogenization of the fuel assembly into four source regions:
  While TSC and concrete cask features are discretely modeled, the fuel assembly is homogenized into upper and lower end-fitting (nozzle) regions, upper plenum regions, and an active fuel region. For shielded applications, such as in the heavily shielded spent fuel transfer cask, homogenizing the fuel region does not introduce a significant bias in the dose results presented.
- The damaged fuel evaluation assumes that the DFCs loaded in the corner basket locations are positioned between the vent shields (i.e. between vent A shield and vent B shield as labeled in Figure 5.9.8-9). This allows damaged fuel dose rates at either vent shield to be evaluated simultaneously.

5.9.1.1 PMTC Undamaged Fuel Dose Rates

The PMTC maximum calculated dose rates are shown in Table 5.9.1-1. Dose rates at the TSC to PMTC annulus for TSC closure and transfer operations are compared in Table 5.9.1-2. Dose rates at the vent shield surface are shown in Table 5.9.1-3. Dose rates at

the door boundary, below the bottom forging, are shown in Table 5.9.1-4. Dose rate contributions for reactor control elements (CEAs) are provided in Table 5.9.1-5.

Dose rates are based on a three-dimensional Monte Carlo analysis using surface detectors and superimposed mesh tally detectors. Detectors were defined to capture all potential streaming paths. Uncertainty in Monte Carlo results is indicated in parentheses. Further detail on the detector geometry is included in Section 5.9.5.

Burnable poison rods are typically employed as replacement rods for CE cores. Poison rods replacing fuel rods are enveloped in the shielding analysis since they are typically constructed with a zirconium alloy clad and do not contain a significant amount of activated material, in particular compared to the fuel rod that they replace.

There is no design basis off-normal or accident event that will affect the shielding performance of the PMTC. Access to the bottom of the cask is limited to pool-to-workstation transfer operations and the workstation-to-vertical concrete cask transfer operations. Site ALARA plans should specify limited access to areas below and around the loaded PMTC during lifting and transfer operations.

5.9.1.2 PMTC Damaged Fuel Dose Rates

Damaged PWR fuel assemblies may be loaded in damaged fuel cans in the four corner assembly locations of the PWR damaged fuel basket. The first scenario assumes the damaged fuel collects over the active fuel length of the fuel assembly. This scenario is modeled by filling the fuel assembly interstitial volume with UO_2 and increasing the fuel neutron, gamma and n-gamma source consistent with this increase in mass. In the second scenario, damaged fuel is assumed to migrate from the active fuel into the lower end fitting region of the fuel assembly, filling all the modeled void space.

Damaged fuel maximum dose rates in the PMTC are summarized in Table 5.9.1-6 and Table 5.9.1-7 for surface and mesh tallies, respectively. Dose rate increases from both scenarios are considered simultaneously by summing their contributions. Details of the damaged fuel evaluation can be found in Section 5.9.10.

Table 5.9.1-1 Summary of PMTC Maximum Dose Rates

Source	Surface (mrem/hr with relative uncertainty)			1 Meter from Surface (mrem/hr with relative uncertainty)		
	Side	Top	Bottom	Side	Top	Bottom
Neutron	25 (4.0%)	87 (0.5%)	611 (2.3%)	12 (2.0%)	52 (1.1%)	129 (1.8%)
Gamma	615 (0.3%)	1,882 (0.4%)	1,397 (1.3%)	161 (0.1%)	571 (2.2%)	778 (0.8%)
Total	640 (0.4%)	1,968 (0.3%)	2,008 (1.1%)	172 (0.2%)	623 (2.0%)	907 (0.7%)

Table 5.9.1-2 Comparison of PMTC Maximum Top Dose Rates for TSC Closure and Transfer Operations

Source	Surface (mrem/hr with relative uncertainty)		1 Meter from Surface (mrem/hr with relative uncertainty)	
	TSC Closure	Transfer	TSC Closure	Transfer
Neutron	87 (0.7%)	87 (0.5%)	18 (0.8%)	52 (1.1%)
Gamma	1,222 (1.5%)	1,882 (0.4%)	327 (1.5%)	571 (2.2%)
Total	1,310 (1.4%)	1,968 (0.3%)	345 (1.4%)	623 (2.0%)

Table 5.9.1-3 Summary of PMTC Maximum Dose Rates at Vent Shield Surface

Source	Dose Rate (mrem/hr)	FSD
Neutron	84	2.1%
Gamma	1,079	1.3%
Total	1,163	1.2%

Table 5.9.1-4 Summary of PMTC Maximum Dose Rates at Door Boundary

Source	Dose Rate (mrem/hr)	FSD
Neutron	478	15.5%
Gamma	1,299	3.4%
Total	1,777	4.8%

Table 5.9.1-5 Summary of PMTC Maximum Dose Rates for CEAs

Source	Dose Rate (mrem/hr)	FSD
Side	0.1	0.6%
Vent Shield	2.0	4.1%
Bottom	51.3	1.2%

Table 5.9.1-6 Summary of PMTC Maximum Dose Rates for Damaged Fuel – Surface Tallies

Source	Side	Top (Closure Ops.)	Top (Transfer Ops.)	Bottom
	(mrem/hr with relative uncertainty)			
Undamaged	640 (0.4%)	1,310 (1.4%)	1,968 (0.3%)	2,008 (1.1%)
Damaged – Active Fuel	27	33	38	23
Damaged – End Fitting	56	-	-	233
Total	723 (0.7%)	1,343 (2.8%)	2,006 (0.8%)	2,264 (1.1%)

Table 5.9.1-7 Summary of PMTC Maximum Dose Rates for Damaged Fuel – Mesh Tallies

Source	Vent Shield	Door Boundary
	(mrem/hr with relative uncertainty)	
Undamaged	1,163 (1.2%)	1,777 (4.8%)
Damaged – Active Fuel	248	259
Damaged – End Fitting	900	465
Total	2,311 (6.5%)	2,501 (5.1%)

5.9.2 Contents Description

Section 5.2 and Section 5.8.1.1 describe the methodology for defining the fuel assembly primary characteristics used in the source term and shielding evaluations. Three-dimensional models of the loaded TSC within the PMTC require the relative elevations of the various source regions, hardware masses, and in-core condition to describe source and shielding models. The elevation of each of the assembly regions also defines the volume into which the fuel assembly is homogenized. The PWR fuel assembly descriptions in Section 5.8.1.1 are retained for this evaluation. Only CE 16×16 PWR fuel assemblies are evaluated for the PMTC.

5.9.3 Source Specification

Source terms were generated for CE 16×16 fuel assemblies as described in Section 5.2 and Section 5.8.1.1. Source terms are produced in the following range:

- Assembly average burnup from 10,000 MWd/MTU to 60,000 MWd/MTU;
- Assembly average initial enrichment 1.3 wt% ^{235}U to 4.9 wt% ^{235}U;
- Cool time from 4 years to 90 years.

Gamma source group structure and fuel and hardware gamma source descriptions are provided in Section 5.2.1. Neutron source group structure and fuel neutron source descriptions are provided in Section 5.2.1. Subcritical neutron multiplication is directly calculated within MCNP for the PMTC shielding evaluation.

The shielding evaluations are performed using a response function approach (see Sections 5.9.6). Allowable cool time, initial enrichment, and maximum assembly average burnup combinations are provided from previous evaluations of transfer and storage casks. Fuel assembly source spectra for the cases (initial enrichment, burnup and cool time) producing the maximum radial surface PMTC dose rates are shown in Table 5.9.3-1 for the gamma source and in Table 5.9.3-2 for the neutron source. Fuel gamma sources in the tables are expressed on a per-assembly basis, while the hardware (nonzirconium alloy) source is expressed on a per-kilogram basis. Source term descriptions for the sources producing maximum dose rates at the surface and 1-meter are summarized in Table 5.9.3-3.

The source terms which produce maximum dose rates at the vent shields and areas around the bottom forging and doors were determined using a select number of burnup, initial enrichment, and cool time combinations. The source terms described in Table 5.9.3-4 produced dose rates at the bottom forging locations only marginally higher than the dose rates produced using the maximum radial surface source terms in Table 5.9.3-1 and Table 5.9.3-2.

The axial burnup profile described in Section 5.3 is retained. The axial burnup profile is converted to an axial source profile as described in Section 5.4.

Table 5.9.3-1 Gamma Source Spectrum – PMTC Maximum Radial Dose Rate Configuration

Assembly Type	CE 16×16	
Burnup	30,000 MWd/MTU	
Cool Time	4.8 yrs	
Initial Enrichment	2.1 wt%	
Group	[γ/sec/assy]	[γ/sec/kg]
1	0.0000E+00	0.0000E+00
2	5.2802E+03	0.0000E+00
3	1.0212E+05	0.0000E+00
4	4.8100E+05	0.0000E+00
5	2.4520E+06	0.0000E+00
6	6.1099E+06	0.0000E+00
7	1.1406E+10	8.3340E-16
8	9.1471E+10	4.0530E+04
9	2.7100E+12	2.6139E+07
10	1.1702E+12	5.2714E+02
11	4.0335E+12	6.9480E+00
12	3.6722E+13	2.4761E+12
13	3.3916E+13	2.6101E+12
14	2.2329E+14	3.5731E+10
15	1.7118E+15	4.6082E+06
16	5.6231E+14	1.3303E+07
17	5.5325E+13	2.0995E+08
18	7.6238E+13	1.6001E+08
19	2.6795E+14	3.2227E+09
20	3.2950E+14	1.3358E+10
21	7.3443E+14	3.8207E+10
22	5.2179E+14	4.5367E+10
Total	4.5613E+15	5.2225E+12

Table 5.9.3-2 Neutron Source Spectrum – PMTC Maximum Radial Dose Rate Configuration

Assembly Type	CE 16×16
Burnup	30,000 MWd/MTU
Cool Time	4.8 yrs
Initial Enrichment	2.1 wt%
Group	[n/sec/assy]
1	0.000E+00
2	1.169E+04
3	4.872E+04
4	1.619E+05
5	5.077E+05
6	1.363E+06
7	2.353E+06
8	7.873E+06
9	1.337E+07
10	1.809E+07
11	4.299E+07
12	6.703E+07
13	1.745E+07
14	6.054E+06
15	1.636E+02
16	0.000E+00
17	0.000E+00
18	0.000E+00
19	0.000E+00
20	0.000E+00
21	0.000E+00
22	0.000E+00
23	0.000E+00
24	0.000E+00
25	0.000E+00
26	0.000E+00
27	0.000E+00
28	0.000E+00
Total	1.773E+08

Table 5.9.3-3 Source Terms for Maximum PMTC Dose Rates – Surface Tallies

	Surface			1-Meter		
Surface	Assembly Average Burnup (GWd/MTU)	Initial Enrichment (wt% ^{235}U)	Cool Time (yrs)	Assembly Average Burnup (GWd/MTU)	Initial Enrichment (wt% ^{235}U)	Cool Time (yrs)
Radial	30	2.1	4.8	25	2.1	4.0
Top	30	2.1	4.8	35	2.3	5.7
Bottom	40	2.5	6.9	35	2.3	5.7

Table 5.9.3-4 Source Terms for Maximum PMTC Dose Rates – Maximum Mesh Tallies

	Surface		
Surface	Assembly Average Burnup (GWd/MTU)	Initial Enrichment (wt% ^{235}U)	Cool Time (yrs)
Above Vent B	35	2.3	5.7
Door Boundary	40	2.5	6.9

5.9.4 Model Specification

The PMTC is evaluated using the MCNP three-dimensional Monte Carlo code. In the MCNP fuel assembly model, the fuel and hardware source regions are homogenized within a volume defined by the fuel assembly width and height. This volume is subdivided axially into active fuel, upper and lower plenum, and upper and lower end fitting source regions. Within these axial volumes, the material masses of the fuel assembly are homogenized.

The three-dimensional shielding analysis allows detailed modeling of the shield regions, including streaming paths. In all models, the cask and TSC shield thicknesses and axial extents are explicitly represented, including streaming paths.

The geometric description of an MCNP model is based on the combinatorial geometry system embedded in the code. In this system, surfaces and bodies, such as cylinders and rectangular parallelepipeds, and their logical intersections and unions, are used to describe the extent of material zones.

The MCNP code employs an automated biasing technique for the Monte Carlo calculation based on weight window adjustments in mesh cells. Radial biasing is performed to estimate dose rates at the PMTC radial surface and vent shields. Axial biasing is used for cask top and bottom surface rates. DXTRAN spheres are applied as an angular biasing technique to increase sampling at the vent shield locations. Exponential transforms are used to direct particles in the area of interest.

5.9.4.1 TSC, Basket, and Fuel Assembly Model Description

The fuel assembly model described in Section 5.8.3.1.1 is retained. The 37-assembly PWR basket model described in Section 5.8.3.1.2 is retained. The TSC model described in Section 5.5.1.1 is retained. The composite closure lid is evaluated for PMTC dose rates.

5.9.4.2 Model Description

The PMTC is evaluated in detail for the TSC closure (welding, draining, and drying) and transfer operations. As with MTC1 and MTC2 models, all basket areas, with the exception of the fuel assembly, are discretely modeled. Six inches of auxiliary shielding are included for TSC closure operations. The TSC cavity and TSC to PMTC annulus are modeled as dry. Key PMTC shield features are listed in Table 5.9.4-1. Figure 5.9.4-1 provides a model sketch of the PMTC with TSC. This sketch includes the PMTC with retaining ring, signifying transfer operations. Figure 5.9.4-2 provides a model sketch of

the PMTC with shield/seal insert assembly, signifying TSC closure operations. Figure 5.9.4-3 provides a model sketch of the radial shielding. Figure 5.9.4-4 provides a model sketch of the inlet structure.

5.9.4.3 Shield Regional Densities

Material densities for the fuel, basket, TSC, and cask components modeled are listed in this section. Basket, TSC, and cask components are explicitly modeled. Density and material compositions for structural components are primarily obtained from the standard composition library included with SCALE6.1 [37]. Exceptions to this rule are the density of the demineralized water and the composition of the neutron absorber sheets in the basket. The demineralized water density, 0.9616 g/cm^3, was determined using a conservative maximum water temperature of 200°F (93.3°C). The neutron absorber sheet composition is based on an aluminum-boron carbide mixture containing an areal density of 0.30 $g^{10}B/cm^2$. The PMTC is evaluated under dry TSC cavity conditions. Therefore, the absorber sheets do not affect system dose rates significantly. Basket, TSC, and cask material densities and compositions are shown in Table 5.9.4-2. Fuel region densities are calculated quantities dependent on the hardware and fuel masses in the assembly. The CE 16×16 homogenized fuel assembly material description is shown in Table 5.9.4-3. The maximum initial enrichment of 5.0 wt% ^{235}U is applied for the fuel material description.

Figure 5.9.4-1 PMTC/TSC Model – Axial Sketch

[redacted]

Figure 5.9.4-2 PMTC/TSC Model – Shield/Seal Insert Assembly

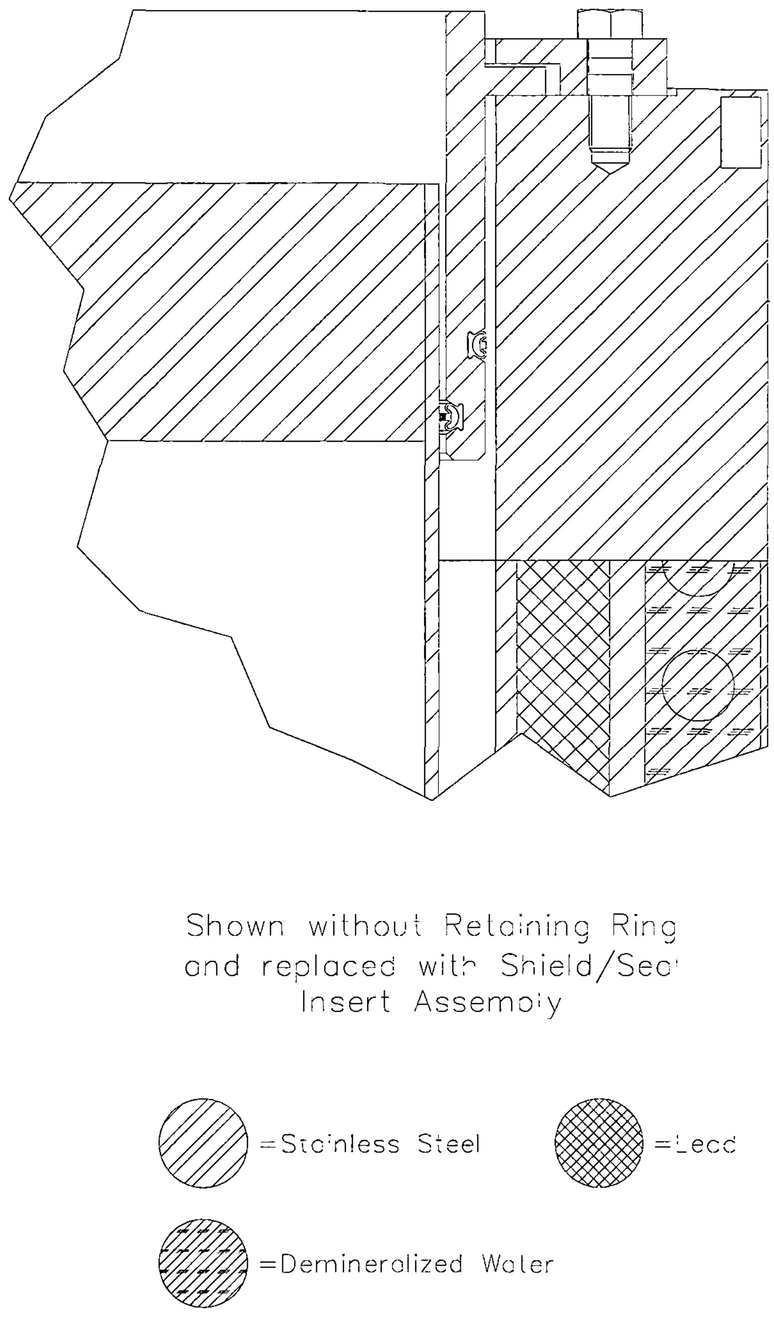


Figure 5.9.4-3 PMTC/TSC Model – Radial Sketch

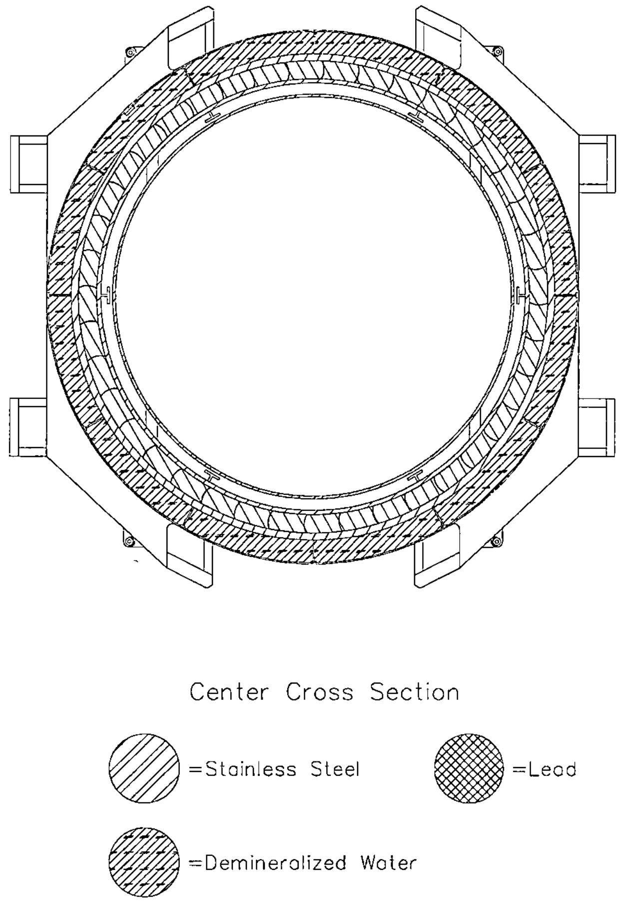


Figure 5.9.4-4 PMTC/TSC Model – Inlet Sketch

[redacted]

Table 5.9.4-1 Key PMTC Shielding Features

Feature	Material	Dimension
Inner Shell	Stainless Steel	0.75-in. thick, 77.5-in. OD
Intermediate Shell	Stainless Steel	1.25-in. thick, 86.6-in. OD
Outer Shell	Stainless Steel	0.25-in. thick, 95-in. OD
Top Weldment	Stainless Steel	16.5-in. height
Bottom Weldment	Stainless Steel	6-in. height
Gamma Shield	Lead	3.2-in. thick
Neutron Shield	Demineralized Water	3.95-in. thick
Door	Stainless Steel	6-in. thick
Door Rails	Stainless Steel	6.25-in. thick
Retaining Ring	Stainless Steel	3-in. thick
Shield/Seal Insert	Stainless Steel	2.75 in. thick
Door Vent Shield	Stainless Steel	1.5 in. – 2.5 in. thick
Rail Vent Shield	Stainless Steel	1.5 in. thick

Table 5.9.4-2 Fuel Basket, TSC, and PMTC Material Description

Material	Density [g/cm^3]	Nuclide / Element	Density [atom/barn-cm]
Carbon and Low-Alloy Steel	7.8212	CARBON	3.9250E-03
		IRON	8.3497E-02
Stainless Steel	7.94	CARBON	3.1848E-04
		SILICON	1.7025E-03
		PHOSPHORUS	6.9409E-05
		CHROMIUM	1.7472E-02
		MANGANESE	1.7387E-03
		IRON	5.8543E-02
		NICKEL	7.7392E-03
Lead	11.344	LEAD	3.2967E-02
Water	0.96162	HYDROGEN	6.4344E-02
		OXYGEN	3.2172E-02
Neutron Absorber (PWR)	2.6336	ALUMINUM	4.3879E-02
		BORON-10	5.6534E-03
		BORON-11	2.3413E-02
		CARBON	7.2622E-03

Table 5.9.4-3 CE16×16 Fuel Region Homogenized Material Description

Material	Density [g/cm³]	Nuclide / Element	Density [atom/barn-cm]
Lower End-Fitting	1.7170	CARBON	6.8869E-05
		SILICON	3.6815E-04
		PHOSPHORUS	1.5009E-05
		CHROMIUM	3.7782E-03
		MANGANESE	3.7599E-04
		IRON	1.2660E-02
		NICKEL	1.6736E-03
Lower Plenum	2.6069	CHROMIUM	3.0192E-05
		TIN	1.9176E-04
		IRON	5.9034E-05
		HAFNIUM	8.7954E-07
		ZIRCONIUM	1.6905E-02
Active Fuel	3.8195	URANIUM-235	3.5109E-04
		URANIUM-238	6.5866E-03
		ZIRCONIUM	4.6106E-03
		CHROMIUM	8.2349E-06
		TIN	5.2301E-05
		HAFNIUM	2.3989E-07
		OXYGEN	1.3864E-02
		IRON	1.6101E-05
Upper Plenum	0.7412	CARBON	2.6174E-05
		SILICON	1.3992E-04
		PHOSPHORUS	5.7043E-06
		CHROMIUM	1.4370E-03
		TIN	6.5216E-06
		MANGANESE	1.4290E-04
		IRON	4.8133E-03
		HAFNIUM	2.9913E-08
		NICKEL	6.3604E-04
		ZIRCONIUM	5.7492E-04
Upper End-Fitting	1.3635	CARBON	5.4692E-05
		SILICON	2.9236E-04
		PHOSPHORUS	1.1919E-05
		CHROMIUM	3.0004E-03
		MANGANESE	2.9858E-04
		IRON	1.0053E-02
		NICKEL	1.3290E-03

5.9.5 Detector Definition

MCNP surface tallies are used to calculate dose rates at various distances from the cask top, bottom, and side surfaces. Surface, 1m, 2m, and 4m detectors are evaluated for the PMTC. The surface tallies are subdivided using the FS tally segmentation card.

Detector grids for the PMTC top and bottom are shown in Table 5.9.5-1. Top dose rates are taken in the vicinity of the TSC to PMTC annulus. Shielding over the TSC surface away from the annulus are not changed from the MTC1 and MTC2 designs. Dose rates for those locations are detailed in Section 5.8.3. For TSC closure operations, top surface detectors are at the axial location of the auxiliary shielding. For transfer operations, top surface detectors are at the axial location of the retaining ring surface. The surface tally is segmented into approximately 1-inch radial bands. This is sufficient to capture streaming through the 2-inch annulus. There are no cask design features at the annulus that would require azimuthal splitting.

Detector grids for the side detectors are shown in Table 5.9.5-2. Side surface detectors extend from the top of the vent shields to the retaining ring surface. The surface tally is segmented into approximately 5-inch axial bands. There are no cask design features that would provide streaming paths in the radial shielding. Therefore, the axial meshing is sufficient. There are no cask design features along the cask surface, above the vent shields, that would require azimuthal splitting.

MCNP superimposed rectangular mesh tallies are used to calculate dose rates at the vent shields, bottom forging, and doors. Mesh descriptions are shown in Table 5.9.5-3. All mesh segments are less than 1.4 inches. The vent openings are 6 inches and 6.6 inches in width. The detector meshing chosen is sufficient to capture dose rates on the surfaces.

The dose maps produced by these methods completely enclose the accessible cask surfaces. Flux to dose rate conversion factors are applied to all tallies using the factors provided in Section 5.6.2.

Table 5.9.5-1 PMTC Top and Bottom Surface Detector Division

	Top		Bottom	
Location	Radial Div	Azimuthal Div	Radial Div	Azimuthal Div
Surface	50	1	40	1
1ft	50	1	40	1
1m	50	1	40	1
2m	50	1	40	1
4m	50	1	40	1

Table 5.9.5-2 PMTC Radial Surface Detector Division

Location	Axial Div	Azimuthal Div
Surface	40	1
1m	40	1
2m	40	1
4m	50	1

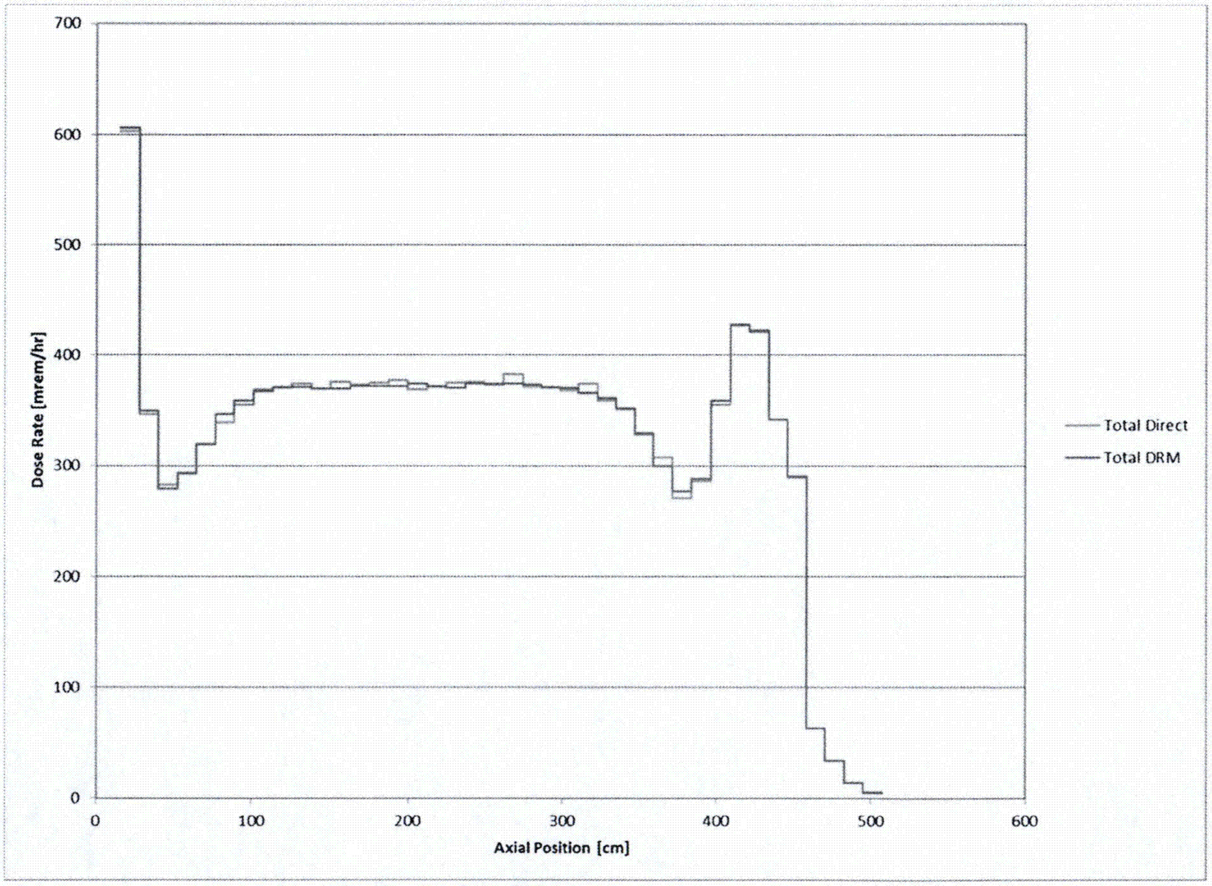
Table 5.9.5-3 PMTC Bottom Forging and Vent Shield Detector Division

Location	Axial (in.)	Y-Direction (in.)	X-Direction (in.)
Vent Shields	1.2	1.2	1.2
Bottom Forging Corner	1.2	--	1.2
Door Boundary	1.2	1.4	1.2

5.9.6 Response Methodology

The response function method is described in Section 5.8.2. A comparison of the results of the direct calculation (i.e., a calculation based on use of the complete gamma, neutron or hardware gamma source spectrum in an MCNP run) and dose response method (summation of dose calculation at each energy group) is shown in Figure 5.9.6-1 for the PMTC. The differences are minimal, justifying the response function method. The comparison was performed with a low burnup and low enrichment combination (25 GWd/MTU assembly average burnup, 2.1 wt% ^{235}U initial enrichment, and 4-year cool time) similar to those in Section 5.9.3.

Figure 5.9.6-1 Comparison of Response Method to Direct Solution: PMTC Radial Surface



5.9.7 Minimum Cool-Time Tables

The PMTC system performance is evaluated for a cask heat load of 30 kW. Minimum cool times are summarized for the cask heat load. Only uniform patterns are evaluated for the PMTC.

Allowed low burnup (up to 25,000 MWd/MTU) fuel loadings are shown in Table 5.9.7-1. Note that the listed minimum cool times at each burnup step are bounding for all initial enrichments above the minimum enrichment specified.

The minimum cool time tables account for potential uncertainties in the source generation abilities of SAS2H at burnups greater than 45 GWd/MTU by reducing allowed heat loads by 5 percent. Fuel assembly loading tables at greater than 45 GWd/MTU are, therefore, generated for a cask heat load of 28.5 kW. Table 5.8.9-2 contains the minimum cool times for heat loads of 811 W/assy for assembly average burnups less than 45 GWd/MTU and heat loads of 770 W/Assy for burnups greater than 45 GWd/MTU.

The extension in cool time for high burnup fuel assemblies would reduce source for those assemblies. All dose rates are calculated with the higher heat load source terms. The source terms producing maximum dose rates for the PMTC all occur at lower burnups and shorter cool time combinations, resulting in no dose rate impact for this assumption.

Decay heat associated with loading nonfuel components requires an increase in the minimum fuel assembly cool time. Fuel assemblies loaded with a reactor control element (CEA) should be cooled an additional 0.4 years to accommodate the hardware heat load.

Table 5.9.7-1 Low Burnup CE 16×16 Fuel in the PMTC Loading Table

Max. Assembly Avg. Burnup (MWd/MTU)	Min. Assembly Avg. Initial Enrichment (wt% ^{235}U)	Minimum Cool Time (yrs)
10,000	1.3	4.0
15,000	1.5	4.0
20,000	1.7	4.0
25,000	1.9	4.1

Table 5.9.7-2 Loading Table for CE 16×16 Fuel in the PMTC

Minimum Initial Assembly Avg. Enrichment (wt% ^{235}U)	Assembly Average Burnup (GWd/MTU)						
	25 < B ≤ 30	30 < B ≤ 35	35 < B ≤ 40	40 < B ≤ 45	45 < B ≤ 50	50 < B ≤ 55	55 < B ≤ 60
	Minimum Cooling Time (years)						
1.3 ≤ E < 1.5	-	-	-	-	-	-	-
1.5 ≤ E < 1.7	-	-	-	-	-	-	-
1.7 ≤ E < 1.9	-	-	-	-	-	-	-
1.9 ≤ E < 2.1	-	-	-	-	-	-	-
2.1 ≤ E < 2.3	4.8	-	-	-	-	-	-
2.3 ≤ E < 2.5	4.7	5.7	-	-	-	-	-
2.5 ≤ E < 2.7	4.7	5.6	6.9	-	-	-	-
2.7 ≤ E < 2.9	4.6	5.5	6.8	8.9	-	-	-
2.9 ≤ E < 3.1	4.6	5.5	6.7	8.8	14.0	-	-
3.1 ≤ E < 3.3	4.5	5.4	6.6	8.6	13.7	19.0	-
3.3 ≤ E < 3.5	4.5	5.3	6.6	8.5	13.4	18.7	23.5
3.5 ≤ E < 3.7	4.5	5.3	6.5	8.3	13.1	18.2	23.1
3.7 ≤ E < 3.9	4.4	5.2	6.4	8.2	12.9	17.9	22.7
3.9 ≤ E < 4.1	4.4	5.2	6.3	8.1	12.6	17.7	22.4
4.1 ≤ E < 4.3	4.4	5.2	6.3	8.0	12.4	17.4	22.1
4.3 ≤ E < 4.5	4.4	5.1	6.2	7.9	12.2	17.1	21.8
4.5 ≤ E < 4.7	4.3	5.1	6.2	7.8	12.0	16.8	21.5
4.7 ≤ E < 4.9	4.3	5.0	6.1	7.8	11.9	16.6	21.3
E ≥ 4.9	4.3	5.0	6.1	7.7	11.8	16.4	21.1

5.9.8 PMTC Dose Rates

PMTC dose rates as a function of distance from the cask are shown in Figure 5.9.8-1 through Figure 5.9.8-4. PMTC dose rates as a function of source type (e.g., fuel gamma source) are shown in Figure 5.9.8-5 through Figure 5.9.8-8. Bottom dose rates peak at the center of the doors or fuel assemblies as expected.

Dose peaks occur on the radial cask surface near the top and bottom forging locations where activated end-fitting contributions control dose rates. Over the fuel region, the dose shape follows the burnup shape.

On the top axial cask surface, dose rates rise in the TSC to PMTC annulus area where significant radiation streaming occurs. For TSC closure operations, the shield/seal insert assembly provides some shielding at the annulus location. For transfer operations, the streaming paths are shielded by the retaining ring. However, just inside the retaining ring ID, the streaming through the annulus and contributions through the TSC closure lid without auxiliary shielding results in maximum dose rates.

Superimposed mesh tallies were used to calculate dose rates on the vent shield and bottom forgings. The vent shields are identified using the labels shown in Figure 5.9.8-9. The maximum dose rate from any of the vent shield surfaces is found on the top of Vent B, the result of streaming through the vents. The dose rate contour map from this assembly is provided in Figure 5.9.8-10. Uncertainties in the mesh results are generally under 5% in areas with higher dose rates. Dose rates around the bottom forging are less than those at the vent shields.

The bottom steel doors do not extend to the full radius of the cask. In combination with the TSC to PMTC annulus, this results in dose rate peaks. The peak does not show on the bottom surface dose rate profiles signifying a localized streaming location. A superimposed mesh tally was used to calculate the dose rates. These are the maximum dose rates which occur on the PMTC. The results are plotted in Figure 5.9.8-11.

Refer to Table 5.9.1-1 through Table 5.9.1-4 for maximum dose rates.

Figure 5.9.8-1 PMTC Side Dose Rate Profile at Various Distances

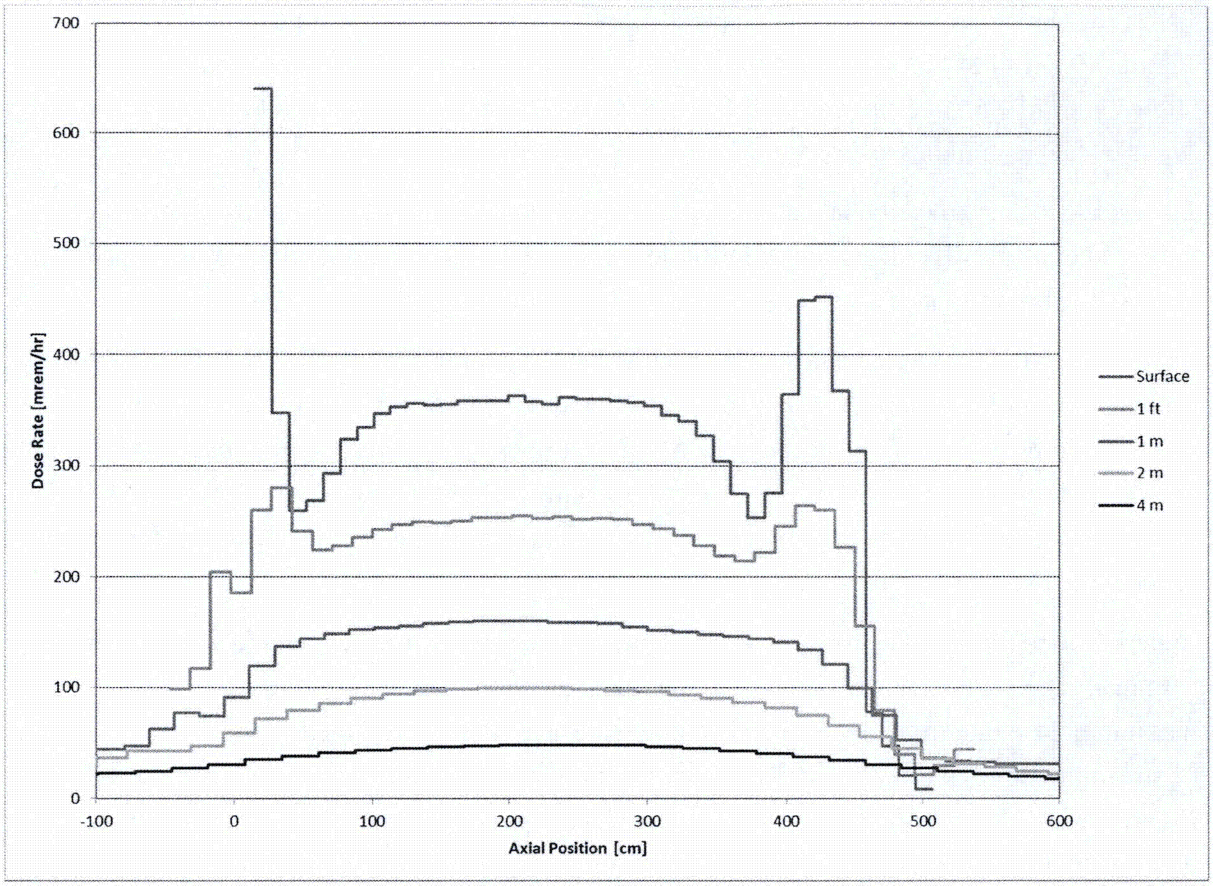


Figure 5.9.8-2 PMTC Top Dose Rate Profile at Various Distances – TSC Closure Operations

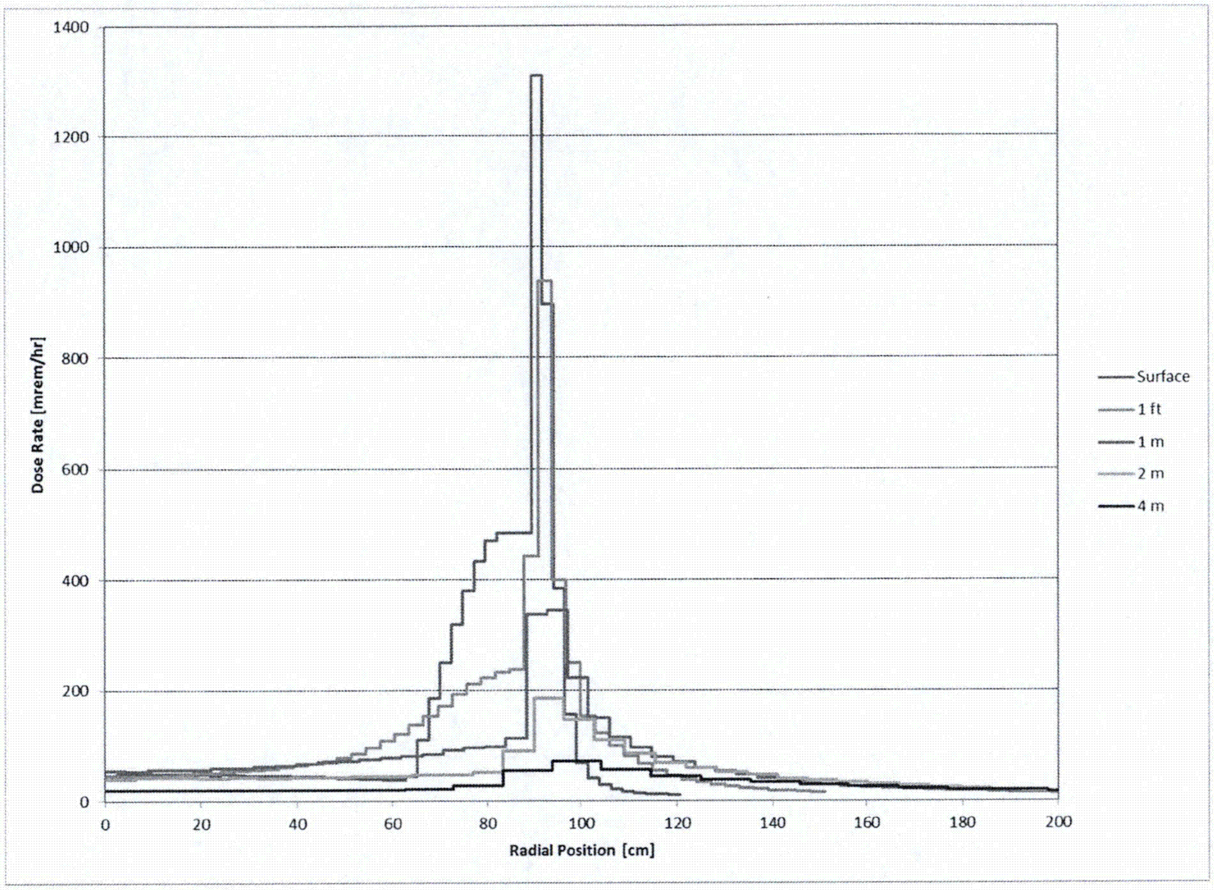


Figure 5.9.8-3 PMTC Top Dose Rate Profile at Various Distances – Transfer Operations

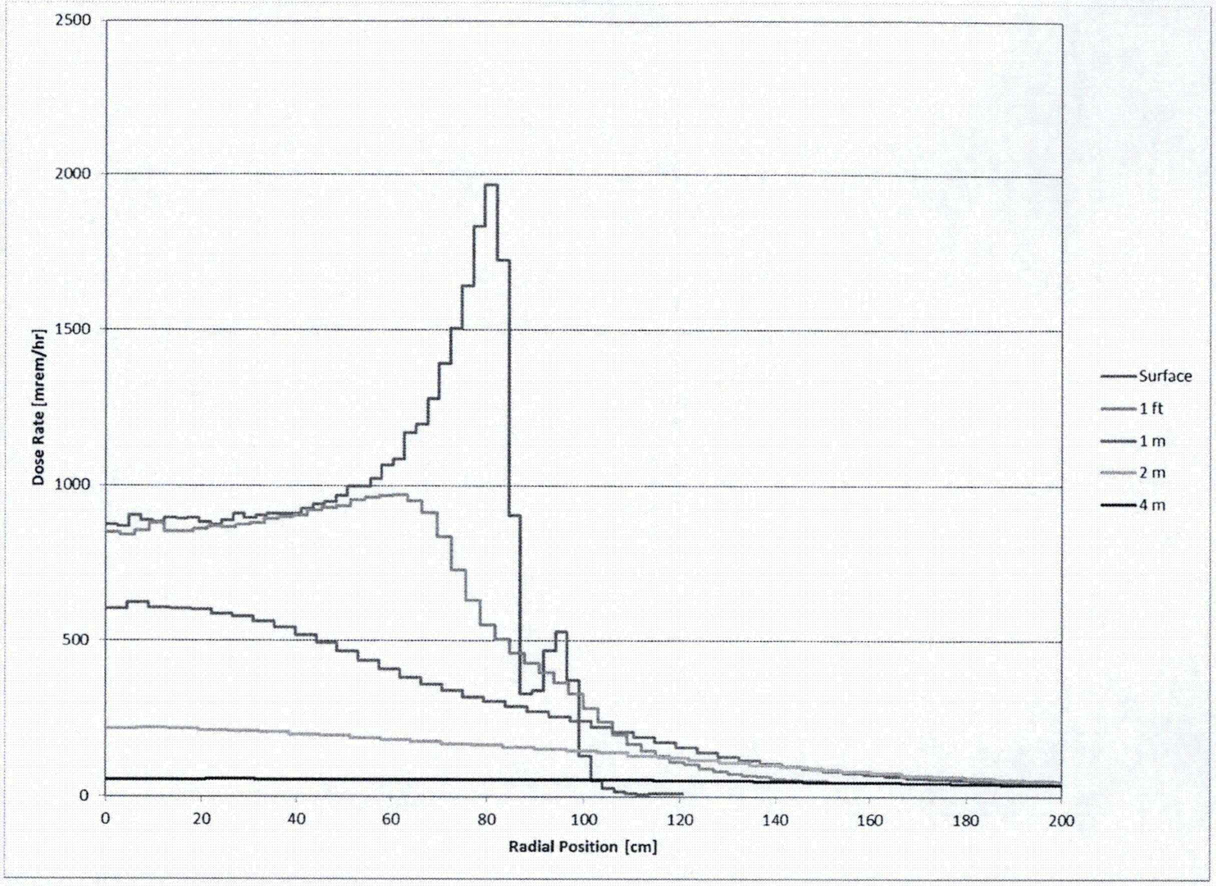


Figure 5.9.8-4 PMTC Bottom Dose Rate Profile at Various Distances

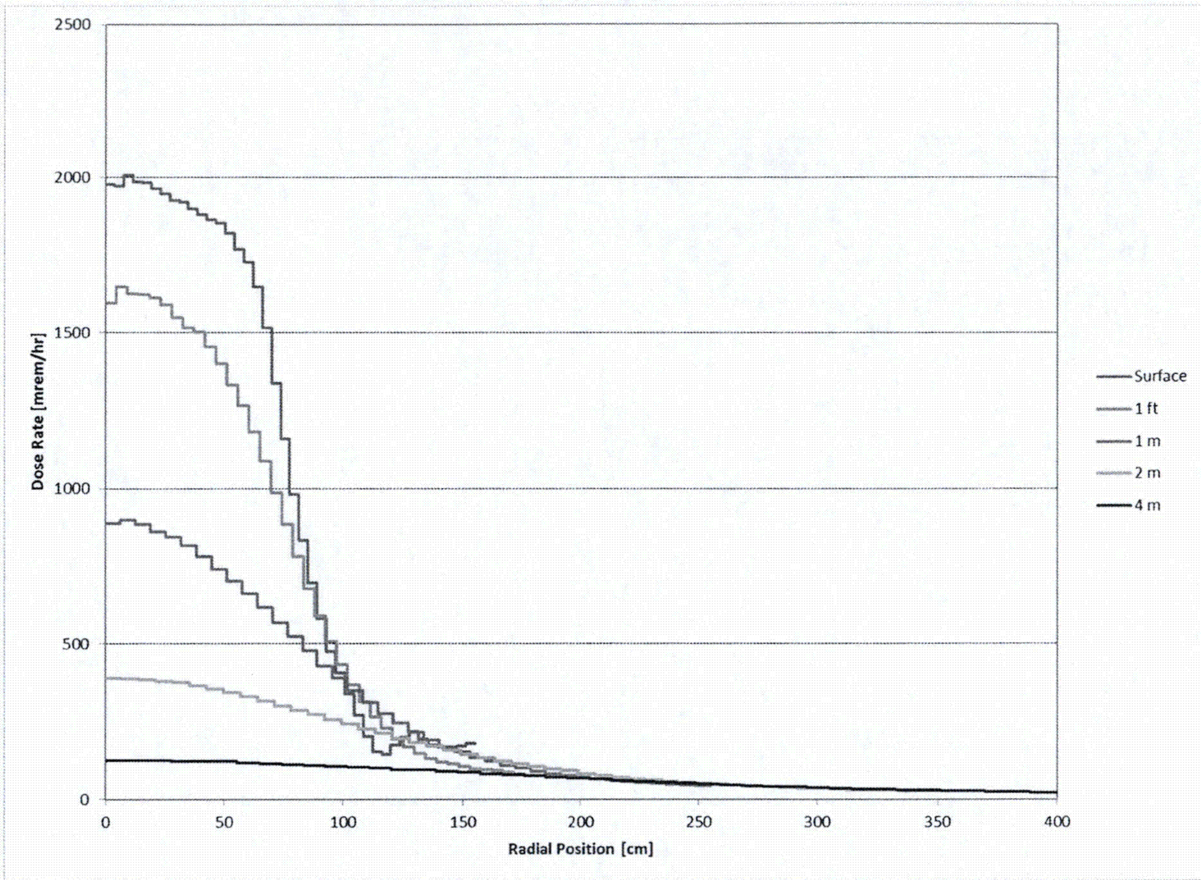


Figure 5.9.8-5 PMTC Side Surface Dose Rate Profile by Source Type

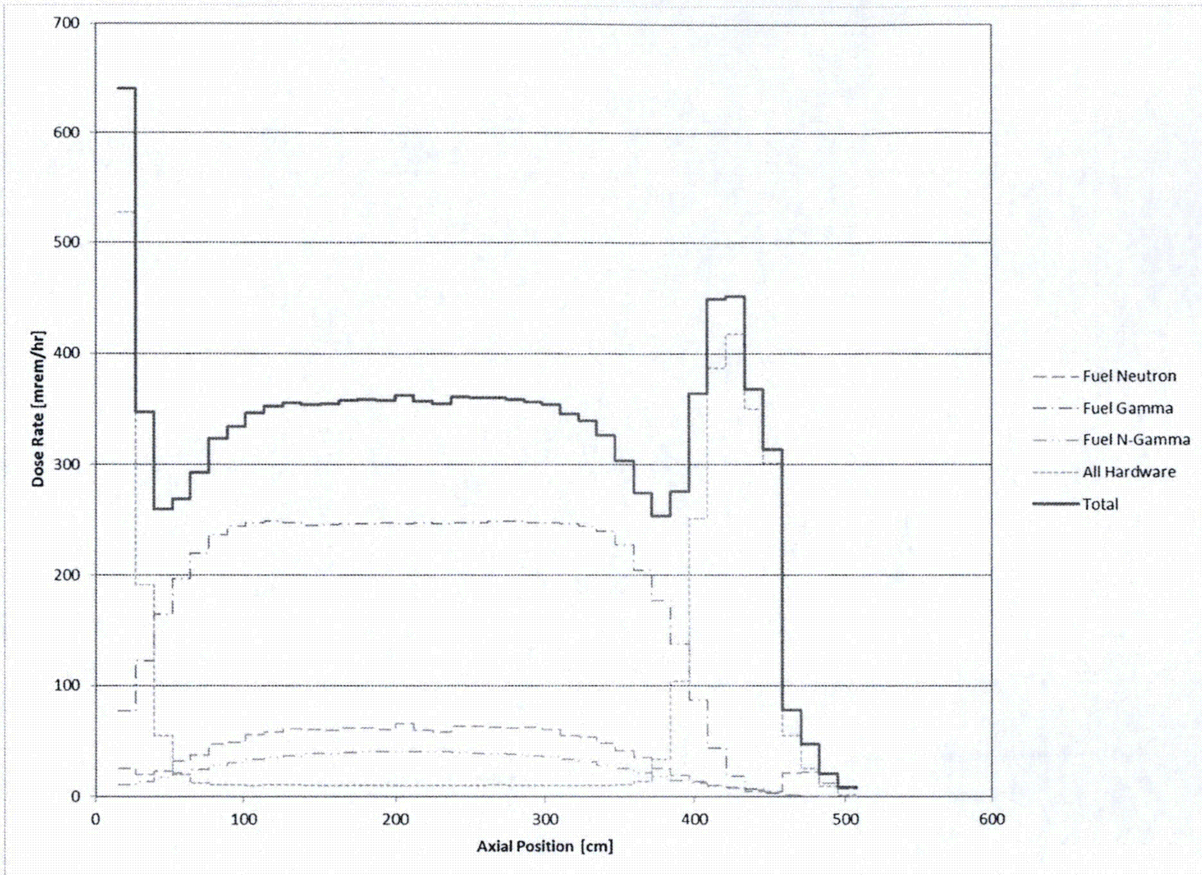


Figure 5.9.8-6 PMTC Top Surface Dose Rate Profile by Source Type – TSC Closure Operations

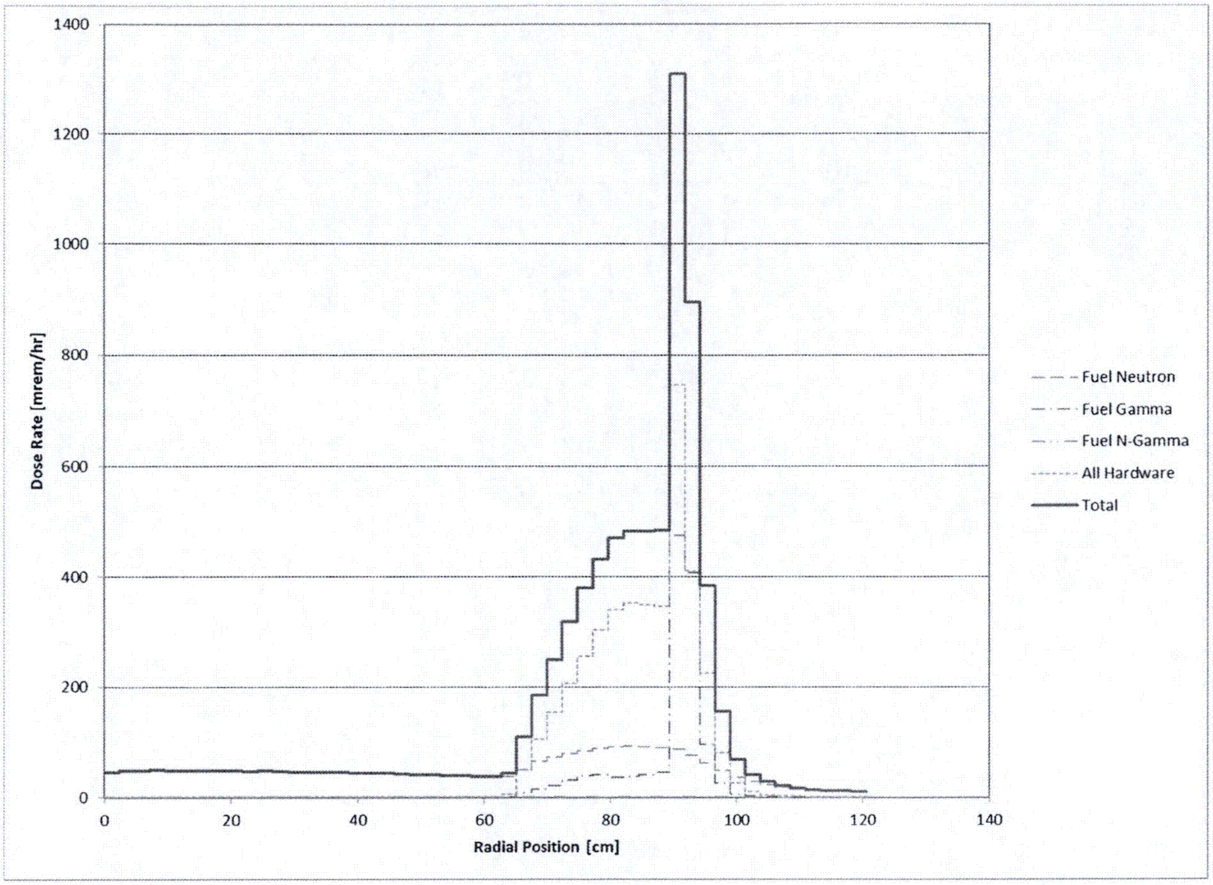


Figure 5.9.8-7 PMTC Top Surface Dose Rate Profile by Source Type – Transfer Operations

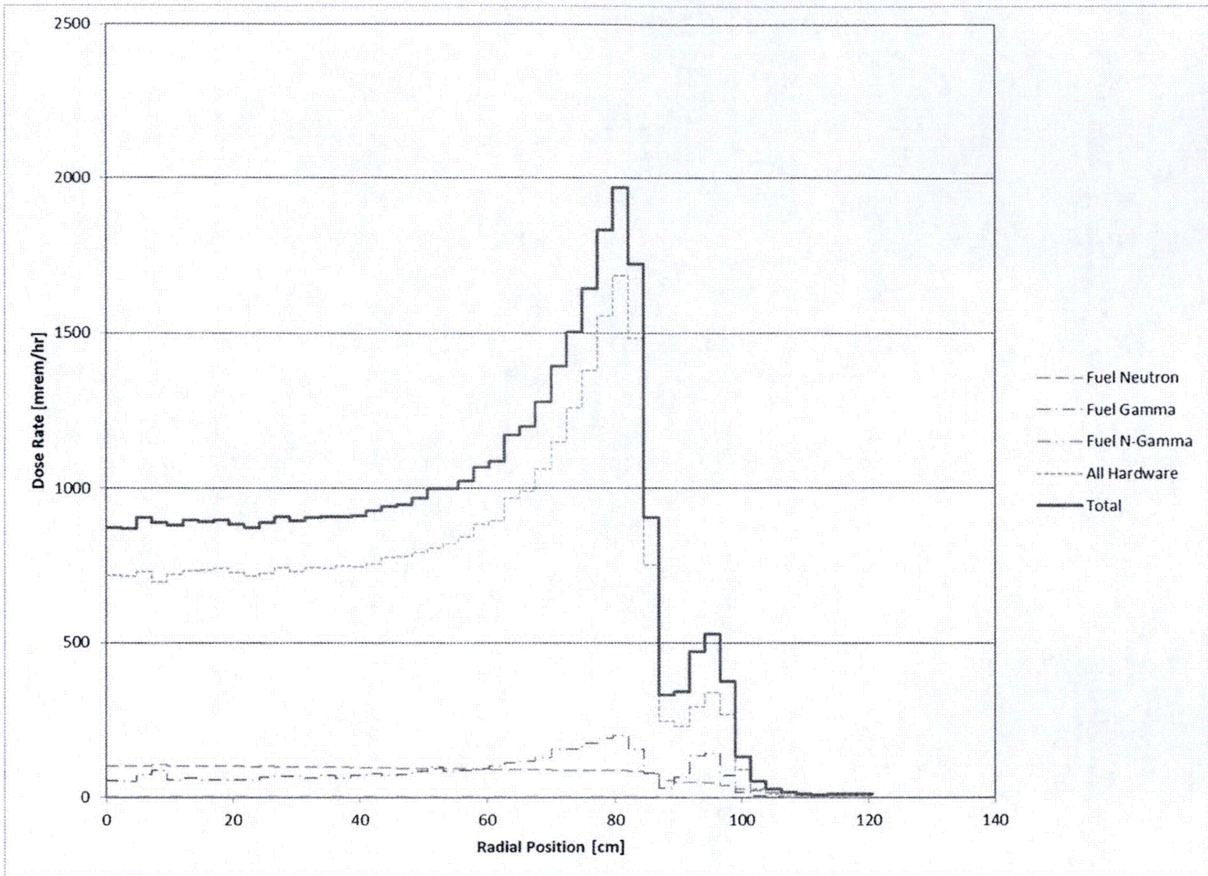


Figure 5.9.8-8 PMTC Bottom Surface Dose Rate Profile by Source Type

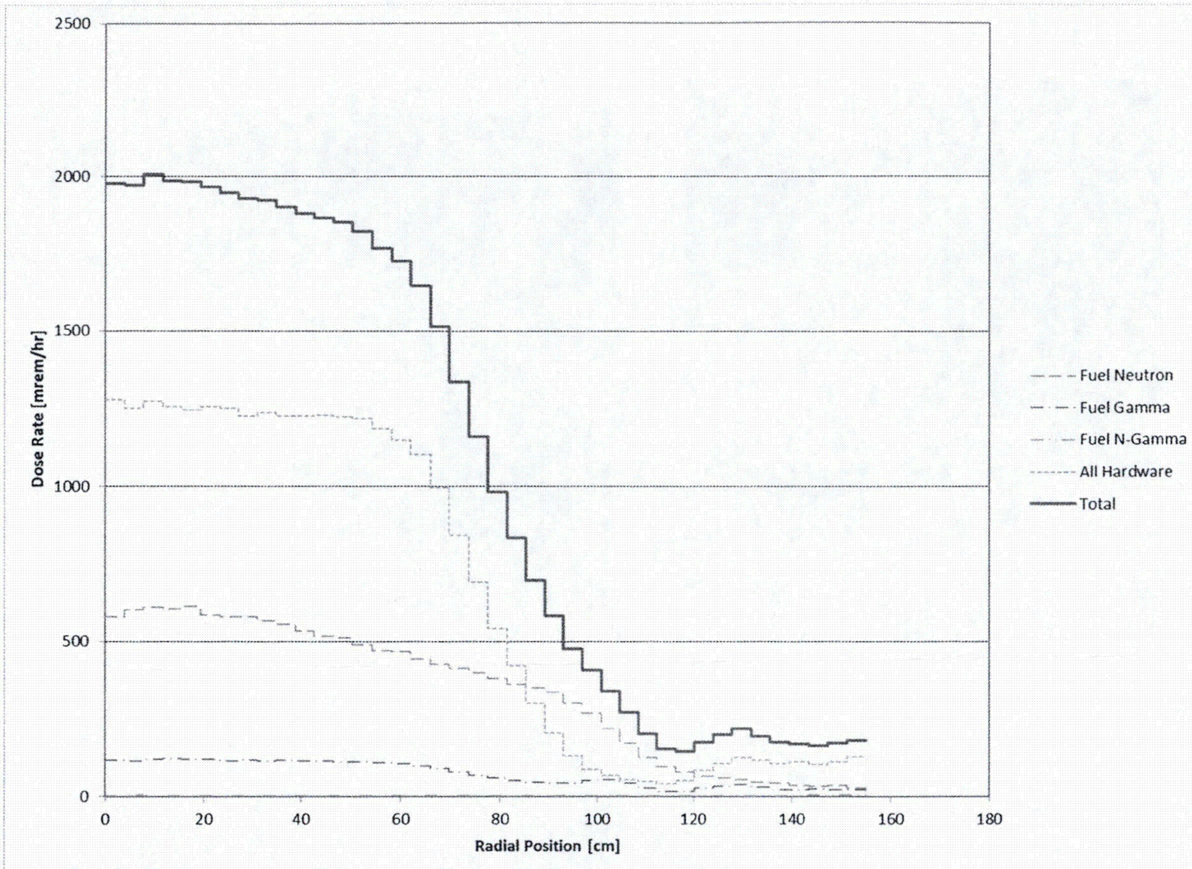


Figure 5.9.8-9 Vent Shield Label Identification

[redacted]

Figure 5.9.8-10 PMTC Vent Shield Maximum Dose Rate (mrem/hr) Contour Plot – Vent B, Top

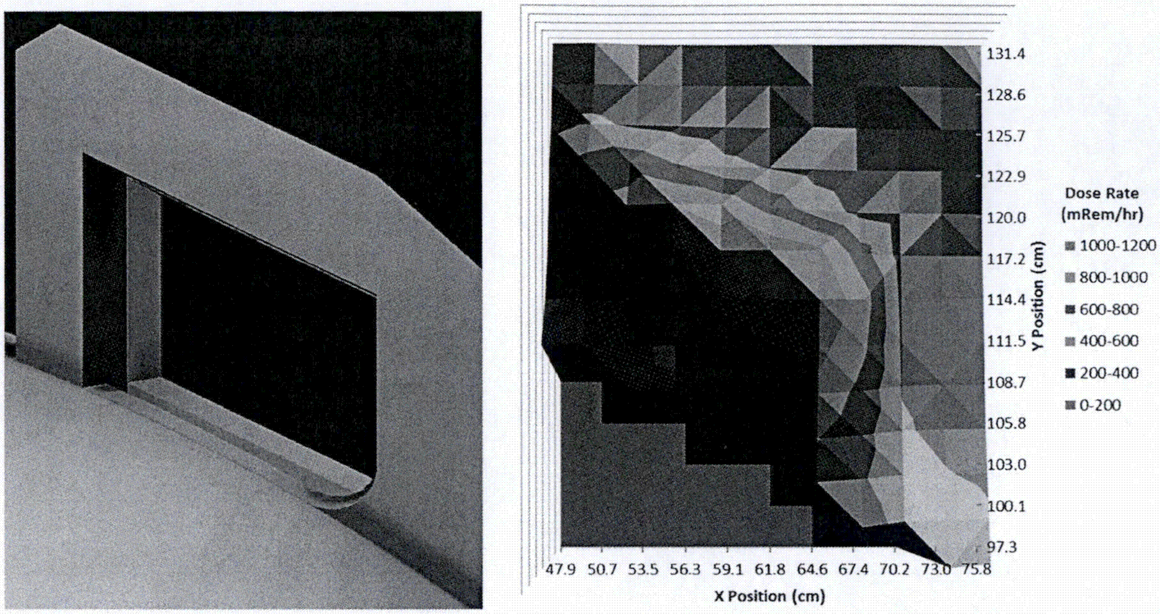
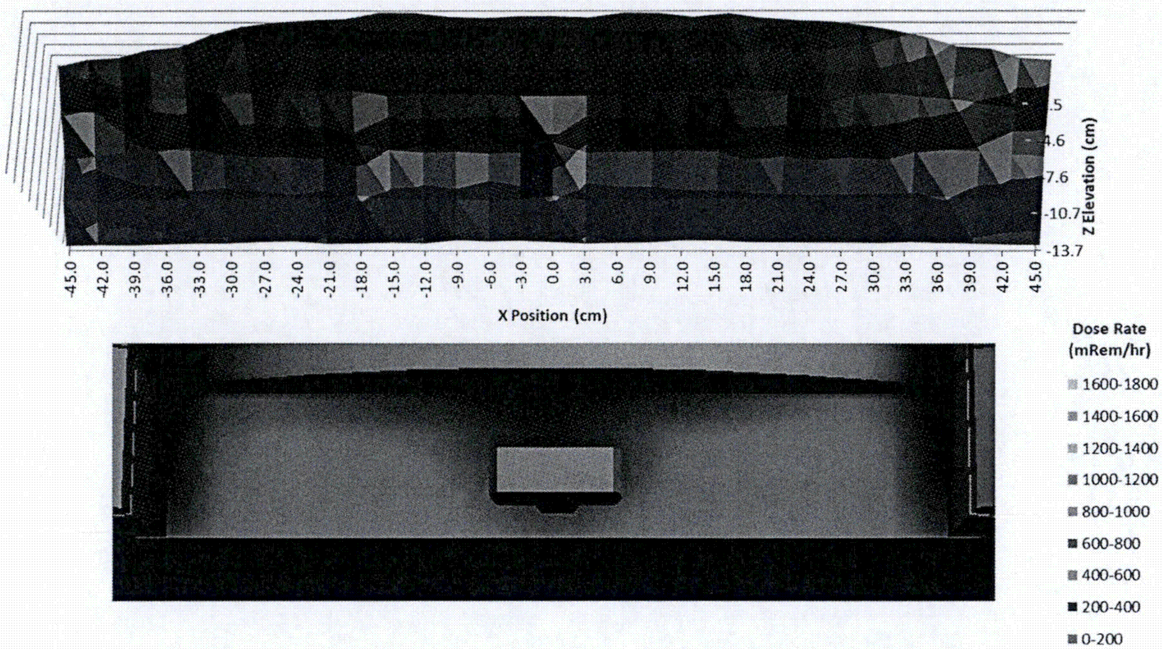


Figure 5.9.8-11 PMTC Door Boundary Dose Rate (mrem/hr) Contour Plot



5.9.9 Non-fuel Hardware – Reactor Control Elements

Reactor control elements (CEAs) are evaluated in the PMTC using the methods described in Section 5.8.6. The CEA material, geometry, and source descriptions are retained, and dose rates are calculated with the PMTC MCNP model, including detectors. Only the center nine basket locations are allowed to contain the hardware. Fuel assemblies loaded with a CEA should be cooled an additional 0.4 years to accommodate the hardware heat load.

The exposure equivalents and required minimum cool times for the CEAs are listed in Table 5.8.6-5. The 180 GWd/MTU exposure equivalent and 10-year cool time remains the bounding source term for dose rates. The dose rate contributions from CEAs are summarized in Table 5.9.1-5. All CEA contributions are minimal in comparison to the total dose rates.

5.9.10 Damaged Fuel

Damaged PWR fuel assemblies may be loaded in damaged fuel cans in the four corner assembly locations of the PWR damaged fuel basket. The damaged fuel evaluation in Section 5.8.12 is repeated for the PMTC.

To ensure that the worst case configuration is considered, two damaged fuel scenarios are evaluated. The first scenario assumes the damaged fuel collects over the active fuel length of the fuel assembly. This scenario is modeled by filling the fuel assembly interstitial volume with UO_2 and increasing the fuel neutron, gamma and n-gamma source consistent with this increase in mass. This scenario models more mass and source than physically possible in each of the four damaged fuel assembly locations. Subcritical neutron multiplication is calculated within MCNP which should conservatively overestimate neutron dose rates due to increased fuel mass.

In the second scenario, damaged fuel is assumed to migrate from the active fuel into the lower end fitting region of the fuel assembly, filling all the modeled void space. However, no credit is taken for the reduction in lower end fitting hardware dose rate due to the added UO_2 mass and self-shielding nor for the reduction in fuel mass migrated from the active fuel region.

The maximum increase as a result of each scenario is added to the maximum dose rate from the undamaged fuel evaluation. This conservatively ignores the location (or subdetector) at which the damaged fuel contribution occurs. Note that for the vent shields and bottom forging, each surface as described in Figure 5.9.8-9 is considered an independent detector. And the mesh cells forming that surface are considered subdetectors.

The resulting material compositions are shown in Table 5.9.10-1 for CE 16×16 PWR fuel.

In the model, no credit is taken for the thicker plates in the corner locations of the damaged fuel basket or the thickness of the damaged fuel cans themselves.

The source term chosen for the damaged fuel is the 25 GWd/MTU burnup, 2.1 wt. % ^{235}U initial enrichment, and 4.0 year cool time. This is the source term which produces maximum dose rates at 1 meter from the cask side surface. At 1 meter, dose rates are driven by fuel gamma source. Therefore, this source term is appropriate for the damaged fuel evaluation. A high burnup source term was applied for dose rates near the bottom forging and vent shields to determine if an increased neutron source resulted in increased dose rates. All undamaged fuel maximum dose rates from Section 5.9.8 are retained for summarizing the final maximum dose rates.

5.9.10.1 Active Fuel Scenario

A comparison of side surface dose rates for the damaged fuel, fuel sources only, is shown in Figure 5.9.10-1. Top dose rates during TSC closure operations, shown in Figure 5.9.10-2, increase slightly with the inclusion of damaged fuel. Top dose rates during transfer operations, shown in Figure 5.9.10-3, are also increased. A comparison of bottom surface dose rates for the damaged fuel is shown in Figure 5.9.10-4.

Maximum dose rates at the vent shields are increased due to damaged fuel. The additional dose as a result of damaged fuel is shown in Table 5.9.1-7.

5.9.10.2 Lower End Fitting Scenario

Side surface dose rate contributions from damaged fuel in the lower end fitting are shown in Figure 5.9.10-5. Top dose rates will not be affected by damaged fuel in the lower end fitting. Bottom dose rates are increased due to the damaged fuel as is shown in Figure 5.9.10-6. A higher burnup source, 40 GWd/MTU, as described in Table 5.9.3-3 was utilized for the damaged fuel contribution to the bottom surface dose rates.

Damaged fuel in the lower end fitting is in the vicinity of the bottom forging, vents, and transfer cask doors. The maximum dose rates for the PMTC occur adjacent to the transfer cask doors. Therefore maximum dose rates are increased in this scenario. The maximum dose rates at the vent shields and door boundary for damaged fuel are shown in Figure 5.9.10-7.

5.9.10.3 Combined Damaged Fuel Dose Rates

Damaged fuel dose rate contributions from the active fuel scenario and lower end fitting scenario are summed for the total dose rate for the PMTC with damaged fuel. The results are provided in Table 5.9.1-6 and Table 5.9.1-7. Total dose rates are conservatively calculated as the maximum increase for each damaged fuel scenario added to the maximum undamaged dose rate. This conservatively ignores the location of the contributions by not summing their individual subdetector results.

Figure 5.9.10-1 Dose Rate Profile Comparison at Radial Surface of PMTC – Active Fuel Damaged – Fuel Source Only

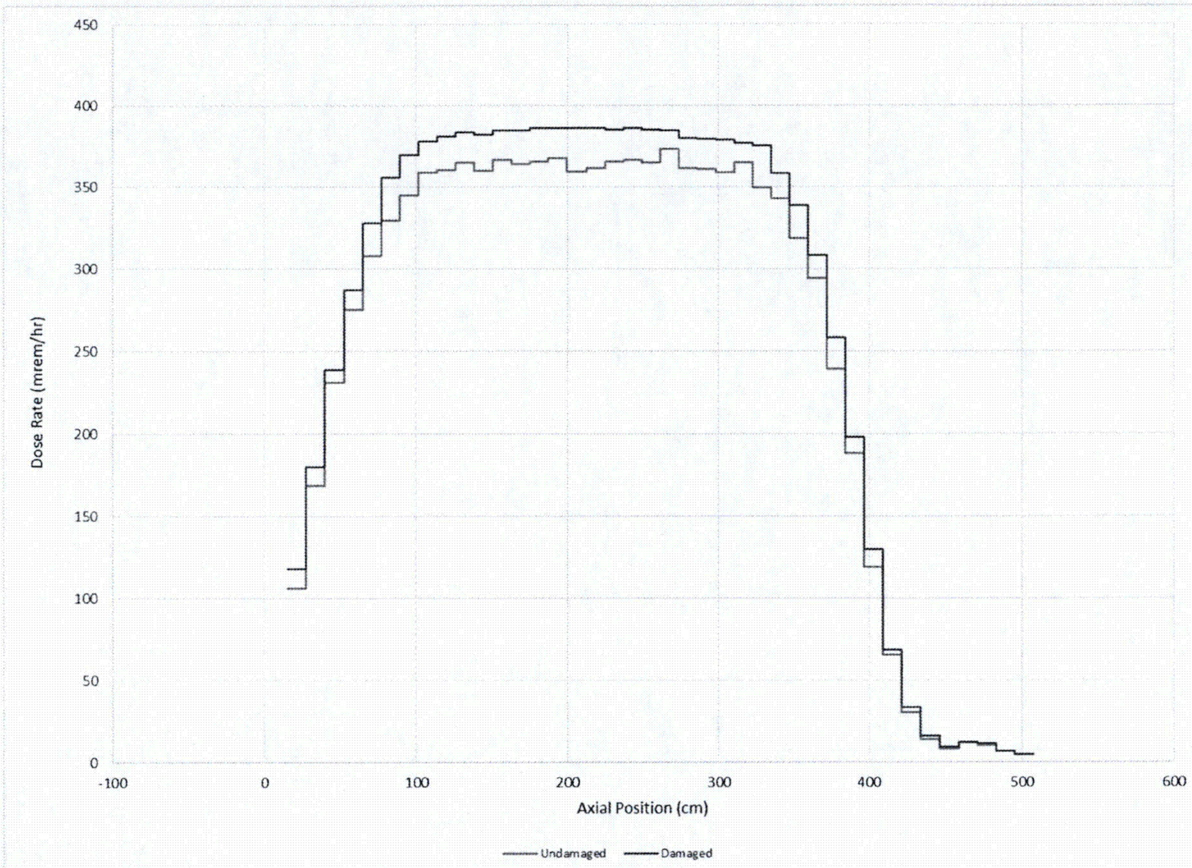


Figure 5.9.10-2 Dose Rate Profile Comparison at Top Surface of PMTC – TSC Closure Operations – Active Fuel Damaged – Fuel Source Only

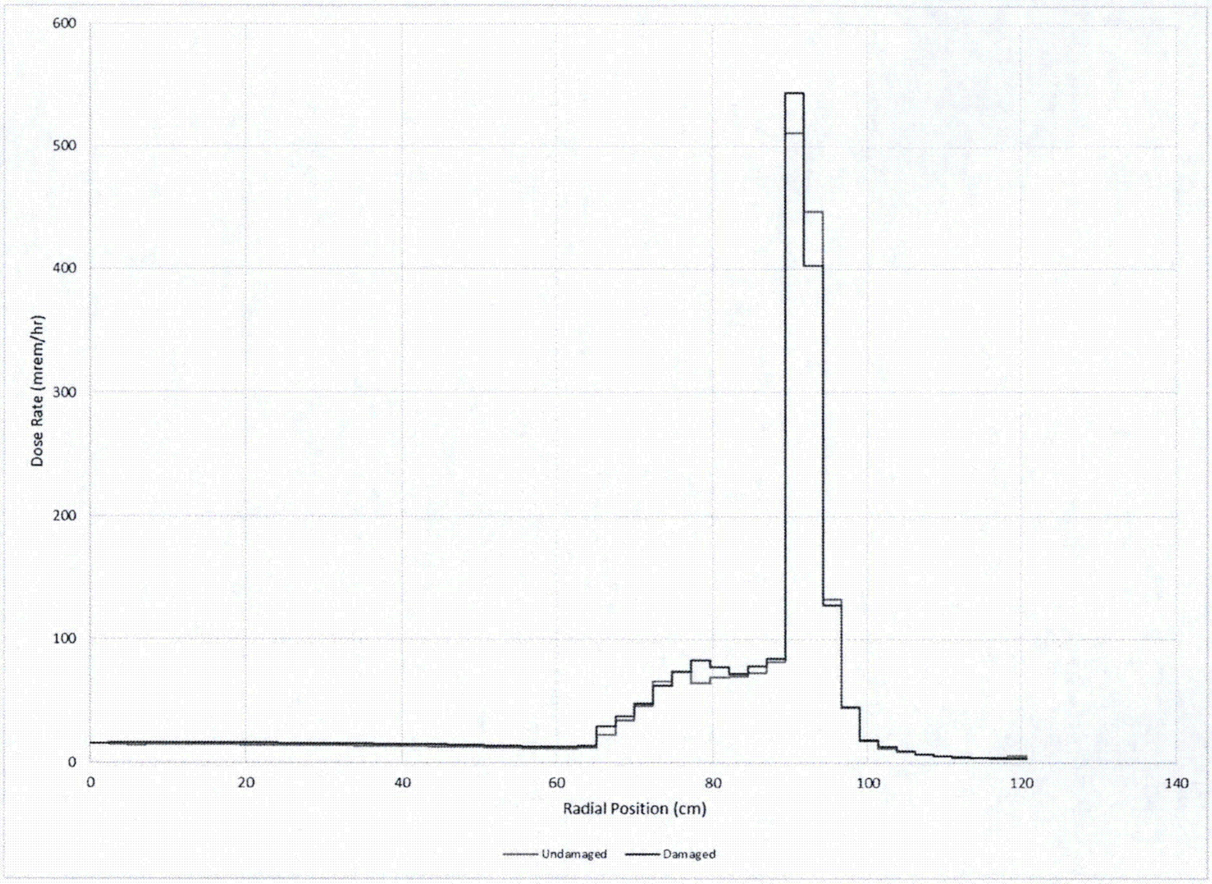


Figure 5.9.10-3 Dose Rate Profile Comparison at Top Surface of PMTC – TSC Transfer Operations – Active Fuel Damaged – Fuel Source Only

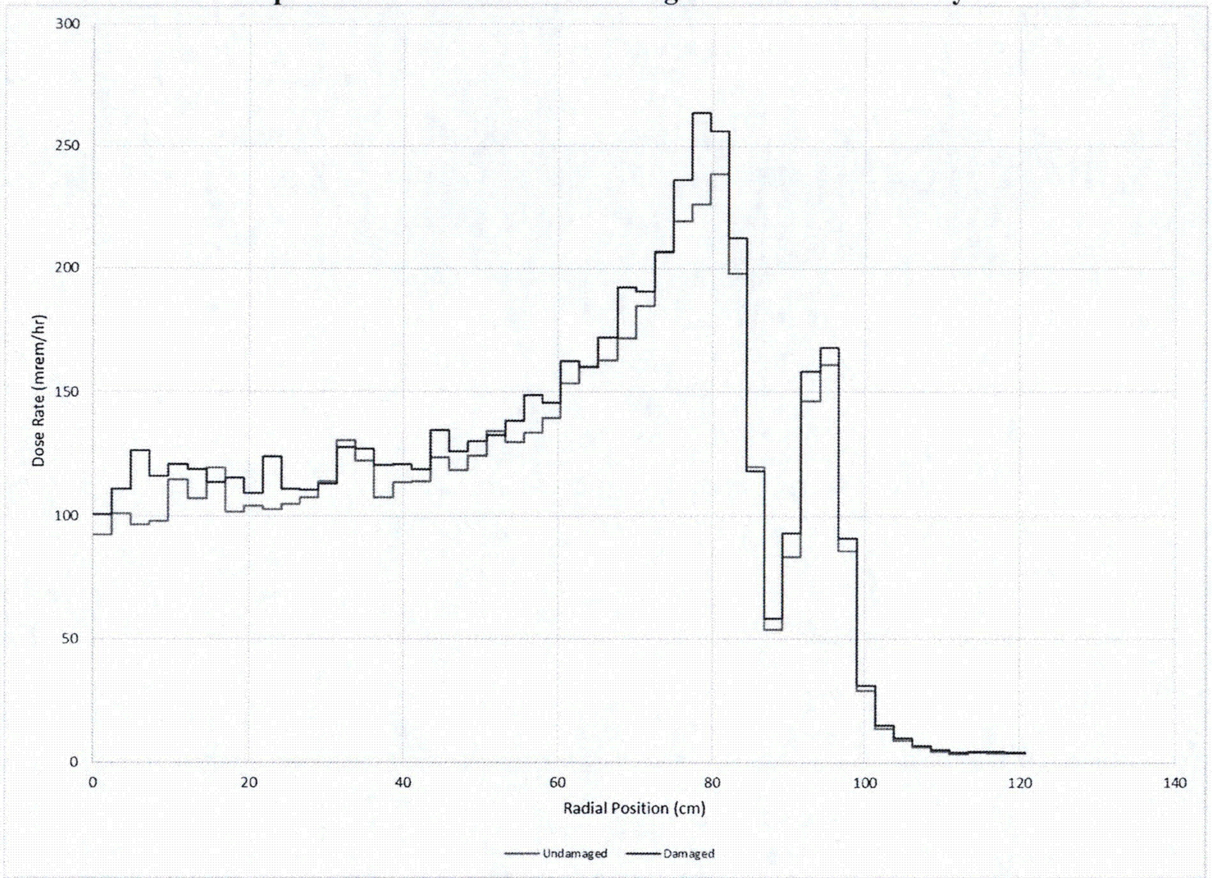


Figure 5.9.10-4 Dose Rate Profile Comparison at Bottom Surface of PMTC – Active Fuel Damaged – Fuel Source Only

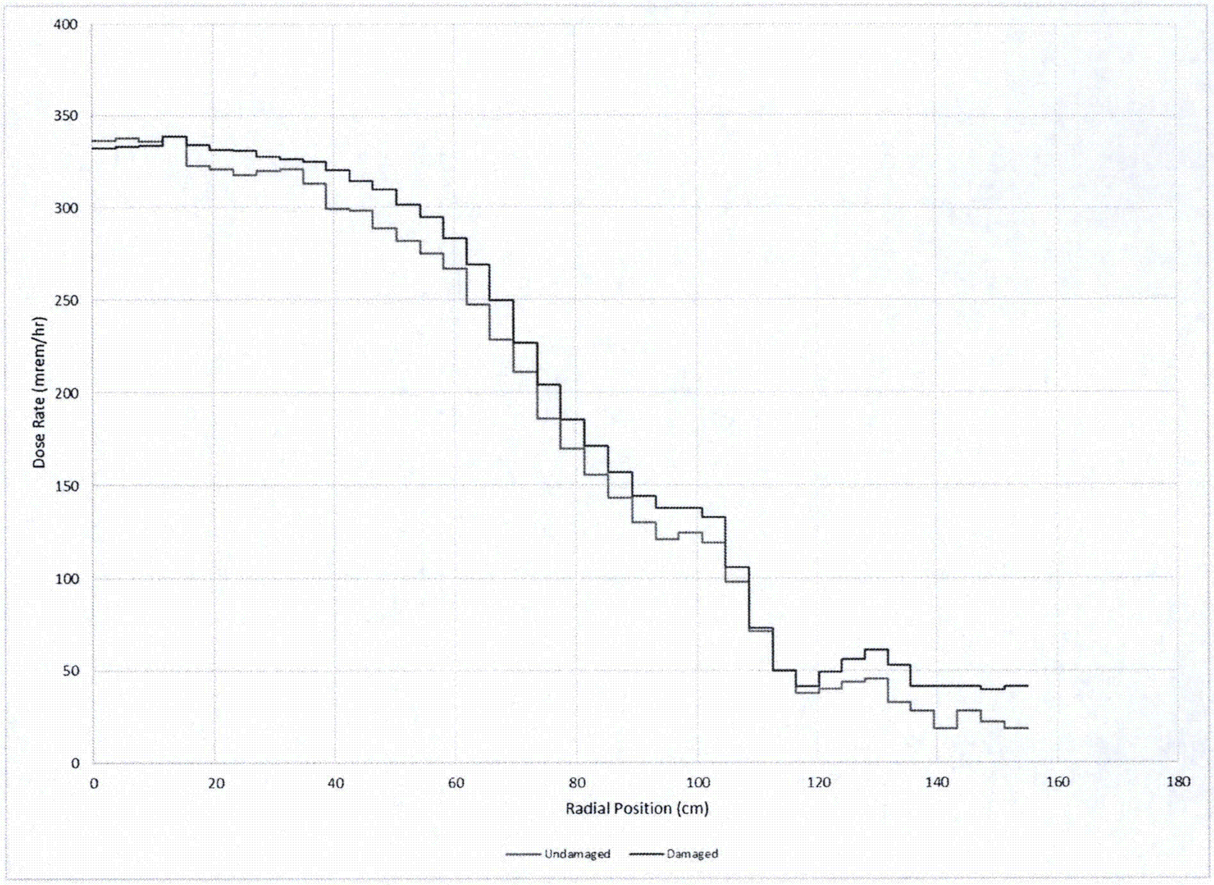


Figure 5.9.10-5 Dose Rate Profile Comparison at Radial Surface of PMTC – Lower End Fitting Damaged – Total Dose Rates

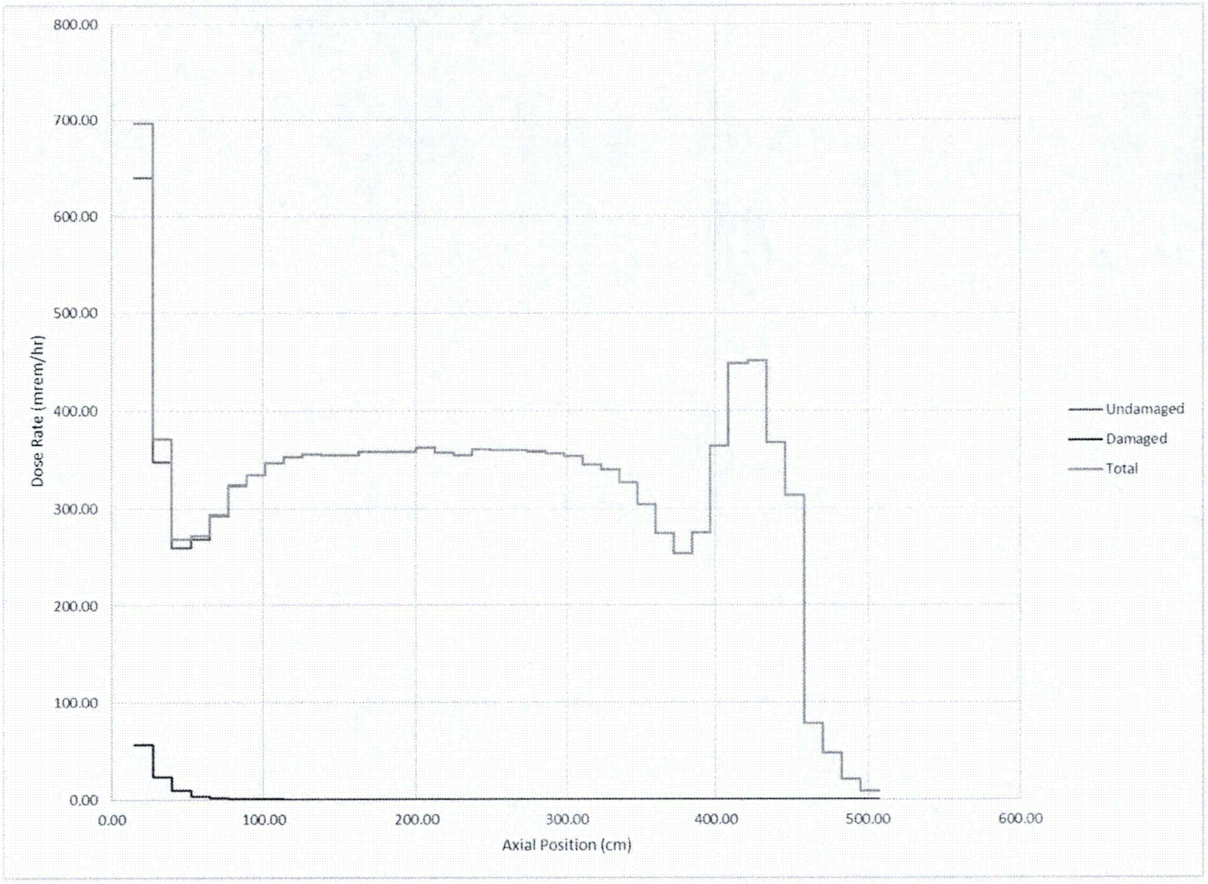


Figure 5.9.10-6 Dose Rate Profile Comparison at Bottom Surface of PMTC – Lower End Fitting Damaged – Total Dose Rates

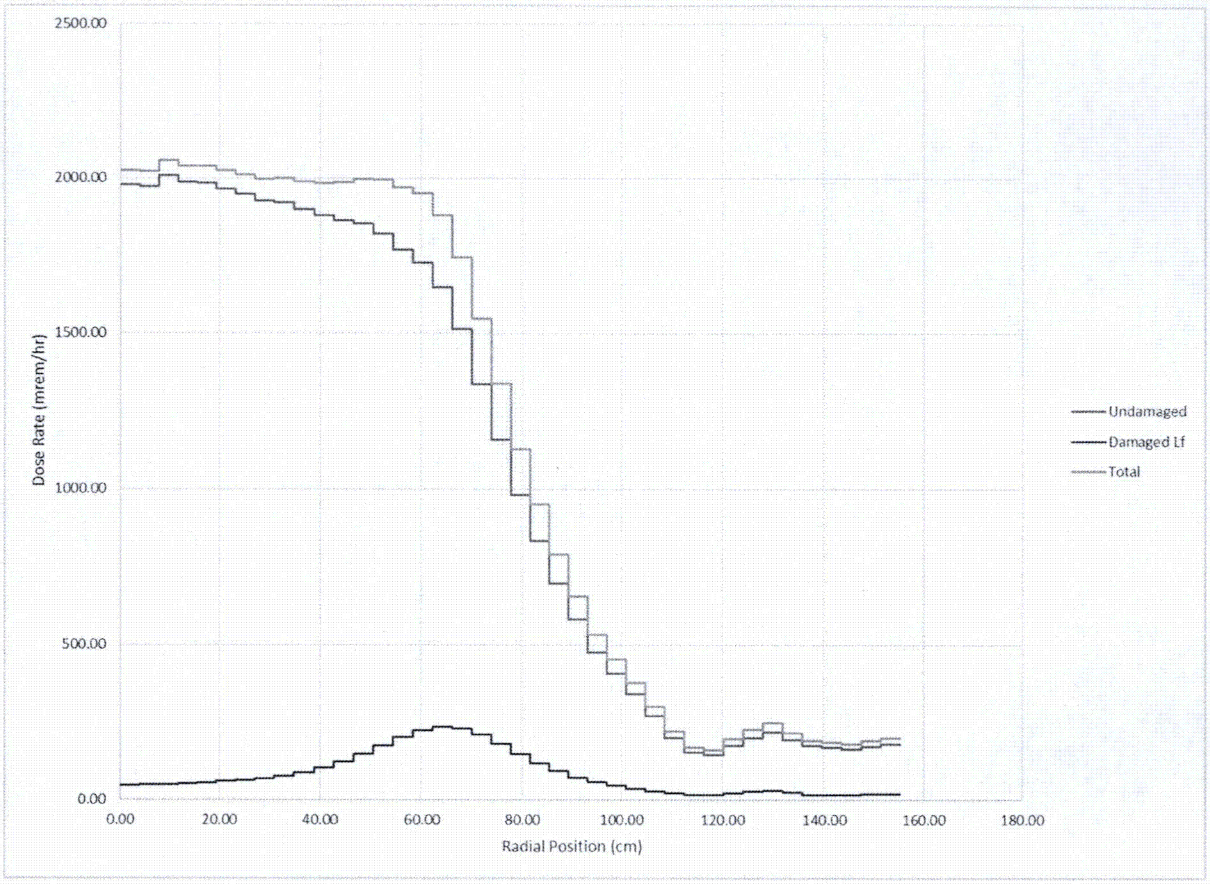


Figure 5.9.10-7 Dose Rate Profile Comparison at Door Boundary of PMTC – Lower End Fitting Damaged – Total Dose Rates

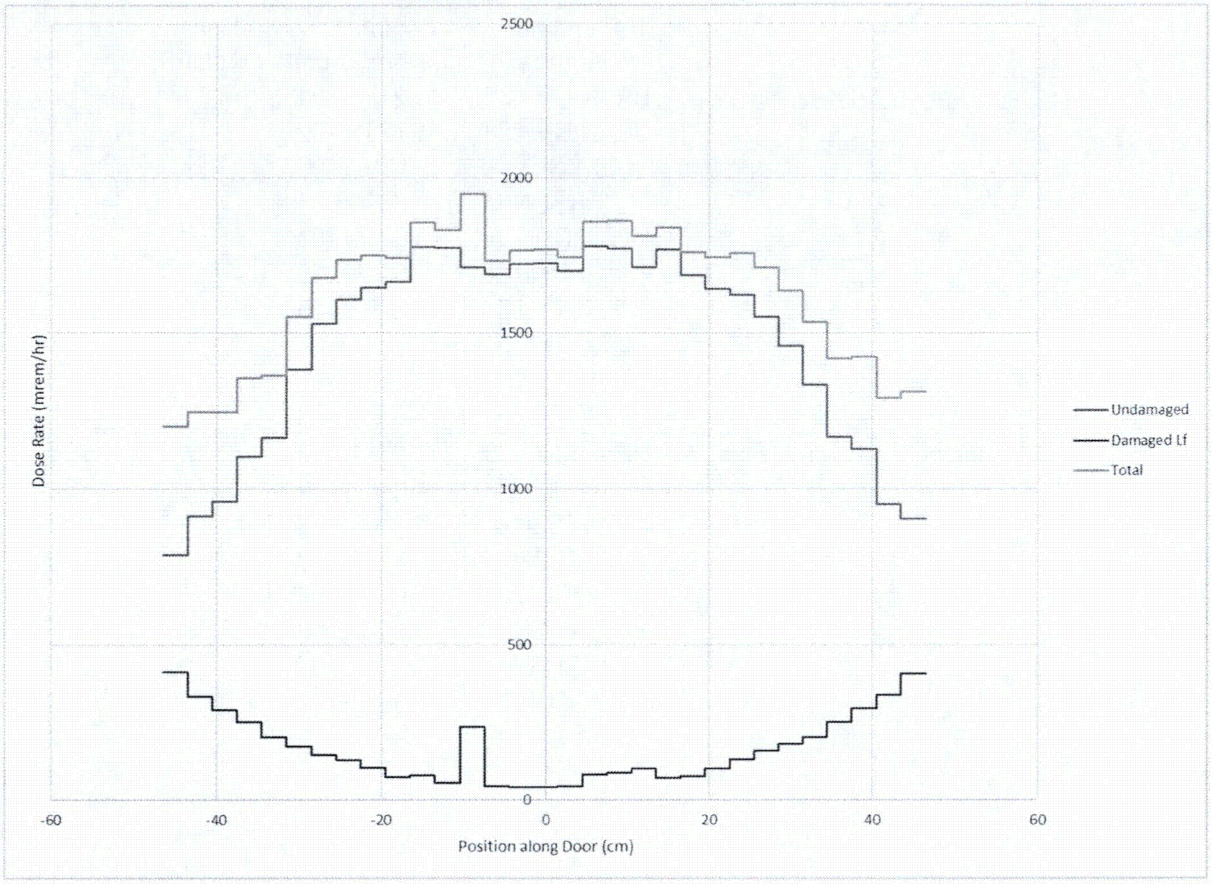


Table 5.9.10-1 Damaged Fuel Material Summary – CE 16×16 PWR Fuel

Material	Element/ Isotope	Density [atom/-b-cm]	Density [g/cm³]
Damaged Fuel (Lower Nozzle)	URANIUM-235	9.2169E-04	9.8774
	URANIUM-238	1.7291E-02	
	OXYGEN	3.6397E-02	
	CARBON	6.8869E-05	
	SILICON	3.6815E-04	
	PHOSPHORUS	1.5009E-05	
	CHROMIUM	3.7782E-03	
	MANGANESE	3.7599E-04	
	IRON	1.2660E-02	
	NICKEL	1.6736E-03	
Damaged Fuel (Active Fuel)	URANIUM-235	1.0384E-03	9.8793
	URANIUM-238	1.9482E-02	
	OXYGEN	4.1008E-02	
	CARBON	4.4423E-03	
	SILICON	7.9342E-06	
	PHOSPHORUS	5.0391E-05	
	CHROMIUM	2.3113E-07	
	MANGANESE	1.5513E-05	

5.9.11 Sample Input Files

This section contains sample input files for the PMTC shielding evaluations. An MCNP input file for the PMTC with undamaged fuel is provided in Figure 5.9.11-1. An MCNP input file for the PMTC with damaged fuel is provided in Figure 5.9.11-2. An MCNP input file for the PMTC with undamaged fuel with mesh detectors at the bottom forging is provided in Figure 5.9.11-3.

Figure 5.9.11-1 PMTC Sample Input File – Undamaged Fuel

```
MAGNASTOR Passively Cooled Transfer Cask - pctShlRadFgRR_ng16a_07g
C Radial Biasing - Fuel Gamma Source
C Fuel Assembly Cells - ng16a - v1.1
1 1 -1.7170 -1      u=6 $ Lower Nozzle
2 2 -2.6069 -2 +1     u=6 $ Lower Plenum
3 3 -3.6800 -3 +2     u=6 $ Fuel
4 4 -0.8683 -4 +3     u=6 $ Upper Plenum
5 5 -1.3635 -5 +4     u=6 $ Upper Nozzle
6 0          +5     u=6 $ Outside
C Cells - Fuel Tube  v1.3
7 8 -7.8212 -8 +7     u=5 $ Tube
8 9 -2.6507 -9 : -10 : -11 : -12      u=5 $ Poison
9 0          #7  #8      u=5 $ Outside
C Cells - PWR Basket v1.5
10 0           -13 -14 fill=5 trcl = ( -23.5331 70.5993 0.0000 )    u=4 $ Assy loc 1
11 like 10 but fill=5 trcl = ( 23.5331 70.5993 0.0000 )    u=4 $ Assy loc 3
12 like 10 but fill=5 trcl = ( -47.0662 47.0662 0.0000 )    u=4 $ Assy loc 4
13 like 10 but fill=5 trcl = ( 0.0000 47.0662 0.0000 )    u=4 $ Assy loc 6
14 like 10 but fill=5 trcl = ( 47.0662 47.0662 0.0000 )    u=4 $ Assy loc 8
15 like 10 but fill=5 trcl = ( -70.5993 23.5331 0.0000 )    u=4 $ Assy loc 9
16 like 10 but fill=5 trcl = ( -23.5331 23.5331 0.0000 )    u=4 $ Assy loc 11
17 like 10 but fill=5 trcl = ( 23.5331 23.5331 0.0000 )    u=4 $ Assy loc 13
18 like 10 but fill=5 trcl = ( 70.5993 23.5331 0.0000 )    u=4 $ Assy loc 15
19 like 10 but fill=5 trcl = ( -47.0662 0.0000 0.0000 )    u=4 $ Assy loc 17
20 like 10 but fill=5 trcl = ( 0.0000 0.0000 0.0000 )    u=4 $ Assy loc 19
21 like 10 but fill=5 trcl = ( 47.0662 0.0000 0.0000 )    u=4 $ Assy loc 21
22 like 10 but fill=5 trcl = ( -70.5993 -23.5331 0.0000 )    u=4 $ Assy loc 23
23 like 10 but fill=5 trcl = ( -23.5331 -23.5331 0.0000 )    u=4 $ Assy loc 25
24 like 10 but fill=5 trcl = ( 23.5331 -23.5331 0.0000 )    u=4 $ Assy loc 27
25 like 10 but fill=5 trcl = ( 70.5993 -23.5331 0.0000 )    u=4 $ Assy loc 29
26 like 10 but fill=5 trcl = ( -47.0662 -47.0662 0.0000 )    u=4 $ Assy loc 30
27 like 10 but fill=5 trcl = ( 0.0000 -47.0662 0.0000 )    u=4 $ Assy loc 32
28 like 10 but fill=5 trcl = ( 47.0662 -47.0662 0.0000 )    u=4 $ Assy loc 34
29 like 10 but fill=5 trcl = ( -23.5331 -70.5993 0.0000 )    u=4 $ Assy loc 35
30 like 10 but fill=5 trcl = ( 23.5331 -70.5993 0.0000 )    u=4 $ Assy loc 37
31 8 -7.8212 -15 #18 #25      u=4 $ Side support +x
32 8 -7.8212 -16 #15 #22      u=4 $ Side support -x
33 8 -7.8212 -17 #10 #11      u=4 $ Side support +y
34 8 -7.8212 -18 #29 #30      u=4 $ Side support -y
35 8 -7.8212 -19 +20 +21      u=4 $ Corner
36 8 -7.8212 -21 +22 +20  +15.2 +16.1 +17.4 +18.3
             #10 #11 #15 #18 #22 #25 #29 #30       u=4 $ Corner diagonal
37 0         -6 #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20
                #21 #22 #23 #24 #25 #26 #27 #28 #29 #30
                #31 #32 #33 #34 #35 #36      u=4 $ Basket below PFE
38 0         +6 #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20
               #21 #22 #23 #24 #25 #26 #27 #28 #29 #30
               #31 #32 #33 #34 #35 #36      u=4 $ Basket above PFE
C Cells - PWR Canister Cavity v1.5
39 0         -23 fill=6 trcl = ( -23.5331 70.5993 0.0000 )    u=3 $ Assy loc 1
40 like 39 but fill=6 trcl = ( 0.0000 70.5993 0.0000 )    u=3 $ Assy loc 2
41 like 39 but fill=6 trcl = ( 23.5331 70.5993 0.0000 )    u=3 $ Assy loc 3
42 like 39 but fill=6 trcl = ( -47.0662 47.0662 0.0000 )    u=3 $ Assy loc 4
43 like 39 but fill=6 trcl = ( -23.5331 47.0662 0.0000 )    u=3 $ Assy loc 5
44 like 39 but fill=6 trcl = ( 0.0000 47.0662 0.0000 )    u=3 $ Assy loc 6
45 like 39 but fill=6 trcl = ( 23.5331 47.0662 0.0000 )    u=3 $ Assy loc 7
46 like 39 but fill=6 trcl = ( 47.0662 47.0662 0.0000 )    u=3 $ Assy loc 8
47 like 39 but fill=6 trcl = ( -70.5993 23.5331 0.0000 )    u=3 $ Assy loc 9
48 like 39 but fill=6 trcl = ( -47.0662 23.5331 0.0000 )    u=3 $ Assy loc 10
49 like 39 but fill=6 trcl = ( -23.5331 23.5331 0.0000 )    u=3 $ Assy loc 11
50 like 39 but fill=6 trcl = ( 0.0000 23.5331 0.0000 )    u=3 $ Assy loc 12
51 like 39 but fill=6 trcl = ( 23.5331 23.5331 0.0000 )    u=3 $ Assy loc 13
52 like 39 but fill=6 trcl = ( 47.0662 23.5331 0.0000 )    u=3 $ Assy loc 14
53 like 39 but fill=6 trcl = ( 70.5993 23.5331 0.0000 )    u=3 $ Assy loc 15
54 like 39 but fill=6 trcl = ( -70.5993 0.0000 0.0000 )    u=3 $ Assy loc 16
55 like 39 but fill=6 trcl = ( -47.0662 0.0000 0.0000 )    u=3 $ Assy loc 17
56 like 39 but fill=6 trcl = ( -23.5331 0.0000 0.0000 )    u=3 $ Assy loc 18
57 like 39 but fill=6 trcl = ( 0.0000 0.0000 0.0000 )    u=3 $ Assy loc 19
58 like 39 but fill=6 trcl = ( 23.5331 0.0000 0.0000 )    u=3 $ Assy loc 20
59 like 39 but fill=6 trcl = ( 47.0662 0.0000 0.0000 )    u=3 $ Assy loc 21
60 like 39 but fill=6 trcl = ( 70.5993 0.0000 0.0000 )    u=3 $ Assy loc 22
61 like 39 but fill=6 trcl = ( -70.5993 -23.5331 0.0000 )    u=3 $ Assy loc 23
62 like 39 but fill=6 trcl = ( -47.0662 -23.5331 0.0000 )    u=3 $ Assy loc 24
63 like 39 but fill=6 trcl = ( -23.5331 -23.5331 0.0000 )    u=3 $ Assy loc 25
64 like 39 but fill=6 trcl = ( 0.0000 -23.5331 0.0000 )    u=3 $ Assy loc 26
65 like 39 but fill=6 trcl = ( 23.5331 -23.5331 0.0000 )    u=3 $ Assy loc 27
66 like 39 but fill=6 trcl = ( 47.0662 -23.5331 0.0000 )    u=3 $ Assy loc 28
67 like 39 but fill=6 trcl = ( 70.5993 -23.5331 0.0000 )    u=3 $ Assy loc 29
68 like 39 but fill=6 trcl = ( -47.0662 -47.0662 0.0000 )    u=3 $ Assy loc 30
69 like 39 but fill=6 trcl = ( -23.5331 -47.0662 0.0000 )    u=3 $ Assy loc 31
70 like 39 but fill=6 trcl = ( 0.0000 -47.0662 0.0000 )    u=3 $ Assy loc 32
71 like 39 but fill=6 trcl = ( 23.5331 -47.0662 0.0000 )    u=3 $ Assy loc 33
72 like 39 but fill=6 trcl = ( 47.0662 -47.0662 0.0000 )    u=3 $ Assy loc 34
73 like 39 but fill=6 trcl = ( -23.5331 -70.5993 0.0000 )    u=3 $ Assy loc 35
74 like 39 but fill=6 trcl = ( 0.0000 -70.5993 0.0000 )    u=3 $ Assy loc 36
75 like 39 but fill=6 trcl = ( 23.5331 -70.5993 0.0000 )    u=3 $ Assy loc 37
76 0         #39 #40 #41 #42 #43 #44 #45 #46 #47 #48 #49 #50 #51
             #52 #53 #54 #55 #56 #57 #58 #59 #60 #61 #62 #63 #64
             #65 #66 #67 #68 #69 #70 #71 #72 #73 #74 #75      fill=4 u=3 $ Cavity
```

```
C Cells - Canister v1.3
77 0         -24 #88  #89  fill=3    u=2 $ Cavity
78 7 -7.9400 -37 +24.3      u=2 $ Canister Bottom
79 0         -28 +24.2 -31 trcl = ( 64.2620 40.8940 0.0000 )    u=2 $ Bottom Drain Port
80 14 -3.9700 -29 +31 -33 trcl = ( 64.2620 40.8940 0.0000 )   u=2 $ Middle Drain Port
81 7 -7.9400 -30 +33 -37.2 trcl = ( 64.2620 40.8940 0.0000 )   u=2 $ Top Drain Port
82 like 79 but   trcl = ( -64.2620 -40.8940 0.0000 )    u=2 $ Bottom Vent Port
83 like 80 but   trcl = ( -64.2620 -40.8940 0.0000 )    u=2 $ Middle Vent Port
84 like 81 but   trcl = ( -64.2620 -40.8940 0.0000 )    u=2 $ Top Vent Port
85 7 -7.9400 -37 -24.3 +24.1      u=2 $ Canister Shell
86 8 -7.8212 -37 -24.1 +24.2 -32 #79 #80  #82 #83  #90  u=2 $ Lower lid
87 7 -7.9400 -37 -24.1 +32 #80 #81  #83 #84  #90 #91   u=2 $ Upper lid
88 7 -7.9400 -36 +35 +34 -24.2 trcl = ( 64.2620 40.8940 0.0000 )   u=2 $ Drain port shield
89 7 -7.9400 -36 +35 +32 -24.2 trcl = ( -64.2620 -40.8940 0.0000 )   u=2 $ Vent port shield
90 0         -37 -24.1 +25 +24.2    u=2 $ Lid spacing
91 0         -37 -26 +27      u=2 $ Closure ring spacing
92 0         +37 #88      u=2 $ Outside
C Passively Cooled Transfer Cask Cells - v1.3.5_ng16a
93 0         ((-38 +72 +73) : -47)    fill=2 ( 0.0 0.0 12.0650 )    u=1 $ Cavity
94 7 -7.9400 -39 -40 +38      u=1 $ Inner shell
95 0         -39 -41 +40      u=1 $ Lead Inner spacing
96 11 -11.3440 -39 -42 +41      u=1 $ Lead shield
97 0         -39 -43 +42      u=1 $ Lead Outer Spacing
98 7 -7.9400 -39 -44 +43      u=1 $ Middle shell
99 6 -0.9616 -45 +44  #130 #131 #132 #133 #134 #135     u=1 $ Neutron shield
100 7 -7.9400 -39 +44 +45     u=1 $ Neutron shield shell
101 7 -7.9400 -46 +47      u=1 $ Retaining ring
102 7 -7.9400 -51 +38 +48 #104 #105 #106 #107 #108 #109
        #110 #111 #112          u=1 $ Top ring
C 103 0  +47 +49 -50      u=1 $ Top ring Overhang
104 0  ((-52 +53) : -54)       u=1 $ Top ring vent
105 0  +38 (-55 : -56)      u=1 $ Top ring vent
106 0  +38 (-57 : -58)      u=1 $ Top ring vent
107 0  +38 (-59 : -60)      u=1 $ Top ring vent
108 0  +38 (-61 : -62)      u=1 $ Top ring vent
109 0  +38 (-63 : -64)      u=1 $ Top ring vent
110 0  +38 (-65 : -66)      u=1 $ Top ring vent
111 0  +38 (-67 : -68)      u=1 $ Top ring vent
112 0  +38 (-69 : -70)      u=1 $ Top ring vent
113 7 -7.9400 (-71 : -78) +38 +89 +90 #126 #127 #128 #129    u=1 $ Bottom ring
C 114 7 -7.9400 (-91 +92 +93 +96 +97 +98 +99 +100)     #C 125  :
C    (+91 -49 -38.1)      u=1 $ Seal shield
115 7 -7.9400 ((-101 +102 -103) : (-103 +104 -101))   +71 +74 +83  u=1 $ Inlet Shield - Door
116 7 -7.9400 -74 -103 +104 +71 +83 #123 #124   u=1 $ Inlet Shield - Door
117 7 -7.9400 ((-101 +102 -105) : (-105 +106 -101))   +71 +74 +83  u=1 $ Inlet Shield - Door
118 7 -7.9400 -74 -105 +106 +71 +83 #123 #124   u=1 $ Inlet Shield - Door
119 7 -7.9400 -107 +108 +77 +78    u=1 $ Inlet Shield - Rail
120 7 -7.9400 -109 +110 +77 +78    u=1 $ Inlet Shield - Rail
121 7 -7.9400 -72      u=1 $ Rail -x
122 7 -7.9400 -73      u=1 $ Rail +x
123 7 -7.9400 (-74 : -77) -75 +76 (+83 +84 +85 +86 +87)  #124   u=1 $ Door steel
124 0  -88      u=1 $ Door  Overhang gap
C 125 0        +94 -95      u=1 $ Seal shield - seal cut
126 0         (-79 +80) +38 -78     u=1 $ Vent
127 0         (-81 +82) +38 -71     u=1 $ Vent
128  like 126 but TRCL= 54     u=1 $ Vent
129  like 127 but TRCL= 54     u=1 $ Vent
130 7 -7.9400 ((+111 -112 -45 +44) : (+113 -114 -45 +115))    +136
        +137 +138 +139 +140 +141 +142 +143 +144 +145 +146
        +147 +148 +149 +150 +151 +152 +153 +154 +155 +156
        +157 +158 +159 +160 +161 +162 +163 +164 +165 +166
        +167 +168 +169 +170 +171 +172 +173 +174 +175 +176      u=1 $ Heat Fin
131 7 -7.9400 ((+116 -117 -45 +44) : (+118 -119 -45 +115))    +136
        +137 +138 +139 +140 +141 +142 +143 +144 +145 +146
        +147 +148 +149 +150 +151 +152 +153 +154 +155 +156
        +157 +158 +159 +160 +161 +162 +163 +164 +165 +166
        +167 +168 +169 +170 +171 +172 +173 +174 +175 +176      u=1 $ Heat Fin
132 7 -7.9400 ((+120 -121 -45 +44) : (+122 -123 -45 +115))    +136
        +137 +138 +139 +140 +141 +142 +143 +144 +145 +146
        +147 +148 +149 +150 +151 +152 +153 +154 +155 +156
        +157 +158 +159 +160 +161 +162 +163 +164 +165 +166
        +167 +168 +169 +170 +171 +172 +173 +174 +175 +176      u=1 $ Heat Fin
133 7 -7.9400 ((+124 -125 -45 +44) : (+126 -127 -45 +115))    +136
        +137 +138 +139 +140 +141 +142 +143 +144 +145 +146
        +147 +148 +149 +150 +151 +152 +153 +154 +155 +156
        +157 +158 +159 +160 +161 +162 +163 +164 +165 +166
        +167 +168 +169 +170 +171 +172 +173 +174 +175 +176      u=1 $ Heat Fin
134 7 -7.9400 ((+128 -129 -45 +44) : (+130 -131 -45 +115))    +136
        +137 +138 +139 +140 +141 +142 +143 +144 +145 +146
        +147 +148 +149 +150 +151 +152 +153 +154 +155 +156
        +157 +158 +159 +160 +161 +162 +163 +164 +165 +166
        +167 +168 +169 +170 +171 +172 +173 +174 +175 +176      u=1 $ Heat Fin
135 7 -7.9400 ((+132 -133 -45 +44) : (+134 -135 -45 +115))    +136
        +137 +138 +139 +140 +141 +142 +143 +144 +145 +146
        +147 +148 +149 +150 +151 +152 +153 +154 +155 +156
        +157 +158 +159 +160 +161 +162 +163 +164 +165 +166
        +167 +168 +169 +170 +171 +172 +173 +174 +175 +176      u=1 $ Heat Fin
136 0         ((+38 +39 +46 +47 +51) : (+46 -48))
        #102  #104 #105 #106 #107 #108 #109 #110 #111 #112 #113
        #115 #116 #117 #118 #119 #120 #121
        #121 #122 #123 #124   #126 #127 #128 #129      u=1 $ Outside
C Detector Cells - Radial Biasing
```

```
400  0  -400  fill=1  $ Surface
500  0  -500  +400  fill=1  $ Surface2
700  0  -700  +400  +500  fill=1  $ 1ft
600  0  -600  +400  +500  +700  fill=1  $ Shield
800  0  -800  +400  +500  +700  +600  fill=1  $ 1m
900  0  -900  +400  +500  +700  +600  +800  fill=1  $ 2m
1000  0  -1000  +400  +500  +700  +600  +800  +900  fill=1  $ 4m
1100  0  +400  +500  +700  +600  +800  +900  +1000  $ Exterior

C Fuel Assembly Surfaces - ng16a - v1.1
1 RPP -10.4775 10.4775 -10.4775 10.4775 0.0000 9.6825  $ Lower Nozzle
2 RPP -10.4775 10.4775 -10.4775 10.4775 0.0000 11.9456  $ Lower Plenum
3 RPP -10.4775 10.4775 -10.4775 10.4775 0.0000 392.9456  $ Fuel
4 RPP -10.4775 10.4775 -10.4775 10.4775 0.0000 424.8226  $ Upper Plenum
5 RPP -10.4775 10.4775 -10.4775 10.4775 0.0000 452.8820  $ Upper Nozzle
6 PZ 265.9456        $ Flood elevation
C Surfaces - Fuel Tube v1.3
7 RPP -11.6015 11.6015 -11.6015 11.6015 7.6200 457.2762  $ Tube void
8 RPP -12.3952 12.3952 -12.3952 12.3952 7.6200 448.3100  $ Tube
9 RPP -11.6015 -11.2840 -10.2362 10.2362 9.2075 446.7225  $ Poison left
10 RPP 11.2840 11.6015 -10.2362 10.2362 9.2075 446.7225  $ Poison right
11 RPP -10.2362 10.2362 11.2840 11.6015 9.2075 446.7225  $ Poison top
12 RPP -10.2362 10.2362 -11.6015 -11.2840 9.2075 446.7225  $ Poison bottom
C Surfaces - PWR Basket v1.5
13  RPP -12.3952 12.3952 -12.3952 12.3952 0.0000 457.2762  $ Tube opening
14 8 RPP -16.6370 16.6370 -16.6370 16.6370 0.0000 457.2762  $ Tube radius
15  RPP 81.8833 83.7883 -33.1851 33.1851 7.6200 448.3100  $ Side support +x
16  RPP -83.7883 -81.8833 -33.1851 33.1851 7.6200 448.3100  $ Side support -x
17  RPP -33.1851 33.1851 81.8833 83.7883 7.6200 448.3100  $ Side support +y
18  RPP -33.1851 33.1851 -83.7883 -81.8833 7.6200 448.3100  $ Side support -y
19  RPP -60.2552 60.2552 -60.2552 60.2552 7.6200 448.3100  $ Corner outer
20  RPP -59.4614 59.4614 -59.4614 59.4614 7.6200 448.3100  $ Corner inner
21 8 RPP -78.6267 78.6267 -78.6267 78.6267 7.6200 448.3100  $ Corner dia. outer
22 8 RPP -77.83291 77.8329 -77.8329 77.8329 7.6200 448.3100  $ Corner dia. inner
C Surfaces - PWR Canister Cavity v1.5
23 RPP -10.4780 10.4780 -10.4780 10.4780 0.0000 452.8821   $ Assy opening
C Surfaces - Canister v1.3
24 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 457.2762 90.1700   $ Cavity
25 CZ 89.8525         $ Lid Gap
26 RCC 0.0000 0.0000 477.9010 0.0000 0.0000 2.2352 89.8525   $ Closure Ring Gap
27 CZ 86.1060         $ Closure Ring Gap
28 CZ 2.6924         $ Bot Cylinder Radius
29 CZ 6.7691         $ Mid Cyclinder Radius
30 CZ 7.4041         $ Top Cylinder Radius
31 PZ 468.6300         $ Port plane bot/mid
32 PZ 469.9762         $ Lower/upper lid
33 PZ 477.2914         $ Port plane mid/top
34 PZ 450.9262         $ Port shield elevation
35 CZ 2.6924         $ Port shield ID
36 CZ 5.0800         $ Port shield OD
C  RCC 0.0000 0.0000 -12.0750 0.0000 0.0000 469.3412 96.6200   $ Water jacket
37 RCC 0.0000 0.0000 -6.9850 0.0000 0.0000 487.1212 91.4400   $ Canister
C Passively Cooled Transfer Cask Surfaces - v1.3.5_ng16a
38 RCC 0.0 0.0 0.0 0.0 0.0 499.745 96.5200   $ Cavity
39 RCC 0.0 0.0 15.2400 0.0 0.0 443.2300 120.6500   $ Cask OD
40 CZ 98.4250         $ Inner shell OD
41 CZ 98.552         $ Lead shield ID
42 CZ 106.680         $ Lead shield OD
43 CZ 106.8070         $ Middle shell ID
44 CZ 109.9820         $ Middle shell OD
45 RCC 0.0 0.0 15.2400 0.0 0.0 443.2300 120.0150   $ NS outline
46 RCC 0.0 0.0 499.7450 0.0 0.0 7.6200 112.0775   $ Retaining ring outline
47 RCC 0.0 0.0 499.7450 0.0 0.0 7.6200 86.9950   $ Retaining ring ID
48 RCC 0.0 0.0 499.7450 0.0 0.0 0.6350 112.6490   $ Top ring notch
49 RCC 0.0 0.0 499.7450 0.0 0.0 2.5400 100.9650
50 RCC 0.0 0.0 499.7450 0.0 0.0 2.8702 102.2350
51 RCC 0.0 0.0 458.4700 0.0 0.0 41.9100 120.6500   $ Top ring
52 RCC 0.0 0.0 493.2680 0.0 0.0 6.4770 120.0150   $ Top ring vent - ring
53 RCC 0.0 0.0 493.2680 0.0 0.0 6.4770 116.5098   $ Top ring vent - ring
54 RCC 116.5098 0.0 496.5700 4.1422 0.0 0.0 2.5400   $ Top ring vent - to nipple
55 4 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017   $ Top ring vent - interior to ring
56 4 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017   $ Top ring vent - interior to ring
57 12 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017   $ Top ring vent - interior to ring
58 12 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017   $ Top ring vent - interior to ring
59 19 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017   $ Top ring vent - interior to ring
60 19 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017   $ Top ring vent - interior to ring
61 27 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017   $ Top ring vent - interior to ring
62 27 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017   $ Top ring vent - interior to ring
63 73 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017   $ Top ring vent - interior to ring
64 73 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017   $ Top ring vent - interior to ring
65 74 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017   $ Top ring vent - interior to ring
66 74 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017   $ Top ring vent - interior to ring
67 75 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017   $ Top ring vent - interior to ring
68 75 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017   $ Top ring vent - interior to ring
69 76 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017   $ Top ring vent - interior to ring
70 76 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017   $ Top ring vent - interior to ring
71 RCC 0.0 0.0 0.0 0.0 0.0 15.2400 120.6500   $ Bottom ring
72 RPP -76.3524 -71.2724 -91.4400 91.4400 0.0 5.0790   $ Rail -x
73 RPP 71.2724 76.3524 -91.4400 91.4400 0.0 5.0790   $ Rail +x
74 RHP 0.0 0.0 -15.2400 0.0 0.0 15.2400 -69.3278 -95.7554 0.0
      69.3278 -95.7554 0.0 101.6000 0.0 0.0   $ Door prism
75 PY 109.5375         $ Door side +y
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76 PY -109.5375         $ Door side -y
77 RPP -120.6500 120.6500 -72.3900 72.3900 -15.2400 0.0    $ Vent forging Door
78 RPP -120.6500 120.6500 -72.3900 72.3900 0.0 15.2400    $ Vent forging Bottom Ring
79 RPP -120.6500 -79.7560 -66.8020 66.8020 0.0 7.6200    $ Vent outline -x
80 RPP -120.6500 -96.5200 -50.0380 50.0380 0.0 7.6200    $ Vent inner -x
81 RPP -67.0560 67.0560 -120.6500 -79.7560 0.0 7.6200    $ Vent outline -y
82 RPP -50.2920 50.2920 -120.6500 -96.5200 0.0 7.6200    $ Vent inner -y
83 RPP -102.2350 102.2350 -200.0000 200.0000 -0.3048 0.0    $ Door Gap
84 RPP -102.2350 -101.6000 -200.0000 200.0000 -10.4648 0.0    $ Door Gap
85 RPP 101.6000 102.2350 -200.0000 200.0000 -10.4648 0.0    $ Door Gap
86 RPP -97.7900 -97.6376 -200.0000 200.0000 -15.2400 -10.4648    $ Door Gap
87 RPP 97.6376 97.7900 -200.0000 200.0000 -15.2400 -10.4648    $ Door Gap
88 RPP -101.6000 101.6000 -0.3175 0.3175 -10.3124 -10.0076    $ Door overhang gap
89 RPP -76.5175 -71.1073 -200.0000 200.0000 0.0000 5.1562    $ Rail -x Gap
90 RPP 71.1073 76.5175 -200.0000 200.0000 0.0000 5.1562    $ Rail +x Gap
91 RCC 0.0 0.0 467.3600 0.0 0.0 34.9250 95.4913    $ Seal Shield OD
92 RCC 0.0 0.0 467.3600 0.0 0.0 34.9250 92.1512    $ Seal Shield ID
93 RCC 0.0 0.0 469.6587 0.0 0.0 3.0226 93.6752    $ Seal Shield seal
94 RCC 0.0 0.0 476.0087 0.0 0.0 3.0226 93.9673    $ Seal Shield seal
95 RCC 0.0 0.0 476.0087 0.0 0.0 3.0226 95.4913    $ Seal Shield seal
96 4 RCC 93.6652 0.0 471.1700 1.3562 0.0 0.0 0.3175    $ Seal Shield vent
97 4 RCC 93.9773 0.0 477.5200 -1.3562 0.0 0.0 0.3175    $ Seal Shield vent
98 4 RCC 95.4913 0.0 474.3450 -2.8702 0.0 0.0 0.2540    $ Seal Shield vent
99 4 RCC 95.0214 0.0 467.3600 0.0 0.0 7.6200 0.2540    $ Seal Shield vent
100 4 RCC 92.6211 0.0 473.8370 0.0 0.0 28.4480 0.2540    $ Seal Shield vent
101 RCC 0.0 0.0 -15.2400 0.0 0.0 30.4800 139.1920    $ Inlet Shield - Door
102 RCC 0.0 0.0 -15.2400 0.0 0.0 30.4800 132.8420    $ Inlet Shield - Door
103 RPP -70.8660 -46.4820 -139.1920 139.1920 -15.2400 15.2400    $ Inlet Shield - Door
104 RPP -67.0560 -50.2920 -139.1920 139.1920 -15.2400 15.2400    $ Inlet Shield - Door
105 RPP 46.4820 70.8660 -139.1920 139.1920 -15.2400 15.2400    $ Inlet Shield - Door
106 RPP 50.2920 67.0560 -139.1920 139.1920 -15.2400 15.2400    $ Inlet Shield - Door
107 RPP -137.1600 137.1600 -72.3900 -46.2280 -15.2400 15.2400    $ Inlet Shield - Rail
108 RPP -133.3500 133.3500 -68.5800 -50.0380 -15.2400 15.2400    $ Inlet Shield - Rail
109 RPP -137.1600 137.1600 46.2280 72.3900 -15.2400 15.2400    $ Inlet Shield - Rail
110 RPP -133.3500 133.3500 50.0380 68.5800 -15.2400 15.2400    $ Inlet Shield - Rail
111 PY -0.3175          $ Heat fin
112 PY 0.3175          $ Heat fin
113 PY -1.27          $ Heat fin
114 PY 1.27          $ Heat fin
115 CZ 119.2530          $ Heat fin
116 39 PY -0.3175          $ Heat fin
117 39 PY 0.3175          $ Heat fin
118 39 PY -1.27          $ Heat fin
119 39 PY 1.27          $ Heat fin
120 42 PY -0.3175          $ Heat fin
121 42 PY 0.3175          $ Heat fin
122 42 PY -1.27          $ Heat fin
123 42 PY 1.27          $ Heat fin
124 45 PY -0.3175          $ Heat fin
125 45 PY 0.3175          $ Heat fin
126 45 PY -1.27          $ Heat fin
127 45 PY 1.27          $ Heat fin
128 48 PY -0.3175          $ Heat fin
129 48 PY 0.3175          $ Heat fin
130 48 PY -1.27          $ Heat fin
131 48 PY 1.27          $ Heat fin
132 51 PY -0.3175          $ Heat fin
133 51 PY 0.3175          $ Heat fin
134 51 PY -1.27          $ Heat fin
135 51 PY 1.27          $ Heat fin
136 TZ 0.0 0.0 15.2400 114.4270 3.1750 3.1750    $ Heat fin hole 1
137 TZ 0.0 0.0 26.4160 114.4270 3.1750 3.1750    $ Heat fin hole 2
138 TZ 0.0 0.0 37.4943 114.4270 3.1750 3.1750    $ Heat fin hole 3
139 TZ 0.0 0.0 48.5726 114.4270 3.1750 3.1750    $ Heat fin hole 4
140 TZ 0.0 0.0 59.6509 114.4270 3.1750 3.1750    $ Heat fin hole 5
141 TZ 0.0 0.0 70.7292 114.4270 3.1750 3.1750    $ Heat fin hole 6
142 TZ 0.0 0.0 81.8075 114.4270 3.1750 3.1750    $ Heat fin hole 7
143 TZ 0.0 0.0 92.8858 114.4270 3.1750 3.1750    $ Heat fin hole 8
144 TZ 0.0 0.0 103.9642 114.4270 3.1750 3.1750    $ Heat fin hole 9
145 TZ 0.0 0.0 115.0425 114.4270 3.1750 3.1750    $ Heat fin hole 10
146 TZ 0.0 0.0 126.1208 114.4270 3.1750 3.1750    $ Heat fin hole 11
147 TZ 0.0 0.0 137.1991 114.4270 3.1750 3.1750    $ Heat fin hole 12
148 TZ 0.0 0.0 148.2774 114.4270 3.1750 3.1750    $ Heat fin hole 13
149 TZ 0.0 0.0 159.3557 114.4270 3.1750 3.1750    $ Heat fin hole 14
150 TZ 0.0 0.0 170.4340 114.4270 3.1750 3.1750    $ Heat fin hole 15
151 TZ 0.0 0.0 181.5123 114.4270 3.1750 3.1750    $ Heat fin hole 16
152 TZ 0.0 0.0 192.5906 114.4270 3.1750 3.1750    $ Heat fin hole 17
153 TZ 0.0 0.0 203.6689 114.4270 3.1750 3.1750    $ Heat fin hole 18
154 TZ 0.0 0.0 214.7472 114.4270 3.1750 3.1750    $ Heat fin hole 19
155 TZ 0.0 0.0 225.8255 114.4270 3.1750 3.1750    $ Heat fin hole 20
156 TZ 0.0 0.0 236.9038 114.4270 3.1750 3.1750    $ Heat fin hole 21
157 TZ 0.0 0.0 247.9822 114.4270 3.1750 3.1750    $ Heat fin hole 22
158 TZ 0.0 0.0 259.0605 114.4270 3.1750 3.1750    $ Heat fin hole 23
159 TZ 0.0 0.0 270.1388 114.4270 3.1750 3.1750    $ Heat fin hole 24
160 TZ 0.0 0.0 281.2171 114.4270 3.1750 3.1750    $ Heat fin hole 25
161 TZ 0.0 0.0 292.2954 114.4270 3.1750 3.1750    $ Heat fin hole 26
162 TZ 0.0 0.0 303.3737 114.4270 3.1750 3.1750    $ Heat fin hole 27
163 TZ 0.0 0.0 314.4520 114.4270 3.1750 3.1750    $ Heat fin hole 28
164 TZ 0.0 0.0 325.5303 114.4270 3.1750 3.1750    $ Heat fin hole 29
165 TZ 0.0 0.0 336.6086 114.4270 3.1750 3.1750    $ Heat fin hole 30
166 TZ 0.0 0.0 347.6869 114.4270 3.1750 3.1750    $ Heat fin hole 31
167 TZ 0.0 0.0 358.7652 114.4270 3.1750 3.1750    $ Heat fin hole 32
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168 TZ 0.0 0.0 369.8435 114.4270 3.1750 3.1750    $ Heat fin hole 33
169 TZ 0.0 0.0 380.9218 114.4270 3.1750 3.1750    $ Heat fin hole 34
170 TZ 0.0 0.0 392.0002 114.4270 3.1750 3.1750    $ Heat fin hole 35
171 TZ 0.0 0.0 403.0785 114.4270 3.1750 3.1750    $ Heat fin hole 36
172 TZ 0.0 0.0 414.1568 114.4270 3.1750 3.1750    $ Heat fin hole 37
173 TZ 0.0 0.0 425.2351 114.4270 3.1750 3.1750    $ Heat fin hole 38
174 TZ 0.0 0.0 436.3134 114.4270 3.1750 3.1750    $ Heat fin hole 39
175 TZ 0.0 0.0 447.3917 114.4270 3.1750 3.1750    $ Heat fin hole 40
176 TZ 0.0 0.0 458.4700 114.4270 3.1750 3.1750    $ Heat fin hole 41
C Radial Detector DRA (Surface)
400  RCC  0.0000  0.0000  -15.2410  0.0000  0.0000  522.6160  120.6610
401  PZ  -4.7887
402  PZ  5.6636
403  PZ  16.1160
404  PZ  26.5683
405  PZ  37.0206
406  PZ  47.4729
407  PZ  57.9252
408  PZ  68.3776
409  PZ  78.8299
410  PZ  89.2822
411  PZ  99.7345
412  PZ  110.1868
413  PZ  120.6392
414  PZ  131.0915
415  PZ  141.5438
416  PZ  151.9961
417  PZ  162.4484
418  PZ  172.9008
419  PZ  183.3531
420  PZ  193.8054
421  PZ  204.2577
422  PZ  214.7100
423  PZ  225.1624
424  PZ  235.6147
425  PZ  246.0670
426  PZ  256.5193
427  PZ  266.9716
428  PZ  277.4240
429  PZ  287.8763
430  PZ  298.3286
431  PZ  308.7809
432  PZ  319.2332
433  PZ  329.6856
434  PZ  340.1379
435  PZ  350.5902
436  PZ  361.0425
437  PZ  371.4948
438  PZ  381.9472
439  PZ  392.3995
440  PZ  402.8518
441  PZ  413.3041
442  PZ  423.7564
443  PZ  434.2088
444  PZ  444.6611
445  PZ  455.1134
446  PZ  465.5657
447  PZ  476.0180
448  PZ  486.4704
449  PZ  496.9227
C Radial Detector DRB (Surface2)
500  RCC  0.0000  0.0000  15.2500  0.0000  0.0000  492.1350  120.6710
501  PZ  27.5534
502  PZ  39.8568
503  PZ  52.1601
504  PZ  64.4635
505  PZ  76.7669
506  PZ  89.0703
507  PZ  101.3736
508  PZ  113.6770
509  PZ  125.9804
510  PZ  138.2838
511  PZ  150.5871
512  PZ  162.8905
513  PZ  175.1939
514  PZ  187.4973
515  PZ  199.8006
516  PZ  212.1040
517  PZ  224.4074
518  PZ  236.7108
519  PZ  249.0141
520  PZ  261.3175
521  PZ  273.6209
522  PZ  285.9243
523  PZ  298.2276
524  PZ  310.5310
525  PZ  322.8344
526  PZ  335.1378
527  PZ  347.4411
528  PZ  359.7445
529  PZ  372.0479
530  PZ  384.3513
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531  PZ  396.6546
532  PZ  408.9580
533  PZ  421.2614
534  PZ  433.5648
535  PZ  445.8681
536  PZ  458.1715
537  PZ  470.4749
538  PZ  482.7783
539  PZ  495.0816
C Radial Detector DRC (1ft)
700  RCC  0.0000  0.0000  -45.7210  0.0000  0.0000  583.5760  151.1410
701  PZ  -31.1316
702  PZ  -16.5422
703  PZ  -1.9528
704  PZ  12.6366
705  PZ  27.2260
706  PZ  41.8154
707  PZ  56.4048
708  PZ  70.9942
709  PZ  85.5836
710  PZ  100.1730
711  PZ  114.7624
712  PZ  129.3518
713  PZ  143.9412
714  PZ  158.5306
715  PZ  173.1200
716  PZ  187.7094
717  PZ  202.2988
718  PZ  216.8882
719  PZ  231.4776
720  PZ  246.0670
721  PZ  260.6564
722  PZ  275.2458
723  PZ  289.8352
724  PZ  304.4246
725  PZ  319.0140
726  PZ  333.6034
727  PZ  348.1928
728  PZ  362.7822
729  PZ  377.3716
730  PZ  391.9610
731  PZ  406.5504
732  PZ  421.1398
733  PZ  435.7292
734  PZ  450.3186
735  PZ  464.9080
736  PZ  479.4974
737  PZ  494.0868
738  PZ  508.6762
739  PZ  523.2656
C Radial Detector DRCA (Shield)
600  RCC  0.0000  0.0000  -15.2410  0.0000  0.0000  30.4910  155.0909
601     PX  0.0001
602  1  PX  0.0001
603  2  PX  0.0001
604  3  PX  0.0001
605  4  PX  0.0001
606  5  PX  0.0001
607  6  PX  0.0001
608  7  PX  0.0001
609  8  PX  0.0001
610  9  PX  0.0001
611  10  PX  0.0001
612  11  PX  0.0001
613  12  PX  0.0001
614  13  PX  0.0001
615  14  PX  0.0001
616  15  PX  0.0001
617     PY  0.0000
618  16  PX  0.0001
619  17  PX  0.0001
620  18  PX  0.0001
621  19  PX  0.0001
622  20  PX  0.0001
623  21  PX  0.0001
624  22  PX  0.0001
625  23  PX  0.0001
626  24  PX  0.0001
627  25  PX  0.0001
628  26  PX  0.0001
629  27  PX  0.0001
630  28  PX  0.0001
631  29  PX  0.0001
632  30  PX  0.0001
C Radial Detector DRE (1m)
800  RCC  0.0000  0.0000  -115.2410  0.0000  0.0000  722.6160  220.6610
801  PZ  -97.1756
802  PZ  -79.1102
803  PZ  -61.0448
804  PZ  -42.9794
805  PZ  -24.9140
806  PZ  -6.8486
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807  PZ  11.2168
808  PZ  29.2822
809  PZ  47.3476
810  PZ  65.4130
811  PZ  83.4784
812  PZ  101.5438
813  PZ  119.6092
814  PZ  137.6746
815  PZ  155.7400
816  PZ  173.8054
817  PZ  191.8708
818  PZ  209.9362
819  PZ  228.0016
820  PZ  246.0670
821  PZ  264.1324
822  PZ  282.1978
823  PZ  300.2632
824  PZ  318.3286
825  PZ  336.3940
826  PZ  354.4594
827  PZ  372.5248
828  PZ  390.5902
829  PZ  408.6556
830  PZ  426.7210
831  PZ  444.7864
832  PZ  462.8518
833  PZ  480.9172
834  PZ  498.9826
835  PZ  517.0480
836  PZ  535.1134
837  PZ  553.1788
838  PZ  571.2442
839  PZ  589.3096
C Radial Detector DRF (2m)
900  RCC  0.0000  0.0000  -215.2410  0.0000  0.0000  922.6160  320.6610
901  PZ  -192.1756
902  PZ  -169.1102
903  PZ  -146.0448
904  PZ  -122.9794
905  PZ  -99.9140
906  PZ  -76.8486
907  PZ  -53.7832
908  PZ  -30.7178
909  PZ  -7.6524
910  PZ  15.4130
911  PZ  38.4784
912  PZ  61.5438
913  PZ  84.6092
914  PZ  107.6746
915  PZ  130.7400
916  PZ  153.8054
917  PZ  176.8708
918  PZ  199.9362
919  PZ  223.0016
920  PZ  246.0670
921  PZ  269.1324
922  PZ  292.1978
923  PZ  315.2632
924  PZ  338.3286
925  PZ  361.3940
926  PZ  384.4594
927  PZ  407.5248
928  PZ  430.5902
929  PZ  453.6556
930  PZ  476.7210
931  PZ  499.7864
932  PZ  522.8518
933  PZ  545.9172
934  PZ  568.9826
935  PZ  592.0480
936  PZ  615.1134
937  PZ  638.1788
938  PZ  661.2442
939  PZ  684.3096
C Radial Detector DRG (4m)
1000  RCC  0.0000  0.0000  -415.2410  0.0000  0.0000  1322.6160  520.6610
1001  PZ  -388.7887
1002  PZ  -362.3364
1003  PZ  -335.8840
1004  PZ  -309.4317
1005  PZ  -282.9794
1006  PZ  -256.5271
1007  PZ  -230.0748
1008  PZ  -203.6224
1009  PZ  -177.1701
1010  PZ  -150.7178
1011  PZ  -124.2655
1012  PZ  -97.8132
1013  PZ  -71.3608
1014  PZ  -44.9085
1015  PZ  -18.4562
1016  PZ  7.9961
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1017  PZ  34.4484
1018  PZ  60.9008
1019  PZ  87.3531
1020  PZ  113.8054
1021  PZ  140.2577
1022  PZ  166.7100
1023  PZ  193.1624
1024  PZ  219.6147
1025  PZ  246.0670
1026  PZ  272.5193
1027  PZ  298.9716
1028  PZ  325.4240
1029  PZ  351.8763
1030  PZ  378.3286
1031  PZ  404.7809
1032  PZ  431.2332
1033  PZ  457.6856
1034  PZ  484.1379
1035  PZ  510.5902
1036  PZ  537.0425
1037  PZ  563.4948
1038  PZ  589.9472
1039  PZ  616.3995
1040  PZ  642.8518
1041  PZ  669.3041
1042  PZ  695.7564
1043  PZ  722.2088
1044  PZ  748.6611
1045  PZ  775.1134
1046  PZ  801.5657
1047  PZ  828.0180
1048  PZ  854.4704
1049  PZ  880.9227

c
C Materials List - Common Materials - v1.7
c
C Homogenized Lower Nozzle
m1     6000 -8.0000E-04 14000 -1.0000E-02 15031 -4.5000E-04
       24000 -1.9000E-01 25055 -2.0000E-02 26000 -6.8375E-01
       28000 -9.5000E-02
C Homogenized Lower Plenum
m2     24000 -1.0000E-03
       26000 -2.1000E-03
       40000 -9.8230E-01
       50000 -1.4500E-02
       72000 -1.0000E-04
C Homogenized UO2 Fuel - Dry
m3     92235 -3.5870E-02 40000 -1.8286E-01 24000 -1.8616E-04
       92238 -6.8153E-01 50000 -2.6993E-03 72000 -1.8616E-05
        8016 -9.6442E-02 26000 -3.9093E-04
C Homogenized Upper Plenum
m4     6000 -7.0431E-04 14000 -8.8038E-03 15031 -3.9617E-04
       24000 -1.6739E-01 50000 -1.7344E-03 25055 -1.7608E-02
       26000 -6.0221E-01 72000 -1.1962E-05 28000 -8.3636E-02
       40000 -1.1750E-01
C Homogenized Upper Nozzle
m5     6000 -8.0000E-04 14000 -1.0000E-02 15031 -4.5000E-04
       24000 -1.9000E-01 25055 -2.0000E-02 26000 -6.8375E-01
       28000 -9.5000E-02
C Water
m6     1001 2 8016 1
C Stainless Steel
m7     6000 -8.0000E-04 14000 -1.0000E-02 15031 -4.5000E-04
       24000 -1.9000E-01 25055 -2.0000E-02 26000 -6.8375E-01
       28000 -9.5000E-02
C Carbon Steel
m8     26000 -0.99  6012 -0.01
C Neutron Poison
m9     13027 -0.7470 5010 -0.0356 5011 -0.1624
       6012 -0.0549
C Aluminum
m10    13027 -1.0
C Lead
m11    82000 -1.0
C Vent Port Middle Cylinder
m14    6000 -8.0000E-04 14000 -1.0000E-02 15031 -4.5000E-04
       24000 -1.9000E-01 25055 -2.0000E-02 26000 -6.8375E-01
       28000 -9.5000E-02
c
C Cell Importances
c
imp:p 1 139r 0
c
C PWR Source Definition - Fuel Gamma Response to Group 7
c
sdef x=d1 y=d2 z=d3 erg=d4 cell=400:93:77:d5:3
si1   -10.4775 10.4775
sp1    0 1
si2   -10.4775 10.4775
sp2    0 1
si3 a 11.9456 21.4706 30.9956 40.5206 50.0456 59.5706 69.0956
```

```
      335.7956 345.3206 354.8456 364.3706 373.8956 383.4206 392.9456
sp3 d 0.5470 0.6358 0.7247 0.8135 0.9023 0.9912 1.0800
      1.0800 0.9912 0.9023 0.8135 0.7247 0.6358 0.5470
sb3 d 1.00E+00 1.00E+00 1.00E+00 1.00E+00 1.00E+00 1.00E+00 1.00E+00
      1.00E+00 1.00E+00 1.00E+00 1.00E+00 1.00E+00 1.00E+00 1.00E+00
si4   3.000E+00 4.000E+00
sp4   0 1
C Source Information
si5 l       39 40 41
         42 43 44 45 46
      47 48 49 50 51 52 53
      54 55 56 57 58 59 60
      61 62 63 64 65 66 67
         68 69 70 71 72
            73 74 75
C Source Probability
sp5           1.0 1.0 1.0
          1.0 1.0 1.0 1.0 1.0
      1.0 1.0 1.0 1.0 1.0 1.0 1.0
      1.0 1.0 1.0 1.0 1.0 1.0 1.0
      1.0 1.0 1.0 1.0 1.0 1.0 1.0
          1.0 1.0 1.0 1.0 1.0
              1.0 1.0 1.0
mode p
nps 1.20E+08
C
C ANSI/ANS-6.1.1-1977 - Gamma Flux-to-Dose Conversion Factors
C (mrem/hr)/(photons/cm2-sec)
C
de0   0.01 0.03 0.05 0.07 0.1 0.15 0.2
      0.25 0.3 0.35 0.4 0.45 0.5 0.55
      0.6 0.65 0.7 0.8 1 1.4 1.8
      2.2 2.6 2.8 3.25 3.75 4.25 4.75
      5 5.25 5.75 6.25 6.75 7.5 9
      11 13 15
df0   3.96E-03 5.82E-04 2.90E-04 2.58E-04 2.83E-04 3.79E-04 5.01E-04
      6.31E-04 7.59E-04 8.78E-04 9.85E-04 1.08E-03 1.17E-03 1.27E-03
      1.36E-03 1.44E-03 1.52E-03 1.68E-03 1.98E-03 2.51E-03 2.99E-03
      3.42E-03 3.82E-03 4.01E-03 4.41E-03 4.83E-03 5.23E-03 5.60E-03
      5.80E-03 6.01E-03 6.37E-03 6.74E-03 7.11E-03 7.66E-03 8.77E-03
      1.03E-02 1.18E-02 1.33E-02
C
C Exponential Transform - Radial
C
ext:p -0.6v1 -0.6v1 -0.6v1  -0.6v1 -0.6v1 0
      -0.6v1 -0.6v1  0
      0 20r -0.6v1 5r 0 0
      0 36r 0
      0 -0.6v1 0 -0.6v1 -0.6v1 0 -0.6v1 6r 0 2r
      0 -0.6v1 0 -0.6v1 0 -0.6v1 4r 0 8r -0.6v1 9r 0 4r -0.6v1 5r 0
      0 7r
vect v1 0.0 0.0 202.4
fc2 Radial Surface Tally
f2:p +400.1
fm2 3.7000E+01
fs2  -401  -402  -403  -404  -405  -406
     -407  -408  -409  -410  -411  -412
     -413  -414  -415  -416  -417  -418
     -419  -420  -421  -422  -423  -424
     -425  -426  -427  -428  -429  -430
     -431  -432  -433  -434  -435  -436
     -437  -438  -439  -440  -441  -442
     -443  -444  -445  -446  -447  -448
     -449  T
tf2
fc12 Radial Surface2 Tally
f12:p +500.1
fm12 3.7000E+01
fs12  -501  -502  -503  -504  -505  -506
     -507  -508  -509  -510  -511  -512
     -513  -514  -515  -516  -517  -518
     -519  -520  -521  -522  -523  -524
     -525  -526  -527  -528  -529  -530
     -531  -532  -533  -534  -535  -536
     -537  -538  -539  T
tf12
fc22 Radial 1ft Tally
f22:p +700.1
fm22 3.7000E+01
fs22  -701  -702  -703  -704  -705  -706
     -707  -708  -709  -710  -711  -712
     -713  -714  -715  -716  -717  -718
     -719  -720  -721  -722  -723  -724
     -725  -726  -727  -728  -729  -730
     -731  -732  -733  -734  -735  -736
     -737  -738  -739  T
tf22
fc32 Radial Shield Tally Q1 (+x+y)
f32:p +600.1
fm32 3.7000E+01
fs32 -601  -617
     +616  +615  +614  +613  +612  +611
```

```
     +610  +609  +608  +607  +606  +605
     +604  +603  +602  T
sd32 1.4856E+04  7.4281E+03  4.6426E+02  15r  2.9712E+04
tf32
fc42 Radial Shield Tally Q2 (-x+y)
f42:p +600.1
fm42 3.7000E+01
fs42 +601  -617
     -632  -631  -630  -629  -628  -627
     -626  -625  -624  -623  -622  -621
     -620  -619  -618  T
sd42 1.4856E+04  7.4281E+03  4.6426E+02  15r  2.9712E+04
tf42
fc52 Radial Shield Tally Q3 (-x-y)
f52:p +600.1
fm52 3.7000E+01
fs52 +601  +617
     -616  -615  -614  -613  -612  -611
     -610  -609  -608  -607  -606  -605
     -604  -603  -602  T
sd52 1.4856E+04  7.4281E+03  4.6426E+02  15r  2.9712E+04
tf52
fc62 Radial Shield Tally Q4 (+x-y)
f62:p +600.1
fm62 3.7000E+01
fs62 -601  +617
     +632  +631  +630  +629  +628  +627
     +626  +625  +624  +623  +622  +621
     +620  +619  +618  T
sd62 1.4856E+04  7.4281E+03  4.6426E+02  15r  2.9712E+04
tf62
fc72 Radial 1m Tally
f72:p +800.1
fm72 3.7000E+01
fs72  -801  -802  -803  -804  -805  -806
     -807  -808  -809  -810  -811  -812
     -813  -814  -815  -816  -817  -818
     -819  -820  -821  -822  -823  -824
     -825  -826  -827  -828  -829  -830
     -831  -832  -833  -834  -835  -836
     -837  -838  -839  T
tf72
fc82 Radial 2m Tally
f82:p +900.1
fm82 3.7000E+01
fs82  -901  -902  -903  -904  -905  -906
     -907  -908  -909  -910  -911  -912
     -913  -914  -915  -916  -917  -918
     -919  -920  -921  -922  -923  -924
     -925  -926  -927  -928  -929  -930
     -931  -932  -933  -934  -935  -936
     -937  -938  -939  T
tf82
fc92 Radial 4m Tally
f92:p +1000.1
fm92 3.7000E+01
fs92  -1001  -1002  -1003  -1004  -1005  -1006
     -1007  -1008  -1009  -1010  -1011  -1012
     -1013  -1014  -1015  -1016  -1017  -1018
     -1019  -1020  -1021  -1022  -1023  -1024
     -1025  -1026  -1027  -1028  -1029  -1030
     -1031  -1032  -1033  -1034  -1035  -1036
     -1037  -1038  -1039  -1040  -1041  -1042
     -1043  -1044  -1045  -1046  -1047  -1048
     -1049  T
tf92
C
C
C Weight Window Generation - Radial
C
wwg 72 0 0 0 0
wwp:p 5 3 5 0 -1 0
mesh geom=cyl ref=89 0 215 origin=0.1 0.1 -515
     imesh 90.2 91.4 96.5 98.6 106.8 120.0 120.7 132.8 150.0 650.0
     iints 5 1 1 1 3 1 1 5 5 5
     jmesh 500 520 527 537 539 920 952 980 985 1007 1507
     jints 1 1 1 1 1 1 1 1 1 1 1
     kmesh 1
     kints 16
C wwge:p  1e-3 1 20
C
C Print Control
C
prdmp 1.20E+07 1.20E+07 1 2
print
C
C Random Number Generator
C
rand gen=2 seed=19073486328125  stride=152917 hist=1
C
C Radial Point Detector
f15:p 111.4753 46.1746 484.6294 0.0
```

```
fm15 3.7000E+01
C
C Rotation Matrix
C
C 5.625 degree rotation around z-axis
*TR1 0.0 0.0 0.0 5.625 95.625 90 -84.375 5.625 90 90 90 0
C 11.25 degree rotation around z-axis
*TR2 0.0 0.0 0.0 11.250 101.250 90 -78.750 11.250 90 90 90 0
C 16.875 degree rotation around z-axis
*TR3 0.0 0.0 0.0 16.875 106.875 90 -73.125 16.875 90 90 90 0
C 22.5 degree rotation around z-axis
*TR4 0.0 0.0 0.0 22.500 112.500 90 -67.500 22.500 90 90 90 0
C 28.125 degree rotation around z-axis
*TR5 0.0 0.0 0.0 28.125 118.125 90 -61.875 28.125 90 90 90 0
C 33.75 degree rotation around z-axis
*TR6 0.0 0.0 0.0 33.750 123.750 90 -56.250 33.750 90 90 90 0
C 39.375 degree rotation around z-axis
*TR7 0.0 0.0 0.0 39.375 129.375 90 -50.625 39.375 90 90 90 0
C 45 degree rotation around z-axis
*TR8 0.0 0.0 0.0 45.000 135.000 90 -45.000 45.000 90 90 90 0
C 50.625 degree rotation around z-axis
*TR9 0.0 0.0 0.0 50.625 140.625 90 -39.375 50.625 90 90 90 0
C 56.25 degree rotation around z-axis
*TR10 0.0 0.0 0.0 56.250 146.250 90 -33.750 56.250 90 90 90 0
C 61.875 degree rotation around z-axis
*TR11 0.0 0.0 0.0 61.875 151.875 90 -28.125 61.875 90 90 90 0
C 67.5 degree rotation around z-axis
*TR12 0.0 0.0 0.0 67.500 157.500 90 -22.500 67.500 90 90 90 0
C 73.125 degree rotation around z-axis
*TR13 0.0 0.0 0.0 73.125 163.125 90 -16.875 73.125 90 90 90 0
C 78.75 degree rotation around z-axis
*TR14 0.0 0.0 0.0 78.750 168.750 90 -11.250 78.750 90 90 90 0
C 84.375 degree rotation around z-axis
*TR15 0.0 0.0 0.0 84.375 174.375 90 -5.625 84.375 90 90 90 0
C 95.625 degree rotation around z-axis
*TR16 0.0 0.0 0.0 95.625 185.625 90 5.625 95.625 90 90 90 0
C 101.25 degree rotation around z-axis
*TR17 0.0 0.0 0.0 101.250 191.250 90 11.250 101.250 90 90 90 0
C 106.875 degree rotation around z-axis
*TR18 0.0 0.0 0.0 106.875 196.875 90 16.875 106.875 90 90 90 0
C 112.5 degree rotation around z-axis
*TR19 0.0 0.0 0.0 112.500 202.500 90 22.500 112.500 90 90 90 0
C 118.125 degree rotation around z-axis
*TR20 0.0 0.0 0.0 118.125 208.125 90 28.125 118.125 90 90 90 0
C 123.75 degree rotation around z-axis
*TR21 0.0 0.0 0.0 123.750 213.750 90 33.750 123.750 90 90 90 0
C 129.375 degree rotation around z-axis
*TR22 0.0 0.0 0.0 129.375 219.375 90 39.375 129.375 90 90 90 0
C 135 degree rotation around z-axis
*TR23 0.0 0.0 0.0 135.000 225.000 90 45.000 135.000 90 90 90 0
C 140.625 degree rotation around z-axis
*TR24 0.0 0.0 0.0 140.625 230.625 90 50.625 140.625 90 90 90 0
C 146.25 degree rotation around z-axis
*TR25 0.0 0.0 0.0 146.250 236.250 90 56.250 146.250 90 90 90 0
C 151.875 degree rotation around z-axis
*TR26 0.0 0.0 0.0 151.875 241.875 90 61.875 151.875 90 90 90 0
C 157.5 degree rotation around z-axis
*TR27 0.0 0.0 0.0 157.500 247.500 90 67.500 157.500 90 90 90 0
C 163.125 degree rotation around z-axis
*TR28 0.0 0.0 0.0 163.125 253.125 90 73.125 163.125 90 90 90 0
C 168.75 degree rotation around z-axis
*TR29 0.0 0.0 0.0 168.750 258.750 90 78.750 168.750 90 90 90 0
C 174.375 degree rotation around z-axis
*TR30 0.0 0.0 0.0 174.375 264.375 90 84.375 174.375 90 90 90 0
C 7 degree rotation around z-axis
*TR31 0.0 0.0 0.0 7.000 97.000 90 -83.000 7.000 90 90 90 0
C 23 degree rotation around z-axis
*TR32 0.0 0.0 0.0 23.000 113.000 90 -67.000 23.000 90 90 90 0
C 127 degree rotation around z-axis
*TR33 0.0 0.0 0.0 127.000 217.000 90 37.000 127.000 90 90 90 0
C 143 degree rotation around z-axis
*TR34 0.0 0.0 0.0 143.000 233.000 90 53.000 143.000 90 90 90 0
C 247 degree rotation around z-axis
*TR35 0.0 0.0 0.0 247.000 337.000 90 157.000 247.000 90 90 90 0
C 263 degree rotation around z-axis
*TR36 0.0 0.0 0.0 263.000 353.000 90 173.000 263.000 90 90 90 0
C 10 degree rotation around z-axis
*TR37 0.0 0.0 0.0 10.000 100.000 90 -80.000 10.000 90 90 90 0
C 20 degree rotation around z-axis
*TR38 0.0 0.0 0.0 20.000 110.000 90 -70.000 20.000 90 90 90 0
C 30 degree rotation around z-axis
*TR39 0.0 0.0 0.0 30.000 120.000 90 -60.000 30.000 90 90 90 0
C 40 degree rotation around z-axis
*TR40 0.0 0.0 0.0 40.000 130.000 90 -50.000 40.000 90 90 90 0
C 50 degree rotation around z-axis
*TR41 0.0 0.0 0.0 50.000 140.000 90 -40.000 50.000 90 90 90 0
C 60 degree rotation around z-axis
*TR42 0.0 0.0 0.0 60.000 150.000 90 -30.000 60.000 90 90 90 0
C 70 degree rotation around z-axis
*TR43 0.0 0.0 0.0 70.000 160.000 90 -20.000 70.000 90 90 90 0
C 80 degree rotation around z-axis
*TR44 0.0 0.0 0.0 80.000 170.000 90 -10.000 80.000 90 90 90 0
```

```
C 90 degree rotation around z-axis
*TR45 0.0 0.0 0.0 90.000 180.000 90 0.000 90.000 90 90 90 0
C 100 degree rotation around z-axis
*TR46 0.0 0.0 0.0 100.000 190.000 90 10.000 100.000 90 90 90 0
C 110 degree rotation around z-axis
*TR47 0.0 0.0 0.0 110.000 200.000 90 20.000 110.000 90 90 90 0
C 120 degree rotation around z-axis
*TR48 0.0 0.0 0.0 120.000 210.000 90 30.000 120.000 90 90 90 0
C 130 degree rotation around z-axis
*TR49 0.0 0.0 0.0 130.000 220.000 90 40.000 130.000 90 90 90 0
C 140 degree rotation around z-axis
*TR50 0.0 0.0 0.0 140.000 230.000 90 50.000 140.000 90 90 90 0
C 150 degree rotation around z-axis
*TR51 0.0 0.0 0.0 150.000 240.000 90 60.000 150.000 90 90 90 0
C 160 degree rotation around z-axis
*TR52 0.0 0.0 0.0 160.000 250.000 90 70.000 160.000 90 90 90 0
C 170 degree rotation around z-axis
*TR53 0.0 0.0 0.0 170.000 260.000 90 80.000 170.000 90 90 90 0
C 180 degree rotation around z-axis
*TR54 0.0 0.0 0.0 180.000 270.000 90 90.000 180.000 90 90 90 0
C 190 degree rotation around z-axis
*TR55 0.0 0.0 0.0 190.000 280.000 90 100.000 190.000 90 90 90 0
C 200 degree rotation around z-axis
*TR56 0.0 0.0 0.0 200.000 290.000 90 110.000 200.000 90 90 90 0
C 210 degree rotation around z-axis
*TR57 0.0 0.0 0.0 210.000 300.000 90 120.000 210.000 90 90 90 0
C 220 degree rotation around z-axis
*TR58 0.0 0.0 0.0 220.000 310.000 90 130.000 220.000 90 90 90 0
C 230 degree rotation around z-axis
*TR59 0.0 0.0 0.0 230.000 320.000 90 140.000 230.000 90 90 90 0
C 240 degree rotation around z-axis
*TR60 0.0 0.0 0.0 240.000 330.000 90 150.000 240.000 90 90 90 0
C 250 degree rotation around z-axis
*TR61 0.0 0.0 0.0 250.000 340.000 90 160.000 250.000 90 90 90 0
C 260 degree rotation around z-axis
*TR62 0.0 0.0 0.0 260.000 350.000 90 170.000 260.000 90 90 90 0
C 270 degree rotation around z-axis
*TR63 0.0 0.0 0.0 270.000 360.000 90 180.000 270.000 90 90 90 0
C 280 degree rotation around z-axis
*TR64 0.0 0.0 0.0 280.000 370.000 90 190.000 280.000 90 90 90 0
C 290 degree rotation around z-axis
*TR65 0.0 0.0 0.0 290.000 380.000 90 200.000 290.000 90 90 90 0
C 300 degree rotation around z-axis
*TR66 0.0 0.0 0.0 300.000 390.000 90 210.000 300.000 90 90 90 0
C 310 degree rotation around z-axis
*TR67 0.0 0.0 0.0 310.000 400.000 90 220.000 310.000 90 90 90 0
C 320 degree rotation around z-axis
*TR68 0.0 0.0 0.0 320.000 410.000 90 230.000 320.000 90 90 90 0
C 330 degree rotation around z-axis
*TR69 0.0 0.0 0.0 330.000 420.000 90 240.000 330.000 90 90 90 0
C 340 degree rotation around z-axis
*TR70 0.0 0.0 0.0 340.000 430.000 90 250.000 340.000 90 90 90 0
C 350 degree rotation around z-axis
*TR71 0.0 0.0 0.0 350.000 440.000 90 260.000 350.000 90 90 90 0
C 225 degree rotation around z-axis
*TR72 0.0 0.0 0.0 225.000 315.000 90 135.000 225.000 90 90 90 0
C 202.5 degree rotation around z-axis
*TR73 0.0 0.0 0.0 202.500 292.500 90 112.500 202.500 90 90 90 0
C 247.5 degree rotation around z-axis
*TR74 0.0 0.0 0.0 247.500 337.500 90 157.500 247.500 90 90 90 0
C 292.5 degree rotation around z-axis
*TR75 0.0 0.0 0.0 292.500 382.500 90 202.500 292.500 90 90 90 0
C 337.5 degree rotation around z-axis
*TR76 0.0 0.0 0.0 337.500 427.500 90 247.500 337.500 90 90 90 0
```

Figure 5.9.11-2 PMTC Sample Input File – Damaged Fuel

```
MAGNASTOR Passively Cooled Transfer Cask - pctShlInlLfgRR_ng16a_25b21e04y
C Inlet Biasing - Lower Nozzle Source
C Fuel Assembly Cells - ng16a - v1.1
1 1 -1.7170 -1      u=7 $ Lower Nozzle
2 2 -2.6069 -2 +1    u=7 $ Lower Plenum
3 3 -3.6800 -3 +2    u=7 $ Fuel
4 4 -0.8683 -4 +3    u=7 $ Upper Plenum
5 5 -1.3635 -5 +4    u=7 $ Upper Nozzle
6 0          +5     u=7 $ Outside
C Cells - Fuel Tube  v1.3
13 8 -7.8212 -8 +7    u=5 $ Tube
14 9 -2.6507 -9 : -10 : -11 : -12     u=5 $ Poison
15 0          #13  #14     u=5 $ Outside
C Cells - PWR Basket v1.5
16 0           -13 -14 fill=5 trcl = ( -23.5331 70.5993 0.0000 )    u=4 $ Assy loc 1
17 like 16 but fill=5 trcl = ( 23.5331 70.5993 0.0000 )    u=4 $ Assy loc 3
18 like 16 but fill=5 trcl = ( -47.0662 47.0662 0.0000 )    u=4 $ Assy loc 4
19 like 16 but fill=5 trcl = ( 0.0000 47.0662 0.0000 )    u=4 $ Assy loc 6
20 like 16 but fill=5 trcl = ( 47.0662 47.0662 0.0000 )    u=4 $ Assy loc 8
21 like 16 but fill=5 trcl = ( -70.5993 23.5331 0.0000 )    u=4 $ Assy loc 9
22 like 16 but fill=5 trcl = ( -23.5331 23.5331 0.0000 )    u=4 $ Assy loc 11
23 like 16 but fill=5 trcl = ( 23.5331 23.5331 0.0000 )    u=4 $ Assy loc 13
24 like 16 but fill=5 trcl = ( 70.5993 23.5331 0.0000 )    u=4 $ Assy loc 15
25 like 16 but fill=5 trcl = ( -47.0662 0.0000 0.0000 )    u=4 $ Assy loc 17
26 like 16 but fill=5 trcl = ( 0.0000 0.0000 0.0000 )    u=4 $ Assy loc 19
27 like 16 but fill=5 trcl = ( 47.0662 0.0000 0.0000 )    u=4 $ Assy loc 21
28 like 16 but fill=5 trcl = ( -70.5993 -23.5331 0.0000 )    u=4 $ Assy loc 23
29 like 16 but fill=5 trcl = ( -23.5331 -23.5331 0.0000 )    u=4 $ Assy loc 25
30 like 16 but fill=5 trcl = ( 23.5331 -23.5331 0.0000 )    u=4 $ Assy loc 27
31 like 16 but fill=5 trcl = ( 70.5993 -23.5331 0.0000 )    u=4 $ Assy loc 29
32 like 16 but fill=5 trcl = ( -47.0662 -47.0662 0.0000 )    u=4 $ Assy loc 30
33 like 16 but fill=5 trcl = ( 0.0000 -47.0662 0.0000 )    u=4 $ Assy loc 32
34 like 16 but fill=5 trcl = ( 47.0662 -47.0662 0.0000 )    u=4 $ Assy loc 34
35 like 16 but fill=5 trcl = ( -23.5331 -70.5993 0.0000 )    u=4 $ Assy loc 35
36 like 16 but fill=5 trcl = ( 23.5331 -70.5993 0.0000 )    u=4 $ Assy loc 37
37 8 -7.8212 -15 #24 #31      u=4 $ Side support +x
38 8 -7.8212 -16 #21 #28      u=4 $ Side support -x
39 8 -7.8212 -17 #16 #17      u=4 $ Side support +y
40 8 -7.8212 -18 #35 #36      u=4 $ Side support -y
41 8 -7.8212 -19 +20 +21     u=4 $ Corner
42 8 -7.8212 -21 +22 +20  +15.2 +16.1 +17.4 +18.3
             #16 #17 #21 #24 #28 #31 #35 #36       u=4 $ Corner diagonal
43 0          -6 #16 #17 #18 #19 #20 #21 #22 #23 #24 #25 #26
                #27 #28 #29 #30 #31 #32 #33 #34 #35 #36
                #37 #38 #39 #40 #41 #42       u=4 $ Basket below PFE
44 0          +6 #16 #17 #18 #19 #20 #21 #22 #23 #24 #25 #26
               #27 #28 #29 #30 #31 #32 #33 #34 #35 #36
               #37 #38 #39 #40 #41 #42      u=4 $ Basket above PFE
C Cells - PWR Canister Cavity v1.5
45 0           -23 fill=7 trcl = ( -23.5331 70.5993 0.0000 )    u=3 $ Assy loc 1
46 like 45 but fill=7 trcl = ( 0.0000 70.5993 0.0000 )    u=3 $ Assy loc 2
47 like 45 but fill=7 trcl = ( 23.5331 70.5993 0.0000 )    u=3 $ Assy loc 3
48 like 45 but fill=6 trcl = ( -47.0662 47.0662 0.0000 )    u=3 $ Assy loc 4
49 like 45 but fill=7 trcl = ( -23.5331 47.0662 0.0000 )    u=3 $ Assy loc 5
50 like 45 but fill=7 trcl = ( 0.0000 47.0662 0.0000 )    u=3 $ Assy loc 6
51 like 45 but fill=7 trcl = ( 23.5331 47.0662 0.0000 )    u=3 $ Assy loc 7
52 like 45 but fill=6 trcl = ( 47.0662 47.0662 0.0000 )    u=3 $ Assy loc 8
53 like 45 but fill=7 trcl = ( -70.5993 23.5331 0.0000 )    u=3 $ Assy loc 9
54 like 45 but fill=7 trcl = ( -47.0662 23.5331 0.0000 )    u=3 $ Assy loc 10
55 like 45 but fill=7 trcl = ( -23.5331 23.5331 0.0000 )    u=3 $ Assy loc 11
56 like 45 but fill=7 trcl = ( 0.0000 23.5331 0.0000 )    u=3 $ Assy loc 12
57 like 45 but fill=7 trcl = ( 23.5331 23.5331 0.0000 )    u=3 $ Assy loc 13
58 like 45 but fill=7 trcl = ( 47.0662 23.5331 0.0000 )    u=3 $ Assy loc 14
59 like 45 but fill=7 trcl = ( 70.5993 23.5331 0.0000 )    u=3 $ Assy loc 15
60 like 45 but fill=7 trcl = ( -70.5993 0.0000 0.0000 )    u=3 $ Assy loc 16
61 like 45 but fill=7 trcl = ( -47.0662 0.0000 0.0000 )    u=3 $ Assy loc 17
62 like 45 but fill=7 trcl = ( -23.5331 0.0000 0.0000 )    u=3 $ Assy loc 18
63 like 45 but fill=7 trcl = ( 0.0000 0.0000 0.0000 )    u=3 $ Assy loc 19
64 like 45 but fill=7 trcl = ( 23.5331 0.0000 0.0000 )    u=3 $ Assy loc 20
65 like 45 but fill=7 trcl = ( 47.0662 0.0000 0.0000 )    u=3 $ Assy loc 21
66 like 45 but fill=7 trcl = ( 70.5993 0.0000 0.0000 )    u=3 $ Assy loc 22
67 like 45 but fill=7 trcl = ( -70.5993 -23.5331 0.0000 )    u=3 $ Assy loc 23
68 like 45 but fill=7 trcl = ( -47.0662 -23.5331 0.0000 )    u=3 $ Assy loc 24
69 like 45 but fill=7 trcl = ( -23.5331 -23.5331 0.0000 )    u=3 $ Assy loc 25
70 like 45 but fill=7 trcl = ( 0.0000 -23.5331 0.0000 )    u=3 $ Assy loc 26
71 like 45 but fill=7 trcl = ( 23.5331 -23.5331 0.0000 )    u=3 $ Assy loc 27
72 like 45 but fill=7 trcl = ( 47.0662 -23.5331 0.0000 )    u=3 $ Assy loc 28
73 like 45 but fill=7 trcl = ( 70.5993 -23.5331 0.0000 )    u=3 $ Assy loc 29
74 like 45 but fill=6 trcl = ( -47.0662 -47.0662 0.0000 )    u=3 $ Assy loc 30
75 like 45 but fill=7 trcl = ( -23.5331 -47.0662 0.0000 )    u=3 $ Assy loc 31
76 like 45 but fill=7 trcl = ( 0.0000 -47.0662 0.0000 )    u=3 $ Assy loc 32
77 like 45 but fill=7 trcl = ( 23.5331 -47.0662 0.0000 )    u=3 $ Assy loc 33
78 like 45 but fill=6 trcl = ( 47.0662 -47.0662 0.0000 )    u=3 $ Assy loc 34
79 like 45 but fill=7 trcl = ( -23.5331 -70.5993 0.0000 )    u=3 $ Assy loc 35
80 like 45 but fill=7 trcl = ( 0.0000 -70.5993 0.0000 )    u=3 $ Assy loc 36
81 like 45 but fill=7 trcl = ( 23.5331 -70.5993 0.0000 )    u=3 $ Assy loc 37
82 0          #45 #46 #47 #48 #49 #50 #51 #52 #53 #54 #55 #56 #57
              #58 #59 #60 #61 #62 #63 #64 #65 #66 #67 #68 #69 #70
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          #71 #72 #73 #74 #75 #76 #77 #78 #79 #80 #81      fill=4 u=3 $ Cavity
C Cells - Canister v1.3
83 0          -24 #94  #95  fill=3    u=2 $ Cavity
84 7 -7.9400 -37 +24.3      u=2 $ Canister Bottom
85 0          -28 +24.2 -31 trcl = ( 64.2620 40.8940 0.0000 )   u=2 $ Bottom Drain Port
86 14 -3.9700 -29 +31 -33 trcl = ( 64.2620 40.8940 0.0000 )   u=2 $ Middle Drain Port
87 7 -7.9400 -30 +33 -37.2 trcl = ( 64.2620 40.8940 0.0000 )   u=2 $ Top Drain Port
88 like 85 but   trcl = ( -64.2620 -40.8940 0.0000 )    u=2 $ Bottom Vent Port
89 like 86 but   trcl = ( -64.2620 -40.8940 0.0000 )    u=2 $ Middle Vent Port
90 like 87 but   trcl = ( -64.2620 -40.8940 0.0000 )    u=2 $ Top Vent Port
91 7 -7.9400 -37 -24.3 +24.1     u=2 $ Canister Shell
92 8 -7.8212 -37 -24.1 +24.2 -32 #85 #86  #88 #89  #96  u=2 $ Lower lid
93 7 -7.9400 -37 -24.1 +32 #86 #87  #89 #90  #96 #97   u=2 $ Upper lid
94 7 -7.9400 -36 +35 +34 -24.2 trcl = ( 64.2620 40.8940 0.0000 )   u=2 $ Drain port shield
95 7 -7.9400 -36 +35 +32 -24.2 trcl = ( -64.2620 -40.8940 0.0000 )   u=2 $ Vent port shield
96 0          -37 -24.1 +25 +24.2    u=2 $ Lid spacing
97 0          -37 -26 +27     u=2 $ Closure ring spacing
98 0          +37 #94      u=2 $ Outside
C Passively Cooled Transfer Cask Cells - v1.3.5_ng16a
99 0          ((-38 +72 +73) : -47)   fill=2 ( 0.0 0.0 12.0650 )    u=1 $ Cavity
100 7 -7.9400 -39 -40 +38     u=1 $ Inner shell
101 0          -39 -41 +40     u=1 $ Lead Inner spacing
102 11 -11.3440 -39 -42 +41     u=1 $ Lead shield
103 0          -39 -43 +42     u=1 $ Lead Outer Spacing
104 7 -7.9400 -39 -44 +43     u=1 $ Middle shell
105 6 -0.9616 -45 +44  #136 #137 #138 #139 #140 #141     u=1 $ Neutron shield
106 7 -7.9400 -39 +44 +45     u=1 $ Neutron shield shell
107 7 -7.9400 -46 +47      u=1 $ Retaining ring
108 7 -7.9400 -51 +38 +48 #110 #111 #112 #113 #114 #115
        #116 #117 #118        u=1 $ Top ring
C 109 0  +47 +49 -50      u=1 $ Top ring Overhang
110 0  ((-52 +53) : -54)       u=1 $ Top ring vent
111 0  +38 (-55 : -56)      u=1 $ Top ring vent
112 0  +38 (-57 : -58)      u=1 $ Top ring vent
113 0  +38 (-59 : -60)      u=1 $ Top ring vent
114 0  +38 (-61 : -62)      u=1 $ Top ring vent
115 0  +38 (-63 : -64)      u=1 $ Top ring vent
116 0  +38 (-65 : -66)      u=1 $ Top ring vent
117 0  +38 (-67 : -68)      u=1 $ Top ring vent
118 0  +38 (-69 : -70)      u=1 $ Top ring vent
119 7 -7.9400 (-71 : -78) +38 +89 +90 #132 #133 #134 #135    u=1 $ Bottom ring
C 120 7 -7.9400 (-91 +92 +93 +96 +97 +98 +99 +100)    #C 131  :
C     (+91 -49 -38.1)      u=1 $ Seal shield
121 7 -7.9400 ((-101 +102 -103) : (-103 +104 -101))   +71 +74 +83  u=1 $ Inlet Shield - Door
122 7 -7.9400 -74 -103 +104 +71 +83 #129 #130  u=1 $ Inlet Shield - Door
123 7 -7.9400 ((-101 +102 -105) : (-105 +106 -101))   +71 +74 +83  u=1 $ Inlet Shield - Door
124 7 -7.9400 -74 -105 +106 +71 +83 #129 #130   u=1 $ Inlet Shield - Door
125 7 -7.9400 -107 +108 +77 +78    u=1 $ Inlet Shield - Rail
126 7 -7.9400 -109 +110 +77 +78    u=1 $ Inlet Shield - Rail
127 7 -7.9400 -72        u=1 $ Rail -x
128 7 -7.9400 -73        u=1 $ Rail +x
129 7 -7.9400 (-74 : -77) -75 +76 (+83 +84 +85 +86 +87)  #130   u=1 $ Door steel
130 0  -88        u=1 $ Door  Overhang gap
C 131 0        +94 -95      u=1 $ Seal shield - seal cut
132 0         (-79 +80) +38 -78     u=1 $ Vent
133 0         (-81 +82) +38 -71     u=1 $ Vent
134  like 132 but TRCL= 54     u=1 $ Vent
135  like 133 but TRCL= 54     u=1 $ Vent
136 7 -7.9400 ((+111 -112 -45 +44) : (+113 -114 -45 +115))    +136
        +137 +138 +139 +140 +141 +142 +143 +144 +145 +146
        +147 +148 +149 +150 +151 +152 +153 +154 +155 +156
        +157 +158 +159 +160 +161 +162 +163 +164 +165 +166
        +167 +168 +169 +170 +171 +172 +173 +174 +175 +176     u=1 $ Baffle
137 7 -7.9400 ((+116 -117 -45 +44) : (+118 -119 -45 +115))    +136
        +137 +138 +139 +140 +141 +142 +143 +144 +145 +146
        +147 +148 +149 +150 +151 +152 +153 +154 +155 +156
        +157 +158 +159 +160 +161 +162 +163 +164 +165 +166
        +167 +168 +169 +170 +171 +172 +173 +174 +175 +176     u=1 $ Baffle
138 7 -7.9400 ((+120 -121 -45 +44) : (+122 -123 -45 +115))    +136
        +137 +138 +139 +140 +141 +142 +143 +144 +145 +146
        +147 +148 +149 +150 +151 +152 +153 +154 +155 +156
        +157 +158 +159 +160 +161 +162 +163 +164 +165 +166
        +167 +168 +169 +170 +171 +172 +173 +174 +175 +176     u=1 $ Baffle
139 7 -7.9400 ((+124 -125 -45 +44) : (+126 -127 -45 +115))    +136
        +137 +138 +139 +140 +141 +142 +143 +144 +145 +146
        +147 +148 +149 +150 +151 +152 +153 +154 +155 +156
        +157 +158 +159 +160 +161 +162 +163 +164 +165 +166
        +167 +168 +169 +170 +171 +172 +173 +174 +175 +176     u=1 $ Baffle
140 7 -7.9400 ((+128 -129 -45 +44) : (+130 -131 -45 +115))    +136
        +137 +138 +139 +140 +141 +142 +143 +144 +145 +146
        +147 +148 +149 +150 +151 +152 +153 +154 +155 +156
        +157 +158 +159 +160 +161 +162 +163 +164 +165 +166
        +167 +168 +169 +170 +171 +172 +173 +174 +175 +176     u=1 $ Baffle
141 7 -7.9400 ((+132 -133 -45 +44) : (+134 -135 -45 +115))    +136
        +137 +138 +139 +140 +141 +142 +143 +144 +145 +146
        +147 +148 +149 +150 +151 +152 +153 +154 +155 +156
        +157 +158 +159 +160 +161 +162 +163 +164 +165 +166
        +167 +168 +169 +170 +171 +172 +173 +174 +175 +176     u=1 $ Baffle
142 0          ((+38 +39 +46 +47 +51) : (+46 -48))
        #108  #110 #111 #112 #113 #114 #115 #116 #117 #118 #119
        #121 #122 #123 #124 #125 #126 #127
        #127 #128 #129 #130    #132 #133 #134 #135      u=1 $ Outside
```

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C Fuel Assembly Cells - ng16a - v1.1
7 19 -9.8774 -1      u=6 $ Lower Nozzle
8 2 -2.6069 -2 +1    u=6 $ Lower Plenum
9 3 -3.6800 -3 +2    u=6 $ Fuel
10 4 -0.8683 -4 +3    u=6 $ Upper Plenum
11 5 -1.3635 -5 +4    u=6 $ Upper Nozzle
12 0          +5     u=6 $ Outside
C Detector Cells - Inlet Biasing
399  0  -399  fill=1  $ Cask
400  0  -400  +399  fill=1  $ Surface
450  0  -450  +399  +400  fill=1  $ Surface
500  0  -500  +399  +400  +450  fill=1  $ Shield Out
550  0  -550  +399  +400  +450  +500  fill=1  $ Shield Out
600  0  -600  +399  +400  +450  +500  +550  fill=1  $ 1ft
700  0  -700  +399  +400  +450  +500  +550  +600  fill=1  $ 1m
800  0  -800  +399  +400  +450  +500  +550  +600  +700  fill=1  $ Outline
900  0  +399  +400  +450  +500  +550  +600  +700  +800  $ Exterior

C Fuel Assembly Surfaces - ng16a - v1.1
1 RPP -10.4775 10.4775 -10.4775 10.4775 0.0000 9.6825  $ Lower Nozzle
2 RPP -10.4775 10.4775 -10.4775 10.4775 0.0000 11.9456  $ Lower Plenum
3 RPP -10.4775 10.4775 -10.4775 10.4775 0.0000 392.9456  $ Fuel
4 RPP -10.4775 10.4775 -10.4775 10.4775 0.0000 424.8226  $ Upper Plenum
5 RPP -10.4775 10.4775 -10.4775 10.4775 0.0000 452.8820  $ Upper Nozzle
6 PZ 265.9456        $ Flood elevation
C Surfaces - Fuel Tube v1.3
7 RPP -11.6015 11.6015 -11.6015 11.6015 7.6200 457.2762  $ Tube void
8 RPP -12.3952 12.3952 -12.3952 12.3952 7.6200 448.3100  $ Tube
9 RPP -11.6015 -11.2840 -10.2362 10.2362 9.2075 446.7225  $ Poison left
10 RPP 11.2840 11.6015 -10.2362 10.2362 9.2075 446.7225  $ Poison right
11 RPP -10.2362 10.2362 11.2840 11.6015 9.2075 446.7225  $ Poison top
12 RPP -10.2362 10.2362 -11.6015 -11.2840 9.2075 446.7225  $ Poison bottom
C Surfaces - PWR Basket v1.5
13  RPP -12.3952 12.3952 -12.3952 12.3952 0.0000 457.2762  $ Tube opening
14 8 RPP -16.6370 16.6370 -16.6370 16.6370 0.0000 457.2762  $ Tube radius
15  RPP 81.8833 83.7883 -33.1851 33.1851 7.6200 448.3100  $ Side support +x
16  RPP -83.7883 -81.8833 -33.1851 33.1851 7.6200 448.3100  $ Side support -x
17  RPP -33.1851 33.1851 81.8833 83.7883 7.6200 448.3100  $ Side support +y
18  RPP -33.1851 33.1851 -83.7883 -81.8833 7.6200 448.3100  $ Side support -y
19  RPP -60.2552 60.2552 -60.2552 60.2552 7.6200 448.3100  $ Corner outer
20  RPP -59.4614 59.4614 -59.4614 59.4614 7.6200 448.3100  $ Corner inner
21 8 RPP -78.6267 78.6267 -78.6267 78.6267 7.6200 448.3100  $ Corner dia. outer
22 8 RPP -77.83291 77.8329 -77.8329 77.8329 7.6200 448.3100  $ Corner dia. inner
C Surfaces - PWR Canister Cavity v1.5
23 RPP -10.4780 10.4780 -10.4780 10.4780 0.0000 452.8821   $ Assy opening
C Surfaces - Canister v1.3
24 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 457.2762 90.1700   $ Cavity
25 CZ 89.8525          $ Lid Gap
26 RCC 0.0000 0.0000 477.9010 0.0000 0.0000 2.2352 89.8525   $ Closure Ring Gap
27 CZ 86.1060          $ Closure Ring Gap
28 CZ 2.6924          $ Bot Cylinder Radius
29 CZ 6.7691          $ Mid Cyclinder Radius
30 CZ 7.4041          $ Top Cylinder Radius
31 PZ 468.6300          $ Port plane bot/mid
32 PZ 469.9762          $ Lower/upper lid
33 PZ 477.2914          $ Port plane mid/top
34 PZ 450.9262          $ Port shield elevation
35 CZ 2.6924          $ Port shield ID
36 CZ 5.0800          $ Port shield OD
C  RCC 0.0000 0.0000 -12.0750 0.0000 0.0000 469.3412 96.6200   $ Water jacket
37 RCC 0.0000 0.0000 -6.9850 0.0000 0.0000 487.1212 91.4400   $ Canister
C Passively Cooled Transfer Cask Surfaces - v1.3.5_ng16a
38 RCC 0.0 0.0 0.0 0.0 0.0 499.745 96.5200   $ Cavity
39 RCC 0.0 0.0 15.2400 0.0 0.0 443.2300 120.6500   $ Cask OD
40 CZ 98.4250          $ Inner shell OD
41 CZ 98.552          $ Lead shield ID
42 CZ 106.680          $ Lead shield OD
43 CZ 106.8070          $ Middle shell ID
44 CZ 109.9820          $ Middle shell OD
45 RCC 0.0 0.0 15.2400 0.0 0.0 443.2300 120.0150   $ NS outline
46 RCC 0.0 0.0 499.7450 0.0 0.0 7.6200 112.0775   $ Retaining ring outline
47 RCC 0.0 0.0 499.7450 0.0 0.0 7.6200 86.9950   $ Retaining ring ID
48 RCC 0.0 0.0 499.7450 0.0 0.0 0.6350 112.6490   $ Top ring notch
49 RCC 0.0 0.0 499.7450 0.0 0.0 2.5400 100.9650
50 RCC 0.0 0.0 499.7450 0.0 0.0 2.8702 102.2350
51 RCC 0.0 0.0 458.4700 0.0 0.0 41.9100 120.6500   $ Top ring
52 RCC 0.0 0.0 493.2680 0.0 0.0 6.4770 120.0150   $ Top ring vent - ring
53 RCC 0.0 0.0 493.2680 0.0 0.0 6.4770 116.5098   $ Top ring vent - ring
54 RCC 116.5098 0.0 496.5700 4.1422 0.0 0.0 2.5400   $ Top ring vent - to nipple
55 4 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017   $ Top ring vent - interior to ring
56 4 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017   $ Top ring vent - interior to ring
57 12 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017   $ Top ring vent - interior to ring
58 12 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017   $ Top ring vent - interior to ring
59 19 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017   $ Top ring vent - interior to ring
60 19 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017   $ Top ring vent - interior to ring
61 27 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017   $ Top ring vent - interior to ring
62 27 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017   $ Top ring vent - interior to ring
63 73 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017   $ Top ring vent - interior to ring
64 73 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017   $ Top ring vent - interior to ring
65 74 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017   $ Top ring vent - interior to ring
66 74 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017   $ Top ring vent - interior to ring
67 75 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017   $ Top ring vent - interior to ring
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68 75 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017   $ Top ring vent - interior to ring
69 76 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017   $ Top ring vent - interior to ring
70 76 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017   $ Top ring vent - interior to ring
71 RCC 0.0 0.0 0.0 0.0 0.0 15.2400 120.6500   $ Bottom ring
72 RPP -76.3524 -71.2724 -91.4400 91.4400 0.0 5.0790   $ Rail -x
73 RPP 71.2724 76.3524 -91.4400 91.4400 0.0 5.0790   $ Rail +x
74 RHP 0.0 0.0 -15.2400 0.0 0.0 15.2400 -69.3278 -95.7554 0.0
       69.3278 -95.7554 0.0 101.6000 0.0 0.0   $ Door prism
75 PY 109.5375         $ Door side +y
76 PY -109.5375        $ Door side -y
77 RPP -120.6500 120.6500 -72.3900 72.3900 -15.2400 0.0   $ Vent forging Door
78 RPP -120.6500 120.6500 -72.3900 72.3900 0.0 15.2400   $ Vent forging Bottom Ring
79 RPP -120.6500 -79.7560 -66.8020 66.8020 0.0 7.6200   $ Vent outline -x
80 RPP -120.6500 -96.5200 -50.0380 50.0380 0.0 7.6200   $ Vent inner -x
81 RPP -67.0560 67.0560 -120.6500 -79.7560 0.0 7.6200   $ Vent outline -y
82 RPP -50.2920 50.2920 -120.6500 -96.5200 0.0 7.6200   $ Vent inner -y
83 RPP -102.2350 102.2350 -200.0000 200.0000 -0.3048 0.0   $ Door Gap
84 RPP -102.2350 -101.6000 -200.0000 200.0000 -10.4648 0.0   $ Door Gap
85 RPP 101.6000 102.2350 -200.0000 200.0000 -10.4648 0.0   $ Door Gap
86 RPP -97.7900 -97.6376 -200.0000 200.0000 -15.2400 -10.4648   $ Door Gap
87 RPP 97.6376 97.7900 -200.0000 200.0000 -15.2400 -10.4648   $ Door Gap
88 RPP -101.6000 101.6000 -0.3175 0.3175 -10.3124 -10.0076   $ Door overhang gap
89 RPP -76.5175 -71.1073 -200.0000 200.0000 0.0000 5.1562   $ Rail -x Gap
90 RPP 71.1073 76.5175 -200.0000 200.0000 0.0000 5.1562   $ Rail +x Gap
91 RCC 0.0 0.0 467.3600 0.0 0.0 34.9250 95.5675   $ Seal Shield OD
92 RCC 0.0 0.0 467.3600 0.0 0.0 34.9250 92.0750   $ Seal Shield ID
93 RCC 0.0 0.0 469.6587 0.0 0.0 3.0226 93.5990   $ Seal Shield seal
94 RCC 0.0 0.0 476.0087 0.0 0.0 3.0226 94.0435   $ Seal Shield seal
95 RCC 0.0 0.0 476.0087 0.0 0.0 3.0226 95.5675   $ Seal Shield seal
96 4 RCC 93.5890 0.0 471.1700 1.3562 0.0 0.0 0.3175   $ Seal Shield vent
97 4 RCC 94.0535 0.0 477.5200 -1.3562 0.0 0.0 0.3175   $ Seal Shield vent
98 4 RCC 95.5675 0.0 474.3450 -2.8702 0.0 0.0 0.2540   $ Seal Shield vent
99 4 RCC 94.9452 0.0 467.3600 0.0 0.0 7.6200 0.2540   $ Seal Shield vent
100 4 RCC 92.6973 0.0 473.8370 0.0 0.0 28.4480 0.2540   $ Seal Shield vent
101 RCC 0.0 0.0 -15.2400 0.0 0.0 30.4800 139.1920   $ Inlet Shield - Door
102 RCC 0.0 0.0 -15.2400 0.0 0.0 30.4800 132.8420   $ Inlet Shield - Door
103 RPP -70.8660 -46.4820 -139.1920 139.1920 -15.2400 15.2400   $ Inlet Shield - Door
104 RPP -67.0560 -50.2920 -139.1920 139.1920 -15.2400 15.2400   $ Inlet Shield - Door
105 RPP 46.4820 70.8660 -139.1920 139.1920 -15.2400 15.2400   $ Inlet Shield - Door
106 RPP 50.2920 67.0560 -139.1920 139.1920 -15.2400 15.2400   $ Inlet Shield - Door
107 RPP -137.1600 137.1600 -72.3900 -46.2280 -15.2400 15.2400   $ Inlet Shield - Rail
108 RPP -133.3500 133.3500 -68.5800 -50.0380 -15.2400 15.2400   $ Inlet Shield - Rail
109 RPP -137.1600 137.1600 46.2280 72.3900 -15.2400 15.2400   $ Inlet Shield - Rail
110 RPP -133.3500 133.3500 50.0380 68.5800 -15.2400 15.2400   $ Inlet Shield - Rail
111 PY -0.3175        $ Baffle
112 PY 0.3175         $ Baffle
113 PY -1.27        $ Baffle
114 PY 1.27        $ Baffle
115 CZ 119.2530        $ Baffle
116 39 PY -0.3175        $ Baffle
117 39 PY 0.3175        $ Baffle
118 39 PY -1.27        $ Baffle
119 39 PY 1.27        $ Baffle
120 42 PY -0.3175        $ Baffle
121 42 PY 0.3175        $ Baffle
122 42 PY -1.27        $ Baffle
123 42 PY 1.27        $ Baffle
124 45 PY -0.3175        $ Baffle
125 45 PY 0.3175        $ Baffle
126 45 PY -1.27        $ Baffle
127 45 PY 1.27        $ Baffle
128 48 PY -0.3175        $ Baffle
129 48 PY 0.3175        $ Baffle
130 48 PY -1.27        $ Baffle
131 48 PY 1.27        $ Baffle
132 51 PY -0.3175        $ Baffle
133 51 PY 0.3175        $ Baffle
134 51 PY -1.27        $ Baffle
135 51 PY 1.27        $ Baffle
136 TZ 0.0 0.0 15.2400 114.4270 3.1750 3.1750    $ Baffle hole 1
137 TZ 0.0 0.0 26.4160 114.4270 3.1750 3.1750    $ Baffle hole 2
138 TZ 0.0 0.0 37.4943 114.4270 3.1750 3.1750    $ Baffle hole 3
139 TZ 0.0 0.0 48.5726 114.4270 3.1750 3.1750    $ Baffle hole 4
140 TZ 0.0 0.0 59.6509 114.4270 3.1750 3.1750    $ Baffle hole 5
141 TZ 0.0 0.0 70.7292 114.4270 3.1750 3.1750    $ Baffle hole 6
142 TZ 0.0 0.0 81.8075 114.4270 3.1750 3.1750    $ Baffle hole 7
143 TZ 0.0 0.0 92.8858 114.4270 3.1750 3.1750    $ Baffle hole 8
144 TZ 0.0 0.0 103.9642 114.4270 3.1750 3.1750    $ Baffle hole 9
145 TZ 0.0 0.0 115.0425 114.4270 3.1750 3.1750    $ Baffle hole 10
146 TZ 0.0 0.0 126.1208 114.4270 3.1750 3.1750    $ Baffle hole 11
147 TZ 0.0 0.0 137.1991 114.4270 3.1750 3.1750    $ Baffle hole 12
148 TZ 0.0 0.0 148.2774 114.4270 3.1750 3.1750    $ Baffle hole 13
149 TZ 0.0 0.0 159.3557 114.4270 3.1750 3.1750    $ Baffle hole 14
150 TZ 0.0 0.0 170.4340 114.4270 3.1750 3.1750    $ Baffle hole 15
151 TZ 0.0 0.0 181.5123 114.4270 3.1750 3.1750    $ Baffle hole 16
152 TZ 0.0 0.0 192.5906 114.4270 3.1750 3.1750    $ Baffle hole 17
153 TZ 0.0 0.0 203.6689 114.4270 3.1750 3.1750    $ Baffle hole 18
154 TZ 0.0 0.0 214.7472 114.4270 3.1750 3.1750    $ Baffle hole 19
155 TZ 0.0 0.0 225.8255 114.4270 3.1750 3.1750    $ Baffle hole 20
156 TZ 0.0 0.0 236.9038 114.4270 3.1750 3.1750    $ Baffle hole 21
157 TZ 0.0 0.0 247.9822 114.4270 3.1750 3.1750    $ Baffle hole 22
158 TZ 0.0 0.0 259.0605 114.4270 3.1750 3.1750    $ Baffle hole 23
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159 TZ 0.0 0.0 270.1388 114.4270 3.1750 3.1750    $ Baffle hole 24
160 TZ 0.0 0.0 281.2171 114.4270 3.1750 3.1750    $ Baffle hole 25
161 TZ 0.0 0.0 292.2954 114.4270 3.1750 3.1750    $ Baffle hole 26
162 TZ 0.0 0.0 303.3737 114.4270 3.1750 3.1750    $ Baffle hole 27
163 TZ 0.0 0.0 314.4520 114.4270 3.1750 3.1750    $ Baffle hole 28
164 TZ 0.0 0.0 325.5303 114.4270 3.1750 3.1750    $ Baffle hole 29
165 TZ 0.0 0.0 336.6086 114.4270 3.1750 3.1750    $ Baffle hole 30
166 TZ 0.0 0.0 347.6869 114.4270 3.1750 3.1750    $ Baffle hole 31
167 TZ 0.0 0.0 358.7652 114.4270 3.1750 3.1750    $ Baffle hole 32
168 TZ 0.0 0.0 369.8435 114.4270 3.1750 3.1750    $ Baffle hole 33
169 TZ 0.0 0.0 380.9218 114.4270 3.1750 3.1750    $ Baffle hole 34
170 TZ 0.0 0.0 392.0002 114.4270 3.1750 3.1750    $ Baffle hole 35
171 TZ 0.0 0.0 403.0785 114.4270 3.1750 3.1750    $ Baffle hole 36
172 TZ 0.0 0.0 414.1568 114.4270 3.1750 3.1750    $ Baffle hole 37
173 TZ 0.0 0.0 425.2351 114.4270 3.1750 3.1750    $ Baffle hole 38
174 TZ 0.0 0.0 436.3134 114.4270 3.1750 3.1750    $ Baffle hole 39
175 TZ 0.0 0.0 447.3917 114.4270 3.1750 3.1750    $ Baffle hole 40
176 TZ 0.0 0.0 458.4700 114.4270 3.1750 3.1750    $ Baffle hole 41
C Storage Cask & Pad Container
399  RCC  0.0000  0.0000  -15.2410  0.0000  0.0000  507.4432  120.6510
C Inlet Detector DIAA (Surface)
400  RCC  0.0000  0.0000  -0.0010  0.0000  0.0000  15.2410  139.2020
401      PX  0.0001
402  1   PX  0.0001
403  2   PX  0.0001
404  3   PX  0.0001
405  4   PX  0.0001
406  5   PX  0.0001
407  6   PX  0.0001
408  7   PX  0.0001
409  8   PX  0.0001
410  9   PX  0.0001
411  10  PX  0.0001
412  11  PX  0.0001
413  12  PX  0.0001
414  13  PX  0.0001
415  14  PX  0.0001
416  15  PX  0.0001
417      PY  0.0000
418  16  PX  0.0001
419  17  PX  0.0001
420  18  PX  0.0001
421  19  PX  0.0001
422  20  PX  0.0001
423  21  PX  0.0001
424  22  PX  0.0001
425  23  PX  0.0001
426  24  PX  0.0001
427  25  PX  0.0001
428  26  PX  0.0001
429  27  PX  0.0001
430  28  PX  0.0001
431  29  PX  0.0001
432  30  PX  0.0001
C Inlet Detector DIAB (Surface)
450  RCC  0.0000  0.0000  -15.2400  0.0000  0.0000  15.2410  139.2120
451      PX  0.0001
452  1   PX  0.0001
453  2   PX  0.0001
454  3   PX  0.0001
455  4   PX  0.0001
456  5   PX  0.0001
457  6   PX  0.0001
458  7   PX  0.0001
459  8   PX  0.0001
460  9   PX  0.0001
461  10  PX  0.0001
462  11  PX  0.0001
463  12  PX  0.0001
464  13  PX  0.0001
465  14  PX  0.0001
466  15  PX  0.0001
467      PY  0.0000
468  16  PX  0.0001
469  17  PX  0.0001
470  18  PX  0.0001
471  19  PX  0.0001
472  20  PX  0.0001
473  21  PX  0.0001
474  22  PX  0.0001
475  23  PX  0.0001
476  24  PX  0.0001
477  25  PX  0.0001
478  26  PX  0.0001
479  27  PX  0.0001
480  28  PX  0.0001
481  29  PX  0.0001
482  30  PX  0.0001
C Inlet Detector DIBA (Shield Out)
500  RCC  0.0000  0.0000  -0.0010  0.0000  0.0000  15.2410  155.0909
501      PX  0.0001
502  1   PX  0.0001
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503  2  PX  0.0001
504  3  PX  0.0001
505  4  PX  0.0001
506  5  PX  0.0001
507  6  PX  0.0001
508  7  PX  0.0001
509  8  PX  0.0001
510  9  PX  0.0001
511  10  PX  0.0001
512  11  PX  0.0001
513  12  PX  0.0001
514  13  PX  0.0001
515  14  PX  0.0001
516  15  PX  0.0001
517     PY  0.0000
518  16  PX  0.0001
519  17  PX  0.0001
520  18  PX  0.0001
521  19  PX  0.0001
522  20  PX  0.0001
523  21  PX  0.0001
524  22  PX  0.0001
525  23  PX  0.0001
526  24  PX  0.0001
527  25  PX  0.0001
528  26  PX  0.0001
529  27  PX  0.0001
530  28  PX  0.0001
531  29  PX  0.0001
532  30  PX  0.0001
C Inlet Detector DIBB (Shield Out)
550  RCC  0.0000  0.0000  -15.2400  0.0000  0.0000  15.2410  155.1009
551     PX  0.0001
552  1  PX  0.0001
553  2  PX  0.0001
554  3  PX  0.0001
555  4  PX  0.0001
556  5  PX  0.0001
557  6  PX  0.0001
558  7  PX  0.0001
559  8  PX  0.0001
560  9  PX  0.0001
561  10  PX  0.0001
562  11  PX  0.0001
563  12  PX  0.0001
564  13  PX  0.0001
565  14  PX  0.0001
566  15  PX  0.0001
567     PY  0.0000
568  16  PX  0.0001
569  17  PX  0.0001
570  18  PX  0.0001
571  19  PX  0.0001
572  20  PX  0.0001
573  21  PX  0.0001
574  22  PX  0.0001
575  23  PX  0.0001
576  24  PX  0.0001
577  25  PX  0.0001
578  26  PX  0.0001
579  27  PX  0.0001
580  28  PX  0.0001
581  29  PX  0.0001
582  30  PX  0.0001
C Inlet Detector DICA (1ft)
600  RCC  0.0000  0.0000  -15.2400  0.0000  0.0000  30.4800  169.6820
601     PX  0.0001
602  1  PX  0.0001
603  2  PX  0.0001
604  3  PX  0.0001
605  4  PX  0.0001
606  5  PX  0.0001
607  6  PX  0.0001
608  7  PX  0.0001
609  8  PX  0.0001
610  9  PX  0.0001
611  10  PX  0.0001
612  11  PX  0.0001
613  12  PX  0.0001
614  13  PX  0.0001
615  14  PX  0.0001
616  15  PX  0.0001
617     PY  0.0000
618  16  PX  0.0001
619  17  PX  0.0001
620  18  PX  0.0001
621  19  PX  0.0001
622  20  PX  0.0001
623  21  PX  0.0001
624  22  PX  0.0001
625  23  PX  0.0001
626  24  PX  0.0001
```

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627  25  PX  0.0001
628  26  PX  0.0001
629  27  PX  0.0001
630  28  PX  0.0001
631  29  PX  0.0001
632  30  PX  0.0001
C Inlet Detector DIDA (1m)
700  RCC  0.0000  0.0000  -15.2400  0.0000  0.0000  30.4800  239.2020
701      PX  0.0001
702  1  PX  0.0001
703  2  PX  0.0001
704  3  PX  0.0001
705  4  PX  0.0001
706  5  PX  0.0001
707  6  PX  0.0001
708  7  PX  0.0001
709  8  PX  0.0001
710  9  PX  0.0001
711  10  PX  0.0001
712  11  PX  0.0001
713  12  PX  0.0001
714  13  PX  0.0001
715  14  PX  0.0001
716  15  PX  0.0001
717      PY  0.0000
718  16  PX  0.0001
719  17  PX  0.0001
720  18  PX  0.0001
721  19  PX  0.0001
722  20  PX  0.0001
723  21  PX  0.0001
724  22  PX  0.0001
725  23  PX  0.0001
726  24  PX  0.0001
727  25  PX  0.0001
728  26  PX  0.0001
729  27  PX  0.0001
730  28  PX  0.0001
731  29  PX  0.0001
732  30  PX  0.0001
C Inlet Detector DIEA (Outline)
800  RCC  0.0000  0.0000  -115.2410  0.0000  0.0000  707.4432  339.2020

C
C Materials List - Common Materials - v1.7
C
C Homogenized Lower Nozzle
m1     6000 -8.0000E-04 14000 -1.0000E-02 15031 -4.5000E-04
       24000 -1.9000E-01 25055 -2.0000E-02 26000 -6.8375E-01
       28000 -9.5000E-02
C Homogenized Lower Plenum
m2     24000 -1.0000E-03
       26000 -2.1000E-03
       40000 -9.8230E-01
       50000 -1.4500E-02
       72000 -1.0000E-04
C Homogenized UO2 Fuel - Dry
m3     92235 -3.5870E-02 40000 -1.8286E-01 24000 -1.8616E-04
       92238 -6.8153E-01 50000 -2.6993E-03 72000 -1.8616E-05
        8016 -9.6442E-02 26000 -3.9093E-04
C Homogenized Upper Plenum
m4     6000 -7.0431E-04 14000 -8.8038E-03 15031 -3.9617E-04
       24000 -1.6739E-01 50000 -1.7344E-03 25055 -1.7608E-02
       26000 -6.0221E-01 72000 -1.1962E-05 28000 -8.3636E-02
       40000 -1.1750E-01
C Homogenized Upper Nozzle
m5     6000 -8.0000E-04 14000 -1.0000E-02 15031 -4.5000E-04
       24000 -1.9000E-01 25055 -2.0000E-02 26000 -6.8375E-01
       28000 -9.5000E-02
C Water
m6     1001 2 8016 1
C Stainless Steel
m7     6000 -8.0000E-04 14000 -1.0000E-02 15031 -4.5000E-04
       24000 -1.9000E-01 25055 -2.0000E-02 26000 -6.8375E-01
       28000 -9.5000E-02
C Carbon Steel
m8     26000 -0.99  6012 -0.01
C Neutron Poison
m9     13027 -0.7470 5010 -0.0356 5011 -0.1624
       6012 -0.0549
C Aluminum
m10    13027 -1.0
C Lead
m11    82000 -1.0
C Vent Port Middle Cylinder
m14    6000 -8.0000E-04 14000 -1.0000E-02 15031 -4.5000E-04
       24000 -1.9000E-01 25055 -2.0000E-02 26000 -6.8375E-01
       28000 -9.5000E-02
C NS-4-FR
m12    5010 -9.3127E-04 13027 -2.1420E-01 6000 -2.7627E-01
       5011 -3.7721E-03 1001 -6.0012E-02 7014 -1.9815E-02
       8016 -4.2500E-01
```

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C Concrete
m13   26000 -0.014 20000 -0.044 14000 -0.337
       1001 -0.010  8016 -0.532 11023 -0.029
      13027 -0.034
C Balsa
m15   6012 6 1001 10 8016 5
C NS-4-FR (Accident)
m16   5010 -1.7596E-03 13027 -4.3257E-01 6012 -5.5793E-01
      5011 -7.7389E-03
C Copper
m17   29063 -6.8499E-01 29065 -3.1501E-01
C Damaged Fuel
m18   92235 -4.1354E-02
      92238 -7.8573E-01
       8016 -1.1119E-01
      40000 -6.0641E-02
      50000 -8.9514E-04
      26000 -1.2964E-04
      24000 -6.1734E-05
      72000 -6.1734E-06
C Damaged Lower Nozzle
m19   92235 -3.6414E-02
      92238 -6.9186E-01
       8016 -9.7903E-02
      24000 -3.3027E-02
      25055 -3.4765E-03
      26000 -1.1885E-01
      28000 -1.6514E-02
C Damaged Lower Plenum
m20   92235 -3.1138E-02
      92238 -5.9162E-01
       8016 -8.3718E-02
      24000 -2.9353E-04
      26000 -6.1641E-04
      40000 -2.8833E-01
      50000 -4.2562E-03
      72000 -2.9353E-05
C Damaged Upper Plenum
m21   92235 -4.0291E-02
      92238 -7.6552E-01
       8016 -1.0833E-01
      24000 -1.4372E-02
      26000 -5.1705E-02
      40000 -1.0088E-02
      50000 -1.4891E-04
      72000 -1.0270E-06
      25055 -1.5118E-03
      28000 -7.1808E-03
C Damaged upper Nozzle
m22   92235 -3.8058E-02
      92238 -7.2310E-01
       8016 -1.0232E-01
      24000 -2.5939E-02
      25055 -2.7304E-03
      26000 -9.3346E-02
      28000 -1.2969E-02
C
C Cell Importances
C
imp:p 1 146r 0
C
C PWR Source Definition - Lower Nozzle Damaged Gamma - ng16a_25b21e04y 1
C
sdef x=d1 y=d2 z=d3 erg=d4 cell=399:99:83:d5:7
si1   -10.4775 10.4775
sp1   0 1
si2   -10.4775 10.4775
sp2   0 1
si3   0.0000 9.6825
sp3   0 1
si4   1.000E-02 2.000E-02 5.000E-02 1.000E-01 2.000E-01 3.000E-01
      4.000E-01 6.000E-01 8.000E-01 1.000E+00 1.220E+00 1.440E+00
      1.660E+00 2.000E+00 2.500E+00 3.000E+00 4.000E+00 5.000E+00
      6.500E+00 8.000E+00 1.000E+01 1.200E+01 1.400E+01
sp4   0.0000E+00 6.0964E+14 8.5049E+14 3.9848E+14 3.3838E+14 9.4062E+13
      7.0557E+13 5.9248E+14 1.5419E+15 2.1528E+14 3.7021E+13 3.2852E+13
      5.3038E+12 1.7128E+12 4.9202E+12 1.3143E+11 1.6261E+10 2.8917E+06
      1.1604E+06 2.2761E+05 4.8323E+04 2.4984E+03 0.0000E+00
C Source Information
si5 1 48 52 74 78
C Source Probability
sp5   1.0 1.0 1.0 1.0
mode p
nps 4.00E+09
C
C ANSI/ANS-6.1.1-1977 - Gamma Flux-to-Dose Conversion Factors
C (mrem/hr)/(photons/cm2-sec)
C
de0   0.01 0.03 0.05 0.07 0.1 0.15 0.2
      0.25 0.3 0.35 0.4 0.45 0.5 0.55
      0.6 0.65 0.7 0.8 1 1.4 1.8
      2.2 2.6 2.8 3.25 3.75 4.25 4.75
```

```
      5 5.25 5.75 6.25 6.75 7.5 9
      11 13 15
df0   3.96E-03 5.82E-04 2.90E-04 2.58E-04 2.83E-04 3.79E-04 5.01E-04
      6.31E-04 7.59E-04 8.78E-04 9.85E-04 1.08E-03 1.17E-03 1.27E-03
      1.36E-03 1.44E-03 1.52E-03 1.68E-03 1.98E-03 2.51E-03 2.99E-03
      3.42E-03 3.82E-03 4.01E-03 4.41E-03 4.83E-03 5.23E-03 5.60E-03
      5.80E-03 6.01E-03 6.37E-03 6.74E-03 7.11E-03 7.66E-03 8.77E-03
      1.03E-02 1.18E-02 1.33E-02
c
c Exponential Transform - Inlet
c
ext:p -0.6v1 -0.6v1 -0.6v1  -0.6v1 -0.6v1 0
      -0.6v1 -0.6v1  0
      0 20r -0.6v1 5r 0 0
      0 36r 0
      0 -0.6v1 0 -0.6v1 -0.6v1 0 -0.6v1 6r 0 2r
      0 -0.6v1 0 -0.6v1 0 -0.6v1 4r 0 8r -0.6v1 9r 0 4r -0.6v1 5r 0
      0 8r
vect v1 0.0 0.0 9.7
fc2 Inlet Surface Tally Q1 (+x+y)
f2:p +400.1
fm2 1.3276E+15
fs2 -401  -417
     +416  +415  +414  +413  +412  +411
     +410  +409  +408  +407  +406  +405
     +404  +403  +402  T
sd2 6.6651E+03  3.3326E+03  2.0829E+02  15r  1.3330E+04
tf2
fc12 Inlet Surface Tally Q2 (-x+y)
f12:p +400.1
fm12 1.3276E+15
fs12 +401  -417
     -432  -431  -430  -429  -428  -427
     -426  -425  -424  -423  -422  -421
     -420  -419  -418  T
sd12 6.6651E+03  3.3326E+03  2.0829E+02  15r  1.3330E+04
tf12
fc22 Inlet Surface Tally Q3 (-x-y)
f22:p +400.1
fm22 1.3276E+15
fs22 +401  +417
     -416  -415  -414  -413  -412  -411
     -410  -409  -408  -407  -406  -405
     -404  -403  -402  T
sd22 6.6651E+03  3.3326E+03  2.0829E+02  15r  1.3330E+04
tf22
fc32 Inlet Surface Tally Q4 (+x-y)
f32:p +400.1
fm32 1.3276E+15
fs32 -401  +417
     +432  +431  +430  +429  +428  +427
     +426  +425  +424  +423  +422  +421
     +420  +419  +418  T
sd32 6.6651E+03  3.3326E+03  2.0829E+02  15r  1.3330E+04
tf32
fc42 Inlet Surface Tally Q1 (+x+y)
f42:p +450.1
fm42 1.3276E+15
fs42 -451  -467
     +466  +465  +464  +463  +462  +461
     +460  +459  +458  +457  +456  +455
     +454  +453  +452  T
sd42 6.6656E+03  3.3328E+03  2.0830E+02  15r  1.3331E+04
tf42
fc52 Inlet Surface Tally Q2 (-x+y)
f52:p +450.1
fm52 1.3276E+15
fs52 +451  -467
     -482  -481  -480  -479  -478  -477
     -476  -475  -474  -473  -472  -471
     -470  -469  -468  T
sd52 6.6656E+03  3.3328E+03  2.0830E+02  15r  1.3331E+04
tf52
fc62 Inlet Surface Tally Q3 (-x-y)
f62:p +450.1
fm62 1.3276E+15
fs62 +451  +467
     -466  -465  -464  -463  -462  -461
     -460  -459  -458  -457  -456  -455
     -454  -453  -452  T
sd62 6.6656E+03  3.3328E+03  2.0830E+02  15r  1.3331E+04
tf62
fc72 Inlet Surface Tally Q4 (+x-y)
f72:p +450.1
fm72 1.3276E+15
fs72 -451  +467
     +482  +481  +480  +479  +478  +477
     +476  +475  +474  +473  +472  +471
     +470  +469  +468  T
sd72 6.6656E+03  3.3328E+03  2.0830E+02  15r  1.3331E+04
tf72
fc82 Inlet Shield Out Tally Q1 (+x+y)
```

```
f82:p +500.1
fm82 1.3276E+15
fs82 -501  -517
     +516  +515  +514  +513  +512  +511
     +510  +509  +508  +507  +506  +505
     +504  +503  +502  T
sd82 7.4259E+03  3.7130E+03  2.3206E+02  15r  1.4852E+04
tf82
fc92 Inlet Shield Out Tally Q2 (-x+y)
f92:p +500.1
fm92 1.3276E+15
fs92 +501  -517
     -532  -531  -530  -529  -528  -527
     -526  -525  -524  -523  -522  -521
     -520  -519  -518  T
sd92 7.4259E+03  3.7130E+03  2.3206E+02  15r  1.4852E+04
tf92
fc102 Inlet Shield Out Tally Q3 (-x-y)
f102:p +500.1
fm102 1.3276E+15
fs102 +501  +517
     -516  -515  -514  -513  -512  -511
     -510  -509  -508  -507  -506  -505
     -504  -503  -502  T
sd102 7.4259E+03  3.7130E+03  2.3206E+02  15r  1.4852E+04
tf102
fc112 Inlet Shield Out Tally Q4 (+x-y)
f112:p +500.1
fm112 1.3276E+15
fs112 -501  +517
     +532  +531  +530  +529  +528  +527
     +526  +525  +524  +523  +522  +521
     +520  +519  +518  T
sd112 7.4259E+03  3.7130E+03  2.3206E+02  15r  1.4852E+04
tf112
fc122 Inlet Shield Out Tally Q1 (+x+y)
f122:p +550.1
fm122 1.3276E+15
fs122 -551  -567
     +566  +565  +564  +563  +562  +561
     +560  +559  +558  +557  +556  +555
     +554  +553  +552  T
sd122 7.4264E+03  3.7132E+03  2.3207E+02  15r  1.4853E+04
tf122
fc132 Inlet Shield Out Tally Q2 (-x+y)
f132:p +550.1
fm132 1.3276E+15
fs132 +551  -567
     -582  -581  -580  -579  -578  -577
     -576  -575  -574  -573  -572  -571
     -570  -569  -568  T
sd132 7.4264E+03  3.7132E+03  2.3207E+02  15r  1.4853E+04
tf132
fc142 Inlet Shield Out Tally Q3 (-x-y)
f142:p +550.1
fm142 1.3276E+15
fs142 +551  +567
     -566  -565  -564  -563  -562  -561
     -560  -559  -558  -557  -556  -555
     -554  -553  -552  T
sd142 7.4264E+03  3.7132E+03  2.3207E+02  15r  1.4853E+04
tf142
fc152 Inlet Shield Out Tally Q4 (+x-y)
f152:p +550.1
fm152 1.3276E+15
fs152 -551  +567
     +582  +581  +580  +579  +578  +577
     +576  +575  +574  +573  +572  +571
     +570  +569  +568  T
sd152 7.4264E+03  3.7132E+03  2.3207E+02  15r  1.4853E+04
tf152
fc162 Inlet 1ft Tally Q1 (+x+y)
f162:p +600.1
fm162 1.3276E+15
fs162 -601  -617
     +616  +615  +614  +613  +612  +611
     +610  +609  +608  +607  +606  +605
     +604  +603  +602  T
sd162 1.6248E+04  8.1240E+03  5.0775E+02  15r  3.2496E+04
tf162
fc172 Inlet 1ft Tally Q2 (-x+y)
f172:p +600.1
fm172 1.3276E+15
fs172 +601  -617
     -632  -631  -630  -629  -628  -627
     -626  -625  -624  -623  -622  -621
     -620  -619  -618  T
sd172 1.6248E+04  8.1240E+03  5.0775E+02  15r  3.2496E+04
tf172
fc182 Inlet 1ft Tally Q3 (-x-y)
f182:p +600.1
fm182 1.3276E+15
```

```
fs182 +601  +617
     -616  -615  -614  -613  -612  -611
     -610  -609  -608  -607  -606  -605
     -604  -603  -602  T
sd182 1.6248E+04  8.1240E+03  5.0775E+02  15r  3.2496E+04
tf182
fc192 Inlet 1ft Tally Q4 (+x-y)
f192:p +600.1
fm192 1.3276E+15
fs192 -601  +617
     +632  +631  +630  +629  +628  +627
     +626  +625  +624  +623  +622  +621
     +620  +619  +618  T
sd192 1.6248E+04  8.1240E+03  5.0775E+02  15r  3.2496E+04
tf192
fc202 Inlet 1m Tally Q1 (+x+y)
f202:p +700.1
fm202 1.3276E+15
fs202 -701  -717
     +716  +715  +714  +713  +712  +711
     +710  +709  +708  +707  +706  +705
     +704  +703  +702  T
sd202 2.2905E+04  1.1452E+04  7.1578E+02  15r  4.5810E+04
tf202
fc212 Inlet 1m Tally Q2 (-x+y)
f212:p +700.1
fm212 1.3276E+15
fs212 +701  -717
     -732  -731  -730  -729  -728  -727
     -726  -725  -724  -723  -722  -721
     -720  -719  -718  T
sd212 2.2905E+04  1.1452E+04  7.1578E+02  15r  4.5810E+04
tf212
fc222 Inlet 1m Tally Q3 (-x-y)
f222:p +700.1
fm222 1.3276E+15
fs222 +701  +717
     -716  -715  -714  -713  -712  -711
     -710  -709  -708  -707  -706  -705
     -704  -703  -702  T
sd222 2.2905E+04  1.1452E+04  7.1578E+02  15r  4.5810E+04
tf222
fc232 Inlet 1m Tally Q4 (+x-y)
f232:p +700.1
fm232 1.3276E+15
fs232 -701  +717
     +732  +731  +730  +729  +728  +727
     +726  +725  +724  +723  +722  +721
     +720  +719  +718  T
sd232 2.2905E+04  1.1452E+04  7.1578E+02  15r  4.5810E+04
tf232
fc242 Inlet Outline Tally
f242:p +800.1
fm242 1.3276E+15
fs242  T
tf242
C
C
C Weight Window Generation - Inlet Azi
C
wwg 202 0 0 0 0
wwp:p 5 3 5 0 -1 0
mesh geom=cyl ref=89 0 13 origin=0.1 0.1 -515
     imesh 90.2 91.4 96.5 98.6 106.8 120.0 120.7 132.8 150.0 650.0
     iints 5 1 1 1 1 1 1 10 10 10 5
     jmesh 500 520 527 537 539 920 952 980 985 1007 1507
     jints 5 20 7 10 1 1 1 1 1 1 1
     kmesh 1
     kints 40
wwge:p  1e-3 1 20
C
C Print Control
C
prdmp 4.00E+08 4.00E+08 1 2
print
C
C Random Number Generator
C
rand gen=2 seed=19073486328125  stride=152917 hist=1
C
C Rotation Matrix
C
C 5.625 degree rotation around z-axis
*TR1 0.0 0.0 0.0 5.625 95.625 90 -84.375 5.625 90 90 90 0
C 11.25 degree rotation around z-axis
*TR2 0.0 0.0 0.0 11.250 101.250 90 -78.750 11.250 90 90 90 0
C 16.875 degree rotation around z-axis
*TR3 0.0 0.0 0.0 16.875 106.875 90 -73.125 16.875 90 90 90 0
C 22.5 degree rotation around z-axis
*TR4 0.0 0.0 0.0 22.500 112.500 90 -67.500 22.500 90 90 90 0
C 28.125 degree rotation around z-axis
*TR5 0.0 0.0 0.0 28.125 118.125 90 -61.875 28.125 90 90 90 0
```

```
C 33.75 degree rotation around z-axis
*TR6 0.0 0.0 0.0 33.750 123.750 90 -56.250 33.750 90 90 90 0
C 39.375 degree rotation around z-axis
*TR7 0.0 0.0 0.0 39.375 129.375 90 -50.625 39.375 90 90 90 0
C 45 degree rotation around z-axis
*TR8 0.0 0.0 0.0 45.000 135.000 90 -45.000 45.000 90 90 90 0
C 50.625 degree rotation around z-axis
*TR9 0.0 0.0 0.0 50.625 140.625 90 -39.375 50.625 90 90 90 0
C 56.25 degree rotation around z-axis
*TR10 0.0 0.0 0.0 56.250 146.250 90 -33.750 56.250 90 90 90 0
C 61.875 degree rotation around z-axis
*TR11 0.0 0.0 0.0 61.875 151.875 90 -28.125 61.875 90 90 90 0
C 67.5 degree rotation around z-axis
*TR12 0.0 0.0 0.0 67.500 157.500 90 -22.500 67.500 90 90 90 0
C 73.125 degree rotation around z-axis
*TR13 0.0 0.0 0.0 73.125 163.125 90 -16.875 73.125 90 90 90 0
C 78.75 degree rotation around z-axis
*TR14 0.0 0.0 0.0 78.750 168.750 90 -11.250 78.750 90 90 90 0
C 84.375 degree rotation around z-axis
*TR15 0.0 0.0 0.0 84.375 174.375 90 -5.625 84.375 90 90 90 0
C 95.625 degree rotation around z-axis
*TR16 0.0 0.0 0.0 95.625 185.625 90 5.625 95.625 90 90 90 0
C 101.25 degree rotation around z-axis
*TR17 0.0 0.0 0.0 101.250 191.250 90 11.250 101.250 90 90 90 0
C 106.875 degree rotation around z-axis
*TR18 0.0 0.0 0.0 106.875 196.875 90 16.875 106.875 90 90 90 0
C 112.5 degree rotation around z-axis
*TR19 0.0 0.0 0.0 112.500 202.500 90 22.500 112.500 90 90 90 0
C 118.125 degree rotation around z-axis
*TR20 0.0 0.0 0.0 118.125 208.125 90 28.125 118.125 90 90 90 0
C 123.75 degree rotation around z-axis
*TR21 0.0 0.0 0.0 123.750 213.750 90 33.750 123.750 90 90 90 0
C 129.375 degree rotation around z-axis
*TR22 0.0 0.0 0.0 129.375 219.375 90 39.375 129.375 90 90 90 0
C 135 degree rotation around z-axis
*TR23 0.0 0.0 0.0 135.000 225.000 90 45.000 135.000 90 90 90 0
C 140.625 degree rotation around z-axis
*TR24 0.0 0.0 0.0 140.625 230.625 90 50.625 140.625 90 90 90 0
C 146.25 degree rotation around z-axis
*TR25 0.0 0.0 0.0 146.250 236.250 90 56.250 146.250 90 90 90 0
C 151.875 degree rotation around z-axis
*TR26 0.0 0.0 0.0 151.875 241.875 90 61.875 151.875 90 90 90 0
C 157.5 degree rotation around z-axis
*TR27 0.0 0.0 0.0 157.500 247.500 90 67.500 157.500 90 90 90 0
C 163.125 degree rotation around z-axis
*TR28 0.0 0.0 0.0 163.125 253.125 90 73.125 163.125 90 90 90 0
C 168.75 degree rotation around z-axis
*TR29 0.0 0.0 0.0 168.750 258.750 90 78.750 168.750 90 90 90 0
C 174.375 degree rotation around z-axis
*TR30 0.0 0.0 0.0 174.375 264.375 90 84.375 174.375 90 90 90 0
C 7 degree rotation around z-axis
*TR31 0.0 0.0 0.0 7.000 97.000 90 -83.000 7.000 90 90 90 0
C 23 degree rotation around z-axis
*TR32 0.0 0.0 0.0 23.000 113.000 90 -67.000 23.000 90 90 90 0
C 127 degree rotation around z-axis
*TR33 0.0 0.0 0.0 127.000 217.000 90 37.000 127.000 90 90 90 0
C 143 degree rotation around z-axis
*TR34 0.0 0.0 0.0 143.000 233.000 90 53.000 143.000 90 90 90 0
C 247 degree rotation around z-axis
*TR35 0.0 0.0 0.0 247.000 337.000 90 157.000 247.000 90 90 90 0
C 263 degree rotation around z-axis
*TR36 0.0 0.0 0.0 263.000 353.000 90 173.000 263.000 90 90 90 0
C 10 degree rotation around z-axis
*TR37 0.0 0.0 0.0 10.000 100.000 90 -80.000 10.000 90 90 90 0
C 20 degree rotation around z-axis
*TR38 0.0 0.0 0.0 20.000 110.000 90 -70.000 20.000 90 90 90 0
C 30 degree rotation around z-axis
*TR39 0.0 0.0 0.0 30.000 120.000 90 -60.000 30.000 90 90 90 0
C 40 degree rotation around z-axis
*TR40 0.0 0.0 0.0 40.000 130.000 90 -50.000 40.000 90 90 90 0
C 50 degree rotation around z-axis
*TR41 0.0 0.0 0.0 50.000 140.000 90 -40.000 50.000 90 90 90 0
C 60 degree rotation around z-axis
*TR42 0.0 0.0 0.0 60.000 150.000 90 -30.000 60.000 90 90 90 0
C 70 degree rotation around z-axis
*TR43 0.0 0.0 0.0 70.000 160.000 90 -20.000 70.000 90 90 90 0
C 80 degree rotation around z-axis
*TR44 0.0 0.0 0.0 80.000 170.000 90 -10.000 80.000 90 90 90 0
C 90 degree rotation around z-axis
*TR45 0.0 0.0 0.0 90.000 180.000 90 0.000 90.000 90 90 90 0
C 100 degree rotation around z-axis
*TR46 0.0 0.0 0.0 100.000 190.000 90 10.000 100.000 90 90 90 0
C 110 degree rotation around z-axis
*TR47 0.0 0.0 0.0 110.000 200.000 90 20.000 110.000 90 90 90 0
C 120 degree rotation around z-axis
*TR48 0.0 0.0 0.0 120.000 210.000 90 30.000 120.000 90 90 90 0
C 130 degree rotation around z-axis
*TR49 0.0 0.0 0.0 130.000 220.000 90 40.000 130.000 90 90 90 0
C 140 degree rotation around z-axis
*TR50 0.0 0.0 0.0 140.000 230.000 90 50.000 140.000 90 90 90 0
C 150 degree rotation around z-axis
*TR51 0.0 0.0 0.0 150.000 240.000 90 60.000 150.000 90 90 90 0
```

```
C 160 degree rotation around z-axis
*TR52 0.0 0.0 0.0 160.000 250.000 90 70.000 160.000 90 90 90 0
C 170 degree rotation around z-axis
*TR53 0.0 0.0 0.0 170.000 260.000 90 80.000 170.000 90 90 90 0
C 180 degree rotation around z-axis
*TR54 0.0 0.0 0.0 180.000 270.000 90 90.000 180.000 90 90 90 0
C 190 degree rotation around z-axis
*TR55 0.0 0.0 0.0 190.000 280.000 90 100.000 190.000 90 90 90 0
C 200 degree rotation around z-axis
*TR56 0.0 0.0 0.0 200.000 290.000 90 110.000 200.000 90 90 90 0
C 210 degree rotation around z-axis
*TR57 0.0 0.0 0.0 210.000 300.000 90 120.000 210.000 90 90 90 0
C 220 degree rotation around z-axis
*TR58 0.0 0.0 0.0 220.000 310.000 90 130.000 220.000 90 90 90 0
C 230 degree rotation around z-axis
*TR59 0.0 0.0 0.0 230.000 320.000 90 140.000 230.000 90 90 90 0
C 240 degree rotation around z-axis
*TR60 0.0 0.0 0.0 240.000 330.000 90 150.000 240.000 90 90 90 0
C 250 degree rotation around z-axis
*TR61 0.0 0.0 0.0 250.000 340.000 90 160.000 250.000 90 90 90 0
C 260 degree rotation around z-axis
*TR62 0.0 0.0 0.0 260.000 350.000 90 170.000 260.000 90 90 90 0
C 270 degree rotation around z-axis
*TR63 0.0 0.0 0.0 270.000 360.000 90 180.000 270.000 90 90 90 0
C 280 degree rotation around z-axis
*TR64 0.0 0.0 0.0 280.000 370.000 90 190.000 280.000 90 90 90 0
C 290 degree rotation around z-axis
*TR65 0.0 0.0 0.0 290.000 380.000 90 200.000 290.000 90 90 90 0
C 300 degree rotation around z-axis
*TR66 0.0 0.0 0.0 300.000 390.000 90 210.000 300.000 90 90 90 0
C 310 degree rotation around z-axis
*TR67 0.0 0.0 0.0 310.000 400.000 90 220.000 310.000 90 90 90 0
C 320 degree rotation around z-axis
*TR68 0.0 0.0 0.0 320.000 410.000 90 230.000 320.000 90 90 90 0
C 330 degree rotation around z-axis
*TR69 0.0 0.0 0.0 330.000 420.000 90 240.000 330.000 90 90 90 0
C 340 degree rotation around z-axis
*TR70 0.0 0.0 0.0 340.000 430.000 90 250.000 340.000 90 90 90 0
C 350 degree rotation around z-axis
*TR71 0.0 0.0 0.0 350.000 440.000 90 260.000 350.000 90 90 90 0
C 225 degree rotation around z-axis
*TR72 0.0 0.0 0.0 225.000 315.000 90 135.000 225.000 90 90 90 0
C 202.5 degree rotation around z-axis
*TR73 0.0 0.0 0.0 202.500 292.500 90 112.500 202.500 90 90 90 0
C 247.5 degree rotation around z-axis
*TR74 0.0 0.0 0.0 247.500 337.500 90 157.500 247.500 90 90 90 0
C 292.5 degree rotation around z-axis
*TR75 0.0 0.0 0.0 292.500 382.500 90 202.500 292.500 90 90 90 0
C 337.5 degree rotation around z-axis
*TR76 0.0 0.0 0.0 337.500 427.500 90 247.500 337.500 90 90 90 0
C
C Mesh Tally - 4 - RZT
C
FMESH4:p geom=cyl origin = 0.0 0.0 -16.24
      axs = 0 0 1
      vec = 1 0 0
      imesh 139.202 140.202
      iints 1 1
      jmesh 32.48
      jints 20
      kmesh =  0.1649 0.1959 1.0
      kints =   1 10 1
      out = jk
fm4 1.3276E+15
C
C Mesh Tally - 14 - XYZ
C
FMESH14:p geom=rec origin = 0.0 0.0 -16.241
      imesh 45.47 46.47 70.88 71.88
      iints 1 1 10 1
      jmesh 97.64 98.64 130.20 131.20
      jints 1 1 10 1
      kmesh =  -15.24 15.24 16.24
      kints =  1 10 1
      out = jk
fm14 1.3276E+15
C
C Mesh Tally - 24 - XYZ
C
FMESH24:p geom=rec origin = 0.0 0.0 -16.241
      imesh 96.52 137.16 138.16
      iints 1 20 1
      jmesh 45.23 46.23 72.39 73.39
      jints 1 1 10 1
      kmesh =  -15.24 15.24 16.24
      kints =  1 10 1
      out = jk
fm24 1.3276E+15
C
C DXTRAN SPHERE
C
dxt:p 128.0 59.0 3.5 12.0 16.0
```

```
C   60.0 118.0 3.5 20.0 24.0
DD 0.1 1000
C   0.1 1000
```

Figure 5.9.11-3 PMTC Sample Input File – Bottom Forging Mesh Detectors

```
MAGNASTOR Passively Cooled Transfer Cask - pctShlInlFgRR_ng16a_07g
C Inlet Biasing - Fuel Gamma Source
C Fuel Assembly Cells - ng16a - v1.1
1 1 -1.7170 -1     u=6 $ Lower Nozzle
2 2 -2.6069 -2 +1    u=6 $ Lower Plenum
3 3 -3.6800 -3 +2    u=6 $ Fuel
4 4 -0.8683 -4 +3    u=6 $ Upper Plenum
5 5 -1.3635 -5 +4    u=6 $ Upper Nozzle
6 0          +5    u=6 $ Outside
C Cells - Fuel Tube  v1.3
7 8 -7.8212 -8 +7    u=5 $ Tube
8 9 -2.6507 -9 : -10 : -11 : -12     u=5 $ Poison
9 0          #7  #8     u=5 $ Outside
C Cells - PWR Basket v1.5
10 0          -13 -14 fill=5 trcl = ( -23.5331 70.5993 0.0000 )    u=4 $ Assy loc 1
11 like 10 but fill=5 trcl = ( 23.5331 70.5993 0.0000 )    u=4 $ Assy loc 3
12 like 10 but fill=5 trcl = ( -47.0662 47.0662 0.0000 )    u=4 $ Assy loc 4
13 like 10 but fill=5 trcl = ( 0.0000 47.0662 0.0000 )    u=4 $ Assy loc 6
14 like 10 but fill=5 trcl = ( 47.0662 47.0662 0.0000 )    u=4 $ Assy loc 8
15 like 10 but fill=5 trcl = ( -70.5993 23.5331 0.0000 )    u=4 $ Assy loc 9
16 like 10 but fill=5 trcl = ( -23.5331 23.5331 0.0000 )    u=4 $ Assy loc 11
17 like 10 but fill=5 trcl = ( 23.5331 23.5331 0.0000 )    u=4 $ Assy loc 13
18 like 10 but fill=5 trcl = ( 70.5993 23.5331 0.0000 )    u=4 $ Assy loc 15
19 like 10 but fill=5 trcl = ( -47.0662 0.0000 0.0000 )    u=4 $ Assy loc 17
20 like 10 but fill=5 trcl = ( 0.0000 0.0000 0.0000 )    u=4 $ Assy loc 19
21 like 10 but fill=5 trcl = ( 47.0662 0.0000 0.0000 )    u=4 $ Assy loc 21
22 like 10 but fill=5 trcl = ( -70.5993 -23.5331 0.0000 )    u=4 $ Assy loc 23
23 like 10 but fill=5 trcl = ( -23.5331 -23.5331 0.0000 )    u=4 $ Assy loc 25
24 like 10 but fill=5 trcl = ( 23.5331 -23.5331 0.0000 )    u=4 $ Assy loc 27
25 like 10 but fill=5 trcl = ( 70.5993 -23.5331 0.0000 )    u=4 $ Assy loc 29
26 like 10 but fill=5 trcl = ( -47.0662 -47.0662 0.0000 )    u=4 $ Assy loc 30
27 like 10 but fill=5 trcl = ( 0.0000 -47.0662 0.0000 )    u=4 $ Assy loc 32
28 like 10 but fill=5 trcl = ( 47.0662 -47.0662 0.0000 )    u=4 $ Assy loc 34
29 like 10 but fill=5 trcl = ( -23.5331 -70.5993 0.0000 )    u=4 $ Assy loc 35
30 like 10 but fill=5 trcl = ( 23.5331 -70.5993 0.0000 )    u=4 $ Assy loc 37
31 8 -7.8212 -15 #18 #25      u=4 $ Side support +x
32 8 -7.8212 -16 #15 #22      u=4 $ Side support -x
33 8 -7.8212 -17 #10 #11      u=4 $ Side support +y
34 8 -7.8212 -18 #29 #30      u=4 $ Side support -y
35 8 -7.8212 -19 +20 +21      u=4 $ Corner
36 8 -7.8212 -21 +22 +20  +15.2 +16.1 +17.4 +18.3
             #10 #11 #15 #18 #22 #25 #29 #30      u=4 $ Corner diagonal
37 0         -6 #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20
                #21 #22 #23 #24 #25 #26 #27 #28 #29 #30
                #31 #32 #33 #34 #35 #36      u=4 $ Basket below PFE
38 0         +6 #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20
               #21 #22 #23 #24 #25 #26 #27 #28 #29 #30
               #31 #32 #33 #34 #35 #36      u=4 $ Basket above PFE
C Cells - PWR Canister Cavity v1.5
39 0         -23 fill=6 trcl = ( -23.5331 70.5993 0.0000 )    u=3 $ Assy loc 1
40 like 39 but fill=6 trcl = ( 0.0000 70.5993 0.0000 )    u=3 $ Assy loc 2
41 like 39 but fill=6 trcl = ( 23.5331 70.5993 0.0000 )    u=3 $ Assy loc 3
42 like 39 but fill=6 trcl = ( -47.0662 47.0662 0.0000 )    u=3 $ Assy loc 4
43 like 39 but fill=6 trcl = ( -23.5331 47.0662 0.0000 )    u=3 $ Assy loc 5
44 like 39 but fill=6 trcl = ( 0.0000 47.0662 0.0000 )    u=3 $ Assy loc 6
45 like 39 but fill=6 trcl = ( 23.5331 47.0662 0.0000 )    u=3 $ Assy loc 7
46 like 39 but fill=6 trcl = ( 47.0662 47.0662 0.0000 )    u=3 $ Assy loc 8
47 like 39 but fill=6 trcl = ( -70.5993 23.5331 0.0000 )    u=3 $ Assy loc 9
48 like 39 but fill=6 trcl = ( -47.0662 23.5331 0.0000 )    u=3 $ Assy loc 10
49 like 39 but fill=6 trcl = ( -23.5331 23.5331 0.0000 )    u=3 $ Assy loc 11
50 like 39 but fill=6 trcl = ( 0.0000 23.5331 0.0000 )    u=3 $ Assy loc 12
51 like 39 but fill=6 trcl = ( 23.5331 23.5331 0.0000 )    u=3 $ Assy loc 13
52 like 39 but fill=6 trcl = ( 47.0662 23.5331 0.0000 )    u=3 $ Assy loc 14
53 like 39 but fill=6 trcl = ( 70.5993 23.5331 0.0000 )    u=3 $ Assy loc 15
54 like 39 but fill=6 trcl = ( -70.5993 0.0000 0.0000 )    u=3 $ Assy loc 16
55 like 39 but fill=6 trcl = ( -47.0662 0.0000 0.0000 )    u=3 $ Assy loc 17
56 like 39 but fill=6 trcl = ( -23.5331 0.0000 0.0000 )    u=3 $ Assy loc 18
57 like 39 but fill=6 trcl = ( 0.0000 0.0000 0.0000 )    u=3 $ Assy loc 19
58 like 39 but fill=6 trcl = ( 23.5331 0.0000 0.0000 )    u=3 $ Assy loc 20
59 like 39 but fill=6 trcl = ( 47.0662 0.0000 0.0000 )    u=3 $ Assy loc 21
60 like 39 but fill=6 trcl = ( 70.5993 0.0000 0.0000 )    u=3 $ Assy loc 22
61 like 39 but fill=6 trcl = ( -70.5993 -23.5331 0.0000 )    u=3 $ Assy loc 23
62 like 39 but fill=6 trcl = ( -47.0662 -23.5331 0.0000 )    u=3 $ Assy loc 24
63 like 39 but fill=6 trcl = ( -23.5331 -23.5331 0.0000 )    u=3 $ Assy loc 25
64 like 39 but fill=6 trcl = ( 0.0000 -23.5331 0.0000 )    u=3 $ Assy loc 26
65 like 39 but fill=6 trcl = ( 23.5331 -23.5331 0.0000 )    u=3 $ Assy loc 27
66 like 39 but fill=6 trcl = ( 47.0662 -23.5331 0.0000 )    u=3 $ Assy loc 28
67 like 39 but fill=6 trcl = ( 70.5993 -23.5331 0.0000 )    u=3 $ Assy loc 29
68 like 39 but fill=6 trcl = ( -47.0662 -47.0662 0.0000 )    u=3 $ Assy loc 30
69 like 39 but fill=6 trcl = ( -23.5331 -47.0662 0.0000 )    u=3 $ Assy loc 31
70 like 39 but fill=6 trcl = ( 0.0000 -47.0662 0.0000 )    u=3 $ Assy loc 32
71 like 39 but fill=6 trcl = ( 23.5331 -47.0662 0.0000 )    u=3 $ Assy loc 33
72 like 39 but fill=6 trcl = ( 47.0662 -47.0662 0.0000 )    u=3 $ Assy loc 34
73 like 39 but fill=6 trcl = ( -23.5331 -70.5993 0.0000 )    u=3 $ Assy loc 35
74 like 39 but fill=6 trcl = ( 0.0000 -70.5993 0.0000 )    u=3 $ Assy loc 36
75 like 39 but fill=6 trcl = ( 23.5331 -70.5993 0.0000 )    u=3 $ Assy loc 37
76 0         #39 #40 #41 #42 #43 #44 #45 #46 #47 #48 #49 #50 #51
             #52 #53 #54 #55 #56 #57 #58 #59 #60 #61 #62 #63 #64
             #65 #66 #67 #68 #69 #70 #71 #72 #73 #74 #75      fill=4 u=3 $ Cavity
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C Cells - Canister v1.3
77 0         -24 #88  #89  fill=3     u=2 $ Cavity
78 7 -7.9400 -37 +24.3      u=2 $ Canister Bottom
79 0         -28 +24.2 -31 trcl = ( 64.2620 40.8940 0.0000 )    u=2 $ Bottom Drain Port
80 14 -3.9700 -29 +31 -33 trcl = ( 64.2620 40.8940 0.0000 )    u=2 $ Middle Drain Port
81 7 -7.9400 -30 +33 -37.2 trcl = ( 64.2620 40.8940 0.0000 )    u=2 $ Top Drain Port
82 like 79 but   trcl = ( -64.2620 -40.8940 0.0000 )    u=2 $ Bottom Vent Port
83 like 80 but   trcl = ( -64.2620 -40.8940 0.0000 )    u=2 $ Middle Vent Port
84 like 81 but   trcl = ( -64.2620 -40.8940 0.0000 )    u=2 $ Top Vent Port
85 7 -7.9400 -37 -24.3 +24.1     u=2 $ Canister Shell
86 8 -7.8212 -37 -24.1 +24.2 -32 #79 #80  #82 #83  #90  u=2 $ Lower lid
87 7 -7.9400 -37 -24.1 +32 #80 #81  #83 #84  #90 #91   u=2 $ Upper lid
88 7 -7.9400 -36 +35 +34 -24.2 trcl = ( 64.2620 40.8940 0.0000 )   u=2 $ Drain port shield
89 7 -7.9400 -36 +35 +32 -24.2 trcl = ( -64.2620 -40.8940 0.0000 )   u=2 $ Vent port shield
90 0         -37 -24.1 +25 +24.2    u=2 $ Lid spacing
91 0         -37 -26 +27     u=2 $ Closure ring spacing
92 0         +37 #88      u=2 $ Outside
C Passively Cooled Transfer Cask Cells - v1.3.5_ng16a
93 0         ((-38 +72 +73) : -47)    fill=2 ( 0.0 0.0 12.0650 )     u=1 $ Cavity
94 7 -7.9400 -39 -40 +38      u=1 $ Inner shell
95 0         -39 -41 +40      u=1 $ Lead Inner spacing
96 11 -11.3440 -39 -42 +41      u=1 $ Lead shield
97 0         -39 -43 +42      u=1 $ Lead Outer Spacing
98 7 -7.9400 -39 -44 +43      u=1 $ Middle shell
99 6 -0.9616 -45 +44  #130 #131 #132 #133 #134 #135     u=1 $ Neutron shield
100 7 -7.9400 -39 +44 +45      u=1 $ Neutron shield shell
101 7 -7.9400 -46 +47      u=1 $ Retaining ring
102 7 -7.9400 -51 +38 +48 #104 #105 #106 #107 #108 #109
        #110 #111 #112         u=1 $ Top ring
C 103 0  +47 +49 -50      u=1 $ Top ring Overhang
104 0  ((-52 +53) : -54)        u=1 $ Top ring vent
105 0  +38 (-55 : -56)      u=1 $ Top ring vent
106 0  +38 (-57 : -58)      u=1 $ Top ring vent
107 0  +38 (-59 : -60)      u=1 $ Top ring vent
108 0  +38 (-61 : -62)      u=1 $ Top ring vent
109 0  +38 (-63 : -64)      u=1 $ Top ring vent
110 0  +38 (-65 : -66)      u=1 $ Top ring vent
111 0  +38 (-67 : -68)      u=1 $ Top ring vent
112 0  +38 (-69 : -70)      u=1 $ Top ring vent
113 7 -7.9400 (-71 : -78) +38 +89 +90 #126 #127 #128 #129  u=1 $ Bottom ring
C 114 7 -7.9400 (-91 +92 +93 +96 +97 +98 +99 +100)     #C 125  :
C    (+91 -49 -38.1)       u=1 $ Seal shield
901 7 -7.9400 -181 182 183 71 u=1
115 7 -7.9400 ((+178 -179 -103 -180) : (-103 +104 -180 -179))    +71
              +74 +83 +89 +90  u=1 $ Inlet Shield - Door
116 7 -7.9400 -74 -103 +104 +71 +83 #123 #124   u=1 $ Inlet Shield - Door
117 7 -7.9400 ((+178 -179 -105 -180) : (-105 +106 -180 -179))    +71
              +74 +83 +89 +90  u=1 $ Inlet Shield - Door
118 7 -7.9400 -74 -105 +106 +71 +83 #123 #124   u=1 $ Inlet Shield - Door
119 7 -7.9400 -107 +108 +77 +78    u=1 $ Inlet Shield - Rail
120 7 -7.9400 -109 +110 +77 +78    u=1 $ Inlet Shield - Rail
121 7 -7.9400 -72        u=1 $ Rail -x
122 7 -7.9400 -73        u=1 $ Rail +x
123 7 -7.9400 (-74 : -77) -75 +76 -177 (+83 +84 +85 +86 +87)  #124   u=1 $ Door steel
124 0  -88        u=1 $ Door  Overhang gap
C 125 0          +94 -95       u=1 $ Seal shield - seal cut
126 0          (305 -308 307 -80):(309 306 307 -80):
               ((-259:-260:-261:(-205 -208):(-209 206)) 38 -78) u=1 $ Vent
127 0          (304 301 303 -82):(300 301 -302 -82):
               ((-281:-282:-283:(-200 -202):(-204 203)) 38 -71) u=1 $ Vent
128 0          (305 -308 307 -80):(309 306 307 -80):
               ((-259:-260:-261:(-205 -208):(-209 206)) 38 -78)
               trcl=54 u=1 $ Vent
129 0          (304 301 303 -82):(300 301 -302 -82):
               ((-281:-282:-283:(-200 -202):(-204 203)) 38 -71)
               trcl=54 u=1 $ Vent
130 7 -7.9400 ((+111 -112 -45 +44) : (+113 -114 -45 +115))    +136
        +137 +138 +139 +140 +141 +142 +143 +144 +145 +146
        +147 +148 +149 +150 +151 +152 +153 +154 +155 +156
        +157 +158 +159 +160 +161 +162 +163 +164 +165 +166
        +167 +168 +169 +170 +171 +172 +173 +174 +175 +176     u=1 $ Baffle
131 7 -7.9400 ((+116 -117 -45 +44) : (+118 -119 -45 +115))    +136
        +137 +138 +139 +140 +141 +142 +143 +144 +145 +146
        +147 +148 +149 +150 +151 +152 +153 +154 +155 +156
        +157 +158 +159 +160 +161 +162 +163 +164 +165 +166
        +167 +168 +169 +170 +171 +172 +173 +174 +175 +176     u=1 $ Baffle
132 7 -7.9400 ((+120 -121 -45 +44) : (+122 -123 -45 +115))    +136
        +137 +138 +139 +140 +141 +142 +143 +144 +145 +146
        +147 +148 +149 +150 +151 +152 +153 +154 +155 +156
        +157 +158 +159 +160 +161 +162 +163 +164 +165 +166
        +167 +168 +169 +170 +171 +172 +173 +174 +175 +176     u=1 $ Baffle
133 7 -7.9400 ((+124 -125 -45 +44) : (+126 -127 -45 +115))    +136
        +137 +138 +139 +140 +141 +142 +143 +144 +145 +146
        +147 +148 +149 +150 +151 +152 +153 +154 +155 +156
        +157 +158 +159 +160 +161 +162 +163 +164 +165 +166
        +167 +168 +169 +170 +171 +172 +173 +174 +175 +176     u=1 $ Baffle
134 7 -7.9400 ((+128 -129 -45 +44) : (+130 -131 -45 +115))    +136
        +137 +138 +139 +140 +141 +142 +143 +144 +145 +146
        +147 +148 +149 +150 +151 +152 +153 +154 +155 +156
        +157 +158 +159 +160 +161 +162 +163 +164 +165 +166
        +167 +168 +169 +170 +171 +172 +173 +174 +175 +176     u=1 $ Baffle
135 7 -7.9400 ((+132 -133 -45 +44) : (+134 -135 -45 +115))    +136
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        +137 +138 +139 +140 +141 +142 +143 +144 +145 +146
        +147 +148 +149 +150 +151 +152 +153 +154 +155 +156
        +157 +158 +159 +160 +161 +162 +163 +164 +165 +166
        +167 +168 +169 +170 +171 +172 +173 +174 +175 +176        u=1 $ Baffle
136 0       ((+38 +39 +46 +47 +51):(+46 -48)) +72 +73 #102 #104
        #105 #106 #107 #108 #109 #110 #111 #112 #113
        #115 #116 #117 #118 #119 #120 #123 #124
        #126 #127 #128 #129  #901 u=1 $ Outside
C Detector Cells - Inlet Biasing
399  0  -399  fill=1  $ Cask
400  0  -400  +399  fill=1  $ Surface
450  0  -450  +399  +400  fill=1  $ Surface
500  0  -500  +399  +400  +450 fill=1  $ Shield Out
550  0  -550  +399  +400  +450  +500  fill=1  $ Shield Out
600  0  -600  +399  +400  +450  +500  +550  fill=1  $ 1ft
700  0  -700  +399  +400  +450  +500  +550  +600  fill=1  $ 1m
800  0  -800  +399  +400  +450  +500  +550  +600  +700  fill=1  $ Outline
900  0  +399  +400  +450  +500  +550  +600  +700  +800  $ Exterior

C Fuel Assembly Surfaces - ng16a - v1.1
1 RPP -10.4775 10.4775 -10.4775 10.4775 0.0000 9.6825  $ Lower Nozzle
2 RPP -10.4775 10.4775 -10.4775 10.4775 0.0000 11.9456  $ Lower Plenum
3 RPP -10.4775 10.4775 -10.4775 10.4775 0.0000 392.9456  $ Fuel
4 RPP -10.4775 10.4775 -10.4775 10.4775 0.0000 424.8226  $ Upper Plenum
5 RPP -10.4775 10.4775 -10.4775 10.4775 0.0000 452.8820  $ Upper Nozzle
6 PZ 265.9456        $ Flood elevation
C Surfaces - Fuel Tube v1.3
7 RPP -11.6015 11.6015 -11.6015 11.6015 7.6200 457.2762  $ Tube void
8 RPP -12.3952 12.3952 -12.3952 12.3952 7.6200 448.3100  $ Tube
9 RPP -11.6015 -11.2840 -10.2362 10.2362 9.2075 446.7225  $ Poison left
10 RPP 11.2840 11.6015 -10.2362 10.2362 9.2075 446.7225  $ Poison right
11 RPP -10.2362 10.2362 11.2840 11.6015 9.2075 446.7225  $ Poison top
12 RPP -10.2362 10.2362 -11.6015 -11.2840 9.2075 446.7225  $ Poison bottom
C Surfaces - PWR Basket v1.5
13  RPP -12.3952 12.3952 -12.3952 12.3952 0.0000 457.2762  $ Tube opening
14 8 RPP -16.6370 16.6370 -16.6370 16.6370 0.0000 457.2762  $ Tube radius
15  RPP 81.8833 83.7883 -33.1851 33.1851 7.6200 448.3100  $ Side support +x
16  RPP -83.7883 -81.8833 -33.1851 33.1851 7.6200 448.3100  $ Side support -x
17  RPP -33.1851 33.1851 81.8833 83.7883 7.6200 448.3100  $ Side support +y
18  RPP -33.1851 33.1851 -83.7883 -81.8833 7.6200 448.3100  $ Side support -y
19  RPP -60.2552 60.2552 -60.2552 60.2552 7.6200 448.3100  $ Corner outer
20  RPP -59.4614 59.4614 -59.4614 59.4614 7.6200 448.3100  $ Corner inner
21 8 RPP -78.6267 78.6267 -78.6267 78.6267 7.6200 448.3100  $ Corner dia. outer
22 8 RPP -77.83291 77.8329 -77.8329 77.8329 7.6200 448.3100  $ Corner dia. inner
C Surfaces - PWR Canister Cavity v1.5
23 RPP -10.4780 10.4780 -10.4780 10.4780 0.0000 452.8821   $ Assy opening
C Surfaces - Canister v1.3
24 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 457.2762 90.1700   $ Cavity
25 CZ 89.8525         $ Lid Gap
26 RCC 0.0000 0.0000 477.9010 0.0000 0.0000 2.2352 89.8525   $ Closure Ring Gap
27 CZ 86.1060          $ Closure Ring Gap
28 CZ 2.6924         $ Bot Cylinder Radius
29 CZ 6.7691         $ Mid Cyclinder Radius
30 CZ 7.4041         $ Top Cylinder Radius
31 PZ 468.6300         $ Port plane bot/mid
32 PZ 469.9762         $ Lower/upper lid
33 PZ 477.2914         $ Port plane mid/top
34 PZ 450.9262         $ Port shield elevation
35 CZ 2.6924         $ Port shield ID
36 CZ 5.0800         $ Port shield OD
C  RCC 0.0000 0.0000 -12.0750 0.0000 0.0000 469.3412 96.6200   $ Water jacket
37 RCC 0.0000 0.0000 -6.9850 0.0000 0.0000 487.1212 91.4400   $ Canister
C Passively Cooled Transfer Cask Surfaces - v1.3.5_ng16a
38 RCC 0.0 0.0 0.0 0.0 0.0 499.745 96.5200  $ Cavity
39 RCC 0.0 0.0 15.2400 0.0 0.0 443.2300 120.6500  $ Cask OD
40 CZ 98.4250          $ Inner shell OD
41 CZ 98.552          $ Lead shield ID
42 CZ 106.680          $ Lead shield OD
43 CZ 106.8070          $ Middle shell ID
44 CZ 109.9820          $ Middle shell OD
45 RCC 0.0 0.0 15.2400 0.0 0.0 443.2300 120.0150  $ NS outline
46 RCC 0.0 0.0 499.7450 0.0 0.0 7.6200 112.0775  $ Retaining ring outline
47 RCC 0.0 0.0 499.7450 0.0 0.0 7.6200 86.9950  $ Retaining ring ID
48 RCC 0.0 0.0 499.7450 0.0 0.0 0.6350 112.6490  $ Top ring notch
49 RCC 0.0 0.0 499.7450 0.0 0.0 2.5400 100.9650
50 RCC 0.0 0.0 499.7450 0.0 0.0 2.8702 102.2350
51 RCC 0.0 0.0 458.4700 0.0 0.0 41.9100 120.6500  $ Top ring
52 RCC 0.0 0.0 493.2680 0.0 0.0 6.4770 120.0150  $ Top ring vent - ring
53 RCC 0.0 0.0 493.2680 0.0 0.0 6.4770 116.5098  $ Top ring vent - ring
54 RCC 116.5098 0.0 496.5700 4.1422 0.0 0.0 2.5400  $ Top ring vent - to nipple
55 4 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017  $ Top ring vent - interior to ring
56 4 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017  $ Top ring vent - interior to ring
57 12 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017  $ Top ring vent - interior to ring
58 12 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017  $ Top ring vent - interior to ring
59 19 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017  $ Top ring vent - interior to ring
60 19 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017  $ Top ring vent - interior to ring
61 27 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017  $ Top ring vent - interior to ring
62 27 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017  $ Top ring vent - interior to ring
63 73 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017  $ Top ring vent - interior to ring
64 73 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017  $ Top ring vent - interior to ring
65 74 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017  $ Top ring vent - interior to ring
66 74 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017  $ Top ring vent - interior to ring
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67 75 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017   $ Top ring vent - interior to ring
68 75 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017   $ Top ring vent - interior to ring
69 76 RCC 118.3640 0.0 479.2980 0.0 0.0 13.9700 0.9017   $ Top ring vent - interior to ring
70 76 RCC 95.8824 0.0 460.4994 22.4816 0.0 22.4816 0.9017   $ Top ring vent - interior to ring
71 RCC 0.0 0.0 0.0 0.0 0.0 15.2400 120.6500   $ Bottom ring
72 RPP -76.3524 -71.2724 -113.0300 113.0300 0.0 5.0790   $ Rail -x
73 RPP 71.2724 76.3524 -113.0300 113.0300 0.0 5.0790   $ Rail +x
74 RHP 0.0 0.0 -15.2400 0.0 0.0 15.2400 -54.4989 -107.4028 0.0
     53.4989 -107.4028 0.0 101.6000 0.0 0.0   $ Door prism
75 PY 109.5375          $ Door side +y
76 PY -109.5375          $ Door side -y
77 RPP -120.6500 120.6500 -83.5025 83.5025 -15.2400 0.0   $ Vent forging Door
78 RPP -120.6500 120.6500 -72.3900 72.3900 0.0 15.2400   $ Vent forging Bottom Ring
79 RPP -120.6500 -81.2800 -66.8020 66.8020 0.0 7.6200   $ Vent outline -x
80 RPP -120.6500 -96.5200 -50.0380 50.0380 0.0 7.6200   $ Vent inner -x
81 RPP -67.0560 67.0560 -120.6500 -81.2800 0.0 7.6200   $ Vent outline -y
82 RPP -50.2920 50.2920 -120.6500 -96.5200 0.0 7.6200   $ Vent inner -y
83 RPP -102.2350 102.2350 -200.0000 200.0000 -0.3048 0.0   $ Door Gap
84 RPP -102.2350 -101.6000 -200.0000 200.0000 -10.4648 0.0   $ Door Gap
85 RPP 101.6000 102.2350 -200.0000 200.0000 -10.4648 0.0   $ Door Gap
86 RPP -97.7900 -97.6376 -200.0000 200.0000 -15.2400 -10.4648   $ Door Gap
87 RPP 97.6376 97.7900 -200.0000 200.0000 -15.2400 -10.4648   $ Door Gap
88 RPP -101.6000 101.6000 -0.3175 0.3175 -10.3124 -10.0076   $ Door overhang gap
89 RPP -76.5175 -71.1073 -200.0000 200.0000 0.0000 5.1562   $ Rail -x Gap
90 RPP 71.1073 76.5175 -200.0000 200.0000 0.0000 5.1562   $ Rail +x Gap
91 RCC 0.0 0.0 467.3600 0.0 0.0 34.9250 95.5675   $ Seal Shield OD
92 RCC 0.0 0.0 467.3600 0.0 0.0 34.9250 92.0750   $ Seal Shield ID
93 RCC 0.0 0.0 469.6587 0.0 0.0 3.0226 93.5990   $ Seal Shield seal
94 RCC 0.0 0.0 476.0087 0.0 0.0 3.0226 94.0435   $ Seal Shield seal
95 RCC 0.0 0.0 476.0087 0.0 0.0 3.0226 95.5675   $ Seal Shield seal
96 4 RCC 93.5890 0.0 471.1700 1.3562 0.0 0.0 0.3175   $ Seal Shield vent
97 4 RCC 94.0535 0.0 477.5200 -1.3562 0.0 0.0 0.3175   $ Seal Shield vent
98 4 RCC 95.5675 0.0 474.3450 -2.8702 0.0 0.0 0.2540   $ Seal Shield vent
99 4 RCC 94.9452 0.0 467.3600 0.0 0.0 7.6200 0.2540   $ Seal Shield vent
100 4 RCC 92.6973 0.0 473.8370 0.0 0.0 28.4480 0.2540   $ Seal Shield vent
101 RCC 0.0 0.0 -15.2400 0.0 0.0 30.4800 139.1920   $ Inlet Shield - Door
102 RCC 0.0 0.0 -15.2400 0.0 0.0 30.4800 132.8420   $ Inlet Shield - Door
103 RPP -77.2160 -46.4820 -139.1920 139.1920 -15.2400 15.2400   $ Inlet Shield - Door
104 RPP -67.0560 -50.2920 -139.1920 139.1920 -15.2400 15.2400   $ Inlet Shield - Door
105 RPP 46.4820 77.2160 -139.1920 139.1920 -15.2400 15.2400   $ Inlet Shield - Door
106 RPP 50.2920 67.0560 -139.1920 139.1920 -15.2400 15.2400   $ Inlet Shield - Door
107 RPP -137.1600 137.1600 -72.3900 -46.2280 -15.2400 15.2400   $ Inlet Shield - Rail
108 RPP -133.3500 133.3500 -68.5800 -50.0380 -15.2400 15.2400   $ Inlet Shield - Rail
109 RPP -137.1600 137.1600 46.2280 72.3900 -15.2400 15.2400   $ Inlet Shield - Rail
110 RPP -133.3500 133.3500 50.0380 68.5800 -15.2400 15.2400   $ Inlet Shield - Rail
111 PY -0.3175          $ Baffle
112 PY 0.3175          $ Baffle
113 PY -1.27          $ Baffle
114 PY 1.27          $ Baffle
115 CZ 119.2530          $ Baffle
116 39 PY -0.3175          $ Baffle
117 39 PY 0.3175          $ Baffle
118 39 PY -1.27          $ Baffle
119 39 PY 1.27          $ Baffle
120 42 PY -0.3175          $ Baffle
121 42 PY 0.3175          $ Baffle
122 42 PY -1.27          $ Baffle
123 42 PY 1.27          $ Baffle
124 45 PY -0.3175          $ Baffle
125 45 PY 0.3175          $ Baffle
126 45 PY -1.27          $ Baffle
127 45 PY 1.27          $ Baffle
128 48 PY -0.3175          $ Baffle
129 48 PY 0.3175          $ Baffle
130 48 PY -1.27          $ Baffle
131 48 PY 1.27          $ Baffle
132 51 PY -0.3175          $ Baffle
133 51 PY 0.3175          $ Baffle
134 51 PY -1.27          $ Baffle
135 51 PY 1.27          $ Baffle
136 TZ 0.0 0.0 15.2400 114.4270 3.1750 3.1750   $ Baffle hole 1
137 TZ 0.0 0.0 26.4160 114.4270 3.1750 3.1750   $ Baffle hole 2
138 TZ 0.0 0.0 37.4943 114.4270 3.1750 3.1750   $ Baffle hole 3
139 TZ 0.0 0.0 48.5726 114.4270 3.1750 3.1750   $ Baffle hole 4
140 TZ 0.0 0.0 59.6509 114.4270 3.1750 3.1750   $ Baffle hole 5
141 TZ 0.0 0.0 70.7292 114.4270 3.1750 3.1750   $ Baffle hole 6
142 TZ 0.0 0.0 81.8075 114.4270 3.1750 3.1750   $ Baffle hole 7
143 TZ 0.0 0.0 92.8858 114.4270 3.1750 3.1750   $ Baffle hole 8
144 TZ 0.0 0.0 103.9642 114.4270 3.1750 3.1750   $ Baffle hole 9
145 TZ 0.0 0.0 115.0425 114.4270 3.1750 3.1750   $ Baffle hole 10
146 TZ 0.0 0.0 126.1208 114.4270 3.1750 3.1750   $ Baffle hole 11
147 TZ 0.0 0.0 137.1991 114.4270 3.1750 3.1750   $ Baffle hole 12
148 TZ 0.0 0.0 148.2774 114.4270 3.1750 3.1750   $ Baffle hole 13
149 TZ 0.0 0.0 159.3557 114.4270 3.1750 3.1750   $ Baffle hole 14
150 TZ 0.0 0.0 170.4340 114.4270 3.1750 3.1750   $ Baffle hole 15
151 TZ 0.0 0.0 181.5123 114.4270 3.1750 3.1750   $ Baffle hole 16
152 TZ 0.0 0.0 192.5906 114.4270 3.1750 3.1750   $ Baffle hole 17
153 TZ 0.0 0.0 203.6689 114.4270 3.1750 3.1750   $ Baffle hole 18
154 TZ 0.0 0.0 214.7472 114.4270 3.1750 3.1750   $ Baffle hole 19
155 TZ 0.0 0.0 225.8255 114.4270 3.1750 3.1750   $ Baffle hole 20
156 TZ 0.0 0.0 236.9038 114.4270 3.1750 3.1750   $ Baffle hole 21
157 TZ 0.0 0.0 247.9822 114.4270 3.1750 3.1750   $ Baffle hole 22
```

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158 TZ 0.0 0.0 259.0605 114.4270 3.1750 3.1750    $ Baffle hole 23
159 TZ 0.0 0.0 270.1388 114.4270 3.1750 3.1750    $ Baffle hole 24
160 TZ 0.0 0.0 281.2171 114.4270 3.1750 3.1750    $ Baffle hole 25
161 TZ 0.0 0.0 292.2954 114.4270 3.1750 3.1750    $ Baffle hole 26
162 TZ 0.0 0.0 303.3737 114.4270 3.1750 3.1750    $ Baffle hole 27
163 TZ 0.0 0.0 314.4520 114.4270 3.1750 3.1750    $ Baffle hole 28
164 TZ 0.0 0.0 325.5303 114.4270 3.1750 3.1750    $ Baffle hole 29
165 TZ 0.0 0.0 336.6086 114.4270 3.1750 3.1750    $ Baffle hole 30
166 TZ 0.0 0.0 347.6869 114.4270 3.1750 3.1750    $ Baffle hole 31
167 TZ 0.0 0.0 358.7652 114.4270 3.1750 3.1750    $ Baffle hole 32
168 TZ 0.0 0.0 369.8435 114.4270 3.1750 3.1750    $ Baffle hole 33
169 TZ 0.0 0.0 380.9218 114.4270 3.1750 3.1750    $ Baffle hole 34
170 TZ 0.0 0.0 392.0002 114.4270 3.1750 3.1750    $ Baffle hole 35
171 TZ 0.0 0.0 403.0785 114.4270 3.1750 3.1750    $ Baffle hole 36
172 TZ 0.0 0.0 414.1568 114.4270 3.1750 3.1750    $ Baffle hole 37
173 TZ 0.0 0.0 425.2351 114.4270 3.1750 3.1750    $ Baffle hole 38
174 TZ 0.0 0.0 436.3134 114.4270 3.1750 3.1750    $ Baffle hole 39
175 TZ 0.0 0.0 447.3917 114.4270 3.1750 3.1750    $ Baffle hole 40
176 TZ 0.0 0.0 458.4700 114.4270 3.1750 3.1750    $ Baffle hole 41
177 rhp 0.0 0.0 -15.2400 0.0 0.0 15.2400 91.6505 99.1862 0.0
        91.6505 -99.1862 0.0 -120.6500 0.0 0.0
178 rhp 0.0 0.0 -15.2400 0.0 0.0 30.4800 60.2457 118.7282 0.0
        60.2457 -118.7282 0.0 -77.2160 0.0 0.0
179 rhp 0.0 0.0 -15.2400 0.0 0.0 30.4800 63.1191 124.3909 0.0
        63.1191 -124.3909 0.0 -77.2160 0.0 0.0
180 rhp 0.0 0.0 -15.2400 0.0 0.0 30.4800 92.2238 98.8979 0.0
        92.2238 -98.8979 0.0 -77.2160 0.0 0.0
181 rhp 0.0 0.0 0.0000 0.0 0.0 15.2400 92.2238 98.8979 0.0
        92.2238 -98.8979 0.0 -120.6500 0.0 0.0
182 rpp -77.2160 77.2160 -200 200 0.0 15.2400
183 rpp -200 200 -72.3900 72.3900 0.0 15.2400
200 rcc -54.356 -93.98 0 0 0 7.62 12.7
201 py 93.98
202 px -54.356                          $changed
203 px 54.356                           $changed
204 rcc 54.356 -93.98 0 0 0 7.62 12.7
205 rcc -93.98 -54.102 0 0 0 7.62 12.7
206 py 54.102
207 px 93.98
208 py -54.102
209 rcc -93.98 54.102 0 0 0 7.62 12.7
259 rpp -120.65 -93.98 -66.802 -50.038 0 7.62  $ Vent outline -x
260 rpp -96.52 -81.28 -54.102 54.102 0 7.62
261 rpp -120.65 -93.98 50.038 66.802 0 7.62
281 rpp -67.056 -50.292 -120.65 -93.98 0 7.62  $ Vent outline -y
282 rpp -54.356 54.356 -96.52 -81.28 0 7.62
283 rpp 50.292 67.056 -120.65 -93.98 0 7.62
300 rcc -47.752 -99.06 0 0 0 7.62 2.54       $changed
301 py -99.06                               $changed
302 px -47.752                              $changed
303 px 47.752                               $changed
304 rcc 47.752 -99.06 0 0 0 7.62 2.54        $changed
305 rcc -99.06 -47.498 0 0 0 7.62 2.54
306 py 47.498
307 px -99.06
308 py -47.498
309 rcc -99.06 47.498 0 0 0 7.62 2.54
380 rpp 96.52 120.65 -50.038 50.038 0 7.62  $ Vent inner -x
382 rpp -50.292 50.292 96.52 120.65 0 7.62  $ Vent inner -y
C Storage Cask & Pad Container
399  RCC  0.0000  0.0000  -15.2410  0.0000  0.0000  507.4432  120.6510
C Inlet Detector DIAA (Surface)
400  RCC  0.0000  0.0000  -0.0010  0.0000  0.0000  15.2410  139.2020
401      PX  0.0001
402  1   PX  0.0001
403  2   PX  0.0001
404  3   PX  0.0001
405  4   PX  0.0001
406  5   PX  0.0001
407  6   PX  0.0001
408  7   PX  0.0001
409  8   PX  0.0001
410  9   PX  0.0001
411  10  PX  0.0001
412  11  PX  0.0001
413  12  PX  0.0001
414  13  PX  0.0001
415  14  PX  0.0001
416  15  PX  0.0001
417      PY  0.0000
418  16  PX  0.0001
419  17  PX  0.0001
420  18  PX  0.0001
421  19  PX  0.0001
422  20  PX  0.0001
423  21  PX  0.0001
424  22  PX  0.0001
425  23  PX  0.0001
426  24  PX  0.0001
427  25  PX  0.0001
428  26  PX  0.0001
429  27  PX  0.0001
```

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430  28  PX  0.0001
431  29  PX  0.0001
432  30  PX  0.0001
C Inlet Detector DIAB (Surface)
450  RCC  0.0000  0.0000  -15.2400  0.0000  0.0000  15.2410  139.2120
451     PX  0.0001
452  1  PX  0.0001
453  2  PX  0.0001
454  3  PX  0.0001
455  4  PX  0.0001
456  5  PX  0.0001
457  6  PX  0.0001
458  7  PX  0.0001
459  8  PX  0.0001
460  9  PX  0.0001
461  10  PX  0.0001
462  11  PX  0.0001
463  12  PX  0.0001
464  13  PX  0.0001
465  14  PX  0.0001
466  15  PX  0.0001
467     PY  0.0000
468  16  PX  0.0001
469  17  PX  0.0001
470  18  PX  0.0001
471  19  PX  0.0001
472  20  PX  0.0001
473  21  PX  0.0001
474  22  PX  0.0001
475  23  PX  0.0001
476  24  PX  0.0001
477  25  PX  0.0001
478  26  PX  0.0001
479  27  PX  0.0001
480  28  PX  0.0001
481  29  PX  0.0001
482  30  PX  0.0001
C Inlet Detector DIBA (Shield Out)
500  RCC  0.0000  0.0000  -0.0010  0.0000  0.0000  15.2410  155.0909
501     PX  0.0001
502  1  PX  0.0001
503  2  PX  0.0001
504  3  PX  0.0001
505  4  PX  0.0001
506  5  PX  0.0001
507  6  PX  0.0001
508  7  PX  0.0001
509  8  PX  0.0001
510  9  PX  0.0001
511  10  PX  0.0001
512  11  PX  0.0001
513  12  PX  0.0001
514  13  PX  0.0001
515  14  PX  0.0001
516  15  PX  0.0001
517     PY  0.0000
518  16  PX  0.0001
519  17  PX  0.0001
520  18  PX  0.0001
521  19  PX  0.0001
522  20  PX  0.0001
523  21  PX  0.0001
524  22  PX  0.0001
525  23  PX  0.0001
526  24  PX  0.0001
527  25  PX  0.0001
528  26  PX  0.0001
529  27  PX  0.0001
530  28  PX  0.0001
531  29  PX  0.0001
532  30  PX  0.0001
C Inlet Detector DIBB (Shield Out)
550  RCC  0.0000  0.0000  -15.2400  0.0000  0.0000  15.2410  155.1009
551     PX  0.0001
552  1  PX  0.0001
553  2  PX  0.0001
554  3  PX  0.0001
555  4  PX  0.0001
556  5  PX  0.0001
557  6  PX  0.0001
558  7  PX  0.0001
559  8  PX  0.0001
560  9  PX  0.0001
561  10  PX  0.0001
562  11  PX  0.0001
563  12  PX  0.0001
564  13  PX  0.0001
565  14  PX  0.0001
566  15  PX  0.0001
567     PY  0.0000
568  16  PX  0.0001
569  17  PX  0.0001
```

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570  18  PX  0.0001
571  19  PX  0.0001
572  20  PX  0.0001
573  21  PX  0.0001
574  22  PX  0.0001
575  23  PX  0.0001
576  24  PX  0.0001
577  25  PX  0.0001
578  26  PX  0.0001
579  27  PX  0.0001
580  28  PX  0.0001
581  29  PX  0.0001
582  30  PX  0.0001
C Inlet Detector DICA (1ft)
600  RCC  0.0000  0.0000  -15.2400  0.0000  0.0000  30.4800  169.6820
601     PX  0.0001
602  1  PX  0.0001
603  2  PX  0.0001
604  3  PX  0.0001
605  4  PX  0.0001
606  5  PX  0.0001
607  6  PX  0.0001
608  7  PX  0.0001
609  8  PX  0.0001
610  9  PX  0.0001
611  10  PX  0.0001
612  11  PX  0.0001
613  12  PX  0.0001
614  13  PX  0.0001
615  14  PX  0.0001
616  15  PX  0.0001
617     PY  0.0000
618  16  PX  0.0001
619  17  PX  0.0001
620  18  PX  0.0001
621  19  PX  0.0001
622  20  PX  0.0001
623  21  PX  0.0001
624  22  PX  0.0001
625  23  PX  '0.0001
626  24  PX  0.0001
627  25  PX  0.0001
628  26  PX  0.0001
629  27  PX  0.0001
630  28  PX  0.0001
631  29  PX  0.0001
632  30  PX  0.0001
C Inlet Detector DIDA (1m)
700  RCC  0.0000  0.0000  -15.2400  0.0000  0.0000  30.4800  239.2020
701     PX  0.0001
702  1  PX  0.0001
703  2  PX  0.0001
704  3  PX  0.0001
705  4  PX  0.0001
706  5  PX  0.0001
707  6  PX  0.0001
708  7  PX  0.0001
709  8  PX  0.0001
710  9  PX  0.0001
711  10  PX  0.0001
712  11  PX  0.0001
713  12  PX  0.0001
714  13  PX  0.0001
715  14  PX  0.0001
716  15  PX  0.0001
717     PY  0.0000
718  16  PX  0.0001
719  17  PX  0.0001
720  18  PX  0.0001
721  19  PX  0.0001
722  20  PX  0.0001
723  21  PX  0.0001
724  22  PX  0.0001
725  23  PX  0.0001
726  24  PX  0.0001
727  25  PX  0.0001
728  26  PX  0.0001
729  27  PX  0.0001
730  28  PX  0.0001
731  29  PX  0.0001
732  30  PX  0.0001
C Inlet Detector DIEA (Outline)
800  RCC  0.0000  0.0000  -115.2410  0.0000  0.0000  707.4432 339.2020

C
C Materials List - Common Materials - v1.7
C
C Homogenized Lower Nozzle
m1    6000 -8.0000E-04 14000 -1.0000E-02 15031 -4.5000E-04
      24000 -1.9000E-01 25055 -2.0000E-02 26000 -6.8375E-01
      28000 -9.5000E-02
C Homogenized Lower Plenum
```

```
m2    24000 -1.0000E-03
      26000 -2.1000E-03
      40000 -9.8230E-01
      50000 -1.4500E-02
      72000 -1.0000E-04
C Homogenized UO2 Fuel - Dry
m3    92235 -3.5870E-02 40000 -1.8286E-01 24000 -1.8616E-04
      92238 -6.8153E-01 50000 -2.6993E-03 72000 -1.8616E-05
       8016 -9.6442E-02 26000 -3.9093E-04
C Homogenized Upper Plenum
m4    6000 -7.0431E-04 14000 -8.8038E-03 15031 -3.9617E-04
      24000 -1.6739E-01 50000 -1.7344E-03 25055 -1.7608E-02
      26000 -6.0221E-01 72000 -1.1962E-05 28000 -8.3636E-02
      40000 -1.1750E-01
C Homogenized Upper Nozzle
m5    6000 -8.0000E-04 14000 -1.0000E-02 15031 -4.5000E-04
      24000 -1.9000E-01 25055 -2.0000E-02 26000 -6.8375E-01
      28000 -9.5000E-02
C Water
m6    1001 2 8016 1
C Stainless Steel
m7    6000 -8.0000E-04 14000 -1.0000E-02 15031 -4.5000E-04
      24000 -1.9000E-01 25055 -2.0000E-02 26000 -6.8375E-01
      28000 -9.5000E-02
C Carbon Steel
m8    26000 -0.99  6012 -0.01
C Neutron Poison
m9    13027 -0.7470 5010 -0.0356 5011 -0.1624
      6012 -0.0549
C Aluminum
m10   13027 -1.0
C Lead
m11   82000 -1.0
C Vent Port Middle Cylinder
m14   6000 -8.0000E-04 14000 -1.0000E-02 15031 -4.5000E-04
      24000 -1.9000E-01 25055 -2.0000E-02 26000 -6.8375E-01
      28000 -9.5000E-02
C
C Cell Importances
C
imp:p 1 141r 0
C
C PWR Source Definition - Fuel Gamma Response to Group 7
C
sdef x=d1 y=d2 z=d3 erg=d4 cell=399:93:77:d5:3
si1   -10.4775 10.4775
sp1   0 1
si2   -10.4775 10.4775
sp2   0 1
si3 a 11.9456 21.4706 30.9956 40.5206 50.0456 59.5706 69.0956
      335.7956 345.3206 354.8456 364.3706 373.8956 383.4206 392.9456
sp3 d 0.5470 0.6358 0.7247 0.8135 0.9023 0.9912 1.0800
      1.0800 0.9912 0.9023 0.8135 0.7247 0.6358 0.5470
sb3 d 1.97E+00 1.70E+00 1.49E+00 1.33E+00 1.20E+00 1.09E+00 1.00E+00
      1.00E+00 1.00E+00 1.00E+00 1.00E+00 1.00E+00 1.00E+00 1.00E+00
si4   3.000E+00 4.000E+00
sp4   0 1
C Source Information
si5 l       39 40 41
         42 43 44 45 46
      47 48 49 50 51 52 53
      54 55 56 57 58 59 60
      61 62 63 64 65 66 67
         68 69 70 71 72
            73 74 75
C Source Probability
sp5             1.0 1.0 1.0
            1.0 1.0 1.0 1.0 1.0
        1.0 1.0 1.0 1.0 1.0 1.0 1.0
        1.0 1.0 1.0 1.0 1.0 1.0 1.0
        1.0 1.0 1.0 1.0 1.0 1.0 1.0
            1.0 1.0 1.0 1.0 1.0
                1.0 1.0 1.0
mode p
nps 1.00E+09
C
C ANSI/ANS-6.1.1-1977 - Gamma Flux-to-Dose Conversion Factors
C (mrem/hr)/(photons/cm2-sec)
C
de0   0.01 0.03 0.05 0.07 0.1 0.15 0.2
      0.25 0.3 0.35 0.4 0.45 0.5 0.55
      0.6 0.65 0.7 0.8 1 1.4 1.8
      2.2 2.6 2.8 3.25 3.75 4.25 4.75
      5 5.25 5.75 6.25 6.75 7.5 9
      11 13 15
df0   3.96E-03 5.82E-04 2.90E-04 2.58E-04 2.83E-04 3.79E-04 5.01E-04
      6.31E-04 7.59E-04 8.78E-04 9.85E-04 1.08E-03 1.17E-03 1.27E-03
      1.36E-03 1.44E-03 1.52E-03 1.68E-03 1.98E-03 2.51E-03 2.99E-03
      3.42E-03 3.82E-03 4.01E-03 4.41E-03 4.83E-03 5.23E-03 5.60E-03
      5.80E-03 6.01E-03 6.37E-03 6.74E-03 7.11E-03 7.66E-03 8.77E-03
      1.03E-02 1.18E-02 1.33E-02
C
```

```
C Exponential Transform - Inlet
C
ext:p -0.6v1 -0.6v1 -0.6v1  -0.6v1 -0.6v1 0
      -0.6v1 -0.6v1  0
      0 20r -0.6v1 5r 0 0
      0 36r 0
      0 -0.6v1 0 -0.6v1 -0.6v1 0 -0.6v1 6r 0 2r
      0 -0.6v1 0 -0.6v1 0 -0.6v1 4r 0 8r -0.6v1 10r 0 4r -0.6v1 5r 0
      0 8r
vect v1 0.0 0.0 392.9
fc2 Inlet Surface Tally Q1 (+x+y)
f2:p +400.1
fm2 3.7000E+01
fs2 -401  -417
     +416  +415  +414  +413  +412  +411
     +410  +409  +408  +407  +406  +405
     +404  +403  +402  T
sd2 6.6651E+03  3.3326E+03  2.0829E+02  15r  1.3330E+04
tf2
fc12 Inlet Surface Tally Q2 (-x+y)
f12:p +400.1
fm12 3.7000E+01
fs12 +401  -417
     -432  -431  -430  -429  -428  -427
     -426  -425  -424  -423  -422  -421
     -420  -419  -418  T
sd12 6.6651E+03  3.3326E+03  2.0829E+02  15r  1.3330E+04
tf12
fc22 Inlet Surface Tally Q3 (-x-y)
f22:p +400.1
fm22 3.7000E+01
fs22 +401  +417
     -416  -415  -414  -413  -412  -411
     -410  -409  -408  -407  -406  -405
     -404  -403  -402  T
sd22 6.6651E+03  3.3326E+03  2.0829E+02  15r  1.3330E+04
tf22
fc32 Inlet Surface Tally Q4 (+x-y)
f32:p +400.1
fm32 3.7000E+01
fs32 -401  +417
     +432  +431  +430  +429  +428  +427
     +426  +425  +424  +423  +422  +421
     +420  +419  +418  T
sd32 6.6651E+03  3.3326E+03  2.0829E+02  15r  1.3330E+04
tf32
fc42 Inlet Surface Tally Q1 (+x+y)
f42:p +450.1
fm42 3.7000E+01
fs42 -451  -467
     +466  +465  +464  +463  +462  +461
     +460  +459  +458  +457  +456  +455
     +454  +453  +452  T
sd42 6.6656E+03  3.3328E+03  2.0830E+02  15r  1.3331E+04
tf42
fc52 Inlet Surface Tally Q2 (-x+y)
f52:p +450.1
fm52 3.7000E+01
fs52 +451  -467
     -482  -481  -480  -479  -478  -477
     -476  -475  -474  -473  -472  -471
     -470  -469  -468  T
sd52 6.6656E+03  3.3328E+03  2.0830E+02  15r  1.3331E+04
tf52
fc62 Inlet Surface Tally Q3 (-x-y)
f62:p +450.1
fm62 3.7000E+01
fs62 +451  +467
     -466  -465  -464  -463  -462  -461
     -460  -459  -458  -457  -456  -455
     -454  -453  -452  T
sd62 6.6656E+03  3.3328E+03  2.0830E+02  15r  1.3331E+04
tf62
fc72 Inlet Surface Tally Q4 (+x-y)
f72:p +450.1
fm72 3.7000E+01
fs72 -451  +467
     +482  +481  +480  +479  +478  +477
     +476  +475  +474  +473  +472  +471
     +470  +469  +468  T
sd72 6.6656E+03  3.3328E+03  2.0830E+02  15r  1.3331E+04
tf72
fc82 Inlet Shield Out Tally Q1 (+x+y)
f82:p +500.1
fm82 3.7000E+01
fs82 -501  -517
     +516  +515  +514  +513  +512  +511
     +510  +509  +508  +507  +506  +505
     +504  +503  +502  T
sd82 7.4259E+03  3.7130E+03  2.3206E+02  15r  1.4852E+04
tf82
fc92 Inlet Shield Out Tally Q2 (-x+y)
```

```
f92:p +500.1
fm92 3.7000E+01
fs92 +501  -517
     -532  -531  -530  -529  -528  -527
     -526  -525  -524  -523  -522  -521
     -520  -519  -518  T
sd92 7.4259E+03  3.7130E+03  2.3206E+02  15r  1.4852E+04
tf92
fc102 Inlet Shield Out Tally Q3 (-x-y)
f102:p +500.1
fm102 3.7000E+01
fs102 +501  +517
     -516  -515  -514  -513  -512  -511
     -510  -509  -508  -507  -506  -505
     -504  -503  -502  T
sd102 7.4259E+03  3.7130E+03  2.3206E+02  15r  1.4852E+04
tf102
fc112 Inlet Shield Out Tally Q4 (+x-y)
f112:p +500.1
fm112 3.7000E+01
fs112 -501  +517
     +532  +531  +530  +529  +528  +527
     +526  +525  +524  +523  +522  +521
     +520  +519  +518  T
sd112 7.4259E+03  3.7130E+03  2.3206E+02  15r  1.4852E+04
tf112
fc122 Inlet Shield Out Tally Q1 (+x+y)
f122:p +550.1
fm122 3.7000E+01
fs122 -551  -567
     +566  +565  +564  +563  +562  +561
     +560  +559  +558  +557  +556  +555
     +554  +553  +552  T
sd122 7.4264E+03  3.7132E+03  2.3207E+02  15r  1.4853E+04
tf122
fc132 Inlet Shield Out Tally Q2 (-x+y)
f132:p +550.1
fm132 3.7000E+01
fs132 +551  -567
     -582  -581  -580  -579  -578  -577
     -576  -575  -574  -573  -572  -571
     -570  -569  -568  T
sd132 7.4264E+03  3.7132E+03  2.3207E+02  15r  1.4853E+04
tf132
fc142 Inlet Shield Out Tally Q3 (-x-y)
f142:p +550.1
fm142 3.7000E+01
fs142 +551  +567
     -566  -565  -564  -563  -562  -561
     -560  -559  -558  -557  -556  -555
     -554  -553  -552  T
sd142 7.4264E+03  3.7132E+03  2.3207E+02  15r  1.4853E+04
tf142
fc152 Inlet Shield Out Tally Q4 (+x-y)
f152:p +550.1
fm152 3.7000E+01
fs152 -551  +567
     +582  +581  +580  +579  +578  +577
     +576  +575  +574  +573  +572  +571
     +570  +569  +568  T
sd152 7.4264E+03  3.7132E+03  2.3207E+02  15r  1.4853E+04
tf152
fc162 Inlet 1ft Tally Q1 (+x+y)
f162:p +600.1
fm162 3.7000E+01
fs162 -601  -617
     +616  +615  +614  +613  +612  +611
     +610  +609  +608  +607  +606  +605
     +604  +603  +602  T
sd162 1.6248E+04  8.1240E+03  5.0775E+02  15r  3.2496E+04
tf162 3J 14
fc172 Inlet 1ft Tally Q2 (-x+y)
f172:p +600.1
fm172 3.7000E+01
fs172 +601  -617
     -632  -631  -630  -629  -628  -627
     -626  -625  -624  -623  -622  -621
     -620  -619  -618  T
sd172 1.6248E+04  8.1240E+03  5.0775E+02  15r  3.2496E+04
tf172
fc182 Inlet 1ft Tally Q3 (-x-y)
f182:p +600.1
fm182 3.7000E+01
fs182 +601  +617
     -616  -615  -614  -613  -612  -611
     -610  -609  -608  -607  -606  -605
     -604  -603  -602  T
sd182 1.6248E+04  8.1240E+03  5.0775E+02  15r  3.2496E+04
tf182
fc192 Inlet 1ft Tally Q4 (+x-y)
f192:p +600.1
fm192 3.7000E+01
```

```
fs192 -601  +617
     +632  +631  +630  +629  +628  +627
     +626  +625  +624  +623  +622  +621
     +620  +619  +618  T
sd192 1.6248E+04  8.1240E+03  5.0775E+02  15r  3.2496E+04
tf192
fc202 Inlet 1m Tally Q1 (+x+y)
f202:p +700.1
fm202 3.7000E+01
fs202 -701  -717
     +716  +715  +714  +713  +712  +711
     +710  +709  +708  +707  +706  +705
     +704  +703  +702  T
sd202 2.2905E+04  1.1452E+04  7.1578E+02  15r  4.5810E+04
tf202
fc212 Inlet 1m Tally Q2 (-x+y)
f212:p +700.1
fm212 3.7000E+01
fs212 +701  -717
     -732  -731  -730  -729  -728  -727
     -726  -725  -724  -723  -722  -721
     -720  -719  -718  T
sd212 2.2905E+04  1.1452E+04  7.1578E+02  15r  4.5810E+04
tf212
fc222 Inlet 1m Tally Q3 (-x-y)
f222:p +700.1
fm222 3.7000E+01
fs222 +701  +717
     -716  -715  -714  -713  -712  -711
     -710  -709  -708  -707  -706  -705
     -704  -703  -702  T
sd222 2.2905E+04  1.1452E+04  7.1578E+02  15r  4.5810E+04
tf222
fc232 Inlet 1m Tally Q4 (+x-y)
f232:p +700.1
fm232 3.7000E+01
fs232 -701  +717
     +732  +731  +730  +729  +728  +727
     +726  +725  +724  +723  +722  +721
     +720  +719  +718  T
sd232 2.2905E+04  1.1452E+04  7.1578E+02  15r  4.5810E+04
tf232
fc242 Inlet Outline Tally
f242:p +800.1
fm242 3.7000E+01
fs242  T
tf242
C
C
C Weight Window Generation - Inlet Azi
C
wwg 162 0 0 0 0
wwp:p 5 3 5 0 -1 0
mesh geom=cyl ref=89 0 25 origin=0.1 0.1 -515
     imesh 90.2 91.4 96.5 98.6 106.8 120.0 120.7 132.8 150.0 650.0
     iints 5 1 1 1 1 1 10 10 10 5
     jmesh 500 520 527 537 539 920 952 980 985 1007 1507
     jints 5 20 7 10 1 1 1 1 1 1 1
     kmesh 1
     kints 40
C wwge:p  1e-3 1 20
C
C Print Control
C
prdmp 1.00E+08 1.00E+08 1 2
print
C
C Random Number Generator
C
rand gen=2 seed=19073486328125  stride=152917 hist=1
C
C Rotation Matrix
C
C 5.625 degree rotation around z-axis
*TR1 0.0 0.0 0.0 5.625 95.625 90 -84.375 5.625 90 90 90 0
C 11.25 degree rotation around z-axis
*TR2 0.0 0.0 0.0 11.250 101.250 90 -78.750 11.250 90 90 90 0
C 16.875 degree rotation around z-axis
*TR3 0.0 0.0 0.0 16.875 106.875 90 -73.125 16.875 90 90 90 0
C 22.5 degree rotation around z-axis
*TR4 0.0 0.0 0.0 22.500 112.500 90 -67.500 22.500 90 90 90 0
C 28.125 degree rotation around z-axis
*TR5 0.0 0.0 0.0 28.125 118.125 90 -61.875 28.125 90 90 90 0
C 33.75 degree rotation around z-axis
*TR6 0.0 0.0 0.0 33.750 123.750 90 -56.250 33.750 90 90 90 0
C 39.375 degree rotation around z-axis
*TR7 0.0 0.0 0.0 39.375 129.375 90 -50.625 39.375 90 90 90 0
C 45 degree rotation around z-axis
*TR8 0.0 0.0 0.0 45.000 135.000 90 -45.000 45.000 90 90 90 0
C 50.625 degree rotation around z-axis
*TR9 0.0 0.0 0.0 50.625 140.625 90 -39.375 50.625 90 90 90 0
C 56.25 degree rotation around z-axis
```

```
*TR10 0.0 0.0 0.0 56.250 146.250 90 -33.750 56.250 90 90 90 0
C 61.875 degree rotation around z-axis
*TR11 0.0 0.0 0.0 61.875 151.875 90 -28.125 61.875 90 90 90 0
C 67.5 degree rotation around z-axis
*TR12 0.0 0.0 0.0 67.500 157.500 90 -22.500 67.500 90 90 90 0
C 73.125 degree rotation around z-axis
*TR13 0.0 0.0 0.0 73.125 163.125 90 -16.875 73.125 90 90 90 0
C 78.75 degree rotation around z-axis
*TR14 0.0 0.0 0.0 78.750 168.750 90 -11.250 78.750 90 90 90 0
C 84.375 degree rotation around z-axis
*TR15 0.0 0.0 0.0 84.375 174.375 90 -5.625 84.375 90 90 90 0
C 95.625 degree rotation around z-axis
*TR16 0.0 0.0 0.0 95.625 185.625 90 5.625 95.625 90 90 90 0
C 101.25 degree rotation around z-axis
*TR17 0.0 0.0 0.0 101.250 191.250 90 11.250 101.250 90 90 90 0
C 106.875 degree rotation around z-axis
*TR18 0.0 0.0 0.0 106.875 196.875 90 16.875 106.875 90 90 90 0
C 112.5 degree rotation around z-axis
*TR19 0.0 0.0 0.0 112.500 202.500 90 22.500 112.500 90 90 90 0
C 118.125 degree rotation around z-axis
*TR20 0.0 0.0 0.0 118.125 208.125 90 28.125 118.125 90 90 90 0
C 123.75 degree rotation around z-axis
*TR21 0.0 0.0 0.0 123.750 213.750 90 33.750 123.750 90 90 90 0
C 129.375 degree rotation around z-axis
*TR22 0.0 0.0 0.0 129.375 219.375 90 39.375 129.375 90 90 90 0
C 135 degree rotation around z-axis
*TR23 0.0 0.0 0.0 135.000 225.000 90 45.000 135.000 90 90 90 0
C 140.625 degree rotation around z-axis
*TR24 0.0 0.0 0.0 140.625 230.625 90 50.625 140.625 90 90 90 0
C 146.25 degree rotation around z-axis
*TR25 0.0 0.0 0.0 146.250 236.250 90 56.250 146.250 90 90 90 0
C 151.875 degree rotation around z-axis
*TR26 0.0 0.0 0.0 151.875 241.875 90 61.875 151.875 90 90 90 0
C 157.5 degree rotation around z-axis
*TR27 0.0 0.0 0.0 157.500 247.500 90 67.500 157.500 90 90 90 0
C 163.125 degree rotation around z-axis
*TR28 0.0 0.0 0.0 163.125 253.125 90 73.125 163.125 90 90 90 0
C 168.75 degree rotation around z-axis
*TR29 0.0 0.0 0.0 168.750 258.750 90 78.750 168.750 90 90 90 0
C 174.375 degree rotation around z-axis
*TR30 0.0 0.0 0.0 174.375 264.375 90 84.375 174.375 90 90 90 0
C 7 degree rotation around z-axis
*TR31 0.0 0.0 0.0 7.000 97.000 90 -83.000 7.000 90 90 90 0
C 23 degree rotation around z-axis
*TR32 0.0 0.0 0.0 23.000 113.000 90 -67.000 23.000 90 90 90 0
C 127 degree rotation around z-axis
*TR33 0.0 0.0 0.0 127.000 217.000 90 37.000 127.000 90 90 90 0
C 143 degree rotation around z-axis
*TR34 0.0 0.0 0.0 143.000 233.000 90 53.000 143.000 90 90 90 0
C 247 degree rotation around z-axis
*TR35 0.0 0.0 0.0 247.000 337.000 90 157.000 247.000 90 90 90 0
C 263 degree rotation around z-axis
*TR36 0.0 0.0 0.0 263.000 353.000 90 173.000 263.000 90 90 90 0
C 10 degree rotation around z-axis
*TR37 0.0 0.0 0.0 10.000 100.000 90 -80.000 10.000 90 90 90 0
C 20 degree rotation around z-axis
*TR38 0.0 0.0 0.0 20.000 110.000 90 -70.000 20.000 90 90 90 0
C 30 degree rotation around z-axis
*TR39 0.0 0.0 0.0 30.000 120.000 90 -60.000 30.000 90 90 90 0
C 40 degree rotation around z-axis
*TR40 0.0 0.0 0.0 40.000 130.000 90 -50.000 40.000 90 90 90 0
C 50 degree rotation around z-axis
*TR41 0.0 0.0 0.0 50.000 140.000 90 -40.000 50.000 90 90 90 0
C 60 degree rotation around z-axis
*TR42 0.0 0.0 0.0 60.000 150.000 90 -30.000 60.000 90 90 90 0
C 70 degree rotation around z-axis
*TR43 0.0 0.0 0.0 70.000 160.000 90 -20.000 70.000 90 90 90 0
C 80 degree rotation around z-axis
*TR44 0.0 0.0 0.0 80.000 170.000 90 -10.000 80.000 90 90 90 0
C 90 degree rotation around z-axis
*TR45 0.0 0.0 0.0 90.000 180.000 90 0.000 90.000 90 90 90 0
C 100 degree rotation around z-axis
*TR46 0.0 0.0 0.0 100.000 190.000 90 10.000 100.000 90 90 90 0
C 110 degree rotation around z-axis
*TR47 0.0 0.0 0.0 110.000 200.000 90 20.000 110.000 90 90 90 0
C 120 degree rotation around z-axis
*TR48 0.0 0.0 0.0 120.000 210.000 90 30.000 120.000 90 90 90 0
C 130 degree rotation around z-axis
*TR49 0.0 0.0 0.0 130.000 220.000 90 40.000 130.000 90 90 90 0
C 140 degree rotation around z-axis
*TR50 0.0 0.0 0.0 140.000 230.000 90 50.000 140.000 90 90 90 0
C 150 degree rotation around z-axis
*TR51 0.0 0.0 0.0 150.000 240.000 90 60.000 150.000 90 90 90 0
C 160 degree rotation around z-axis
*TR52 0.0 0.0 0.0 160.000 250.000 90 70.000 160.000 90 90 90 0
C 170 degree rotation around z-axis
*TR53 0.0 0.0 0.0 170.000 260.000 90 80.000 170.000 90 90 90 0
C 180 degree rotation around z-axis
*TR54 0.0 0.0 0.0 180.000 270.000 90 90.000 180.000 90 90 90 0
C 190 degree rotation around z-axis
*TR55 0.0 0.0 0.0 190.000 280.000 90 100.000 190.000 90 90 90 0
C 200 degree rotation around z-axis
```

```
*TR56 0.0 0.0 0.0 200.000 290.000 90 110.000 200.000 90 90 90 0
C 210 degree rotation around z-axis
*TR57 0.0 0.0 0.0 210.000 300.000 90 120.000 210.000 90 90 90 0
C 220 degree rotation around z-axis
*TR58 0.0 0.0 0.0 220.000 310.000 90 130.000 220.000 90 90 90 0
C 230 degree rotation around z-axis
*TR59 0.0 0.0 0.0 230.000 320.000 90 140.000 230.000 90 90 90 0
C 240 degree rotation around z-axis
*TR60 0.0 0.0 0.0 240.000 330.000 90 150.000 240.000 90 90 90 0
C 250 degree rotation around z-axis
*TR61 0.0 0.0 0.0 250.000 340.000 90 160.000 250.000 90 90 90 0
C 260 degree rotation around z-axis
*TR62 0.0 0.0 0.0 260.000 350.000 90 170.000 260.000 90 90 90 0
C 270 degree rotation around z-axis
*TR63 0.0 0.0 0.0 270.000 360.000 90 180.000 270.000 90 90 90 0
C 280 degree rotation around z-axis
*TR64 0.0 0.0 0.0 280.000 370.000 90 190.000 280.000 90 90 90 0
C 290 degree rotation around z-axis
*TR65 0.0 0.0 0.0 290.000 380.000 90 200.000 290.000 90 90 90 0
C 300 degree rotation around z-axis
*TR66 0.0 0.0 0.0 300.000 390.000 90 210.000 300.000 90 90 90 0
C 310 degree rotation around z-axis
*TR67 0.0 0.0 0.0 310.000 400.000 90 220.000 310.000 90 90 90 0
C 320 degree rotation around z-axis
*TR68 0.0 0.0 0.0 320.000 410.000 90 230.000 320.000 90 90 90 0
C 330 degree rotation around z-axis
*TR69 0.0 0.0 0.0 330.000 420.000 90 240.000 330.000 90 90 90 0
C 340 degree rotation around z-axis
*TR70 0.0 0.0 0.0 340.000 430.000 90 250.000 340.000 90 90 90 0
C 350 degree rotation around z-axis
*TR71 0.0 0.0 0.0 350.000 440.000 90 260.000 350.000 90 90 90 0
C 225 degree rotation around z-axis
*TR72 0.0 0.0 0.0 225.000 315.000 90 135.000 225.000 90 90 90 0
C 202.5 degree rotation around z-axis
*TR73 0.0 0.0 0.0 202.500 292.500 90 112.500 202.500 90 90 90 0
C 247.5 degree rotation around z-axis
*TR74 0.0 0.0 0.0 247.500 337.500 90 157.500 247.500 90 90 90 0
C 292.5 degree rotation around z-axis
*TR75 0.0 0.0 0.0 292.500 382.500 90 202.500 292.500 90 90 90 0
C 337.5 degree rotation around z-axis
*TR76 0.0 0.0 0.0 337.500 427.500 90 247.500 337.500 90 90 90 0
C 39.0 degree rotation around z-axis - translated to vent A
*TR77 99.9525 76.9910 0.0 39.000 129.000 90 -51.000 39.000 90 90 90 0
C 39.0 degree rotation around z-axis - translated to vent B
*TR78 74.5007 98.2020 0.0 39.000 129.000 90 -51.000 39.000 90 90 90 0
C 63.1 degree rotation around z-axis
*TR79 0.0 0.0 0.0 -63.096 26.904 90 -153.096 -63.096 90 90 90 0
C 43 degree rotation around z-axis
*TR80 0.0 0.0 0.0 -47 43 90 -137 -47 90 90 90 0
C
C Mesh Tally - 4 - XYZ
C
FMESH4:p geom=rec origin = 101.6 45.228 -16.24
      imesh 120.65 137.16 138.16
      iints 7 6 1
      jmesh 46.228 72.39 73.39 83.5025 84.5025
      jints 1 9 1 1 1
      kmesh -15.24 15.24 16.24
      kints 1 10 1
      out = jk
fm4 3.7000E+01
C
C Mesh Tally - 14 - XYZ
C
FMESH14:p geom=rec origin = 45.482 95.8756 -16.24
      imesh 46.482 77.216 78.216
      iints 1 11 1
      jmesh 132.833
      jints 13
      kmesh -15.24 15.24 16.24
      kints 1 10 1
      out = jk
fm14 3.7000E+01
C
C Mesh Tally - 24 - XYZ
C
FMESH24:p geom=rec origin = 120.4387 -52.8179 -16.24
      imesh 121.4387 139.4887 140.4887
      iints 1 1 1
      jmesh -25.4743 -4.4146 18.6565
      jints 8 1 8
      kmesh -15.24 15.24 16.24
      kints 1 10 1
      out = jk
      tr = 79
fm24 3.7000E+01
C
C Mesh Tally - 34 - XYZ
C
FMESH34:p geom=rec origin =  135.2258 -38.8680 -16.24
      imesh 136.2258
      iints 1
```

```
      jmesh 34.4644
      jints 25
      kmesh -15.24 15.24 16.24
      kints 1 10 1
      out = jk
      tr = 80
fm34 3.7000E+01
C
C Mesh Tally - 44 - XYZ
C
FMESH44:p geom=rec origin =  -46.482 109.5375 -15.24
      imesh 46.482
      iints 31
      jmesh 110.5375 120.65
      jints 1 11
      kmesh 0.000
      kints 5
      out = ik
fm44 3.7000E+01
C
C Mesh Tally - 54 - RZT
C
FMESH54:p geom=cyl origin =  0.0 0.0 -1.0
      axs = 0 0 1
      vec = 1 0 0
      imesh 120.65 121.65
      iints 1 1 1 1
      jmesh 16.25
      jints 10
      kmesh =  0.1871 0.3129 1.0
      kints =   1 32 1
      out = jk
fm54 3.7000E+01
C
C DXTRAN SPHERE
C
dxt:p 60.0 118.0 3.5 20.0 24.0
DD 0.1 1000
```

6. Criticality Evaluation

6.1 Discussion and Results

6.1.1 MAGNASTOR System Criticality Evaluation

MAGNASTOR consists of a TSC (Transportable Storage Canister), a transfer cask, and a concrete cask. The system is designed to safely store up to 37 undamaged PWR fuel assemblies in the 37 PWR basket assembly or up to 87 undamaged BWR fuel assemblies in the 87 BWR basket assembly. 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 4 DFC locations. DFCs may be placed in up to four of the DFC locations. Each DFC may contain an undamaged PWR fuel assembly, a damaged PWR fuel assembly, or PWR fuel debris equivalent to one PWR fuel assembly. Undamaged PWR fuel assemblies may be placed directly in the DFC locations of a DF Basket Assembly.

The TSC is comprised of a stainless steel canister and a basket within which fuel is loaded. The PWR and BWR system each includes two TSC lengths to store fuel assemblies without the requirement of spacers. Spacers may be employed to simplify loading or unloading operations. The TSC is loaded into the concrete cask for storage. A transfer cask is used for handling the TSC during loading of spent fuel. Fuel is loaded into the TSC contained within the transfer cask underwater in the spent fuel pool. Once loaded with fuel, 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. Multiple-size concrete and transfer casks accommodate all of the PWR and BWR TSCs. Differences between the cask types (i.e. CC1 through CC4 for the concrete casks and MTC1, MTC2, and PMTC for the transfer casks) will not significantly affect criticality evaluations.

Under normal conditions, such as loading in a spent fuel pool, moderator (water) is present in the TSC during the initial stages of fuel 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. Cask accident conditions are bounded by inclusion in the analysis of the most reactive mechanical basket configuration as well as moderator intrusion into the fuel cladding. The PWR TSC is evaluated at minimum soluble boron levels during flooded conditions.

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.

PWR system criticality control is achieved through a combination of neutron absorber sheets on the interior faces of the fuel tubes/developed cells and soluble boron. BWR system criticality control relies solely on the absorber sheets. Individual fuel assemblies are held in place by the fuel tubes, by developed cells formed from fuel tubes, or by a combination of fuel tubes and side or corner weldments. The neutron absorber modeled is a borated aluminum sheet. Any material meeting the physical dimension requirements specified on the License Drawings and the effective ^{10}B areal density specified in Table 6.1.1-5 will produce similar reactivity results. A combination of steel cover sheets and weld posts holds the neutron absorber sheets in place. The PWR undamaged fuel basket design includes 21 fuel tubes forming 37 fuel-assembly-sized openings while the PWR damaged fuel basket design includes 17 fuel tubes and four corner weldments forming 37 openings. A sketch of a cross-section of the damaged fuel basket is shown in figure 6.1.1-2. The BWR basket contains 45 fuel tubes forming 89 fuel-assembly-sized openings.

The combination of 45 BWR fuel tubes with four corner and four side weldments form 89 fuel-assembly-sized openings; however, two openings are below the vent and drain ports and are not loaded. For simplicity and cask symmetry, all 89 slots are modeled as filled with fuel.

An optional "82-assembly" configuration of the BWR basket is evaluated, where five center openings in an "X" pattern are left unoccupied (the basket model fills the openings below the port cover and, therefore, contains 84 assemblies). See Figure 6.1.1-1 for the loadable basket locations in the 82-assembly basket configuration.

Initial criticality evaluations rely on neutron absorber sheet effective ^{10}B loadings of 0.036 g/cm^2 and 0.027 g/cm^2 for the PWR and BWR system, respectively. The system is also evaluated for effective ^{10}B loading of 0.030 and 0.027 g/cm^2 for PWR baskets and 0.0225 and 0.020 g/cm^2 for BWR baskets. Depending on the PWR payload, variable soluble boron concentrations in the pool water are necessary to achieve sufficient neutron absorber content in the system. The soluble boron absorbs thermal neutrons inside the assembly, in addition to the neutrons removed by the absorber sheets on the tubes.

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}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.

6.1.1.1 Undamaged Fuel Criticality Results

The maximum multiplication factors ($k_{eff}+2\sigma$) 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.

Cask Body	Gap Condition	Operating Condition	Water Density (g/cc) Interior	Water Density (g/cc) Exterior	PWR $k_{eff} + 2\sigma$	BWR $k_{eff} + 2\sigma$
Transfer	Dry	Normal	0.9982	0.0001	0.93183	0.92900
Transfer	Wet	Normal	0.9982	0.0001	0.93712	0.93679
Transfer	Dry	Normal	0.9982	0.9982	0.92975	0.92839
Transfer	Wet	Normal	0.9982	0.9982	0.93615	0.93674
Storage	Dry	Normal	0.0001	0.0001	0.48145	0.43685
Storage	Dry	Accident	0.0001	0.9982	0.47104	0.42991

Analysis of simultaneous moderator density variation inside and outside either the transfer or concrete cask shows a monotonic decrease in reactivity with decreasing moderator density. For the BWR system, there is a statistically significant increase in reactivity when moving from void to full moderator density. In the PWR system, reactivity increases as moderator density rises from void conditions, but there is no significant reactivity difference at water densities above 0.9 g/cm^3. The use of soluble boron in PWR systems, specified in parts per million of moderator, flattens out the reactivity curve by increasing absorber quantity in conjunction with increasing moderator. The full moderator density TSC interior condition bounds any off-normal or accident condition. Analysis of moderator intrusion into the concrete cask heat transfer annulus with the dry TSC shows a slight decrease in reactivity from the completely dry condition.

6.1.1.2 Damaged PWR Fuel Criticality Results

The PWR system is designed to safely store up to 37 PWR fuel assemblies of which up to 4 may be classified as damaged and be placed into damaged fuel cans (DFCs) in the four corner basket locations. The DFC provides a screened container to prevent gross fissile material release into the TSC cavity from failed fuel rod cladding. The results of the analyses are presented in detail in Section 6.7.8 and are summarized as follows. All results are below the USL of 0.9376.

Cask Body	Gap Condition	Operating Condition	Water Density (g/cc)		PWR
			Interior	Exterior	$k_{eff} + 2\sigma$
Transfer	Wet	Normal	0.9982	N/A[a]	0.93757
Storage	Dry	Normal	0.0001	0.0001	0.49142
Storage	Dry	Accident	0.0001	0.9982	0.48211

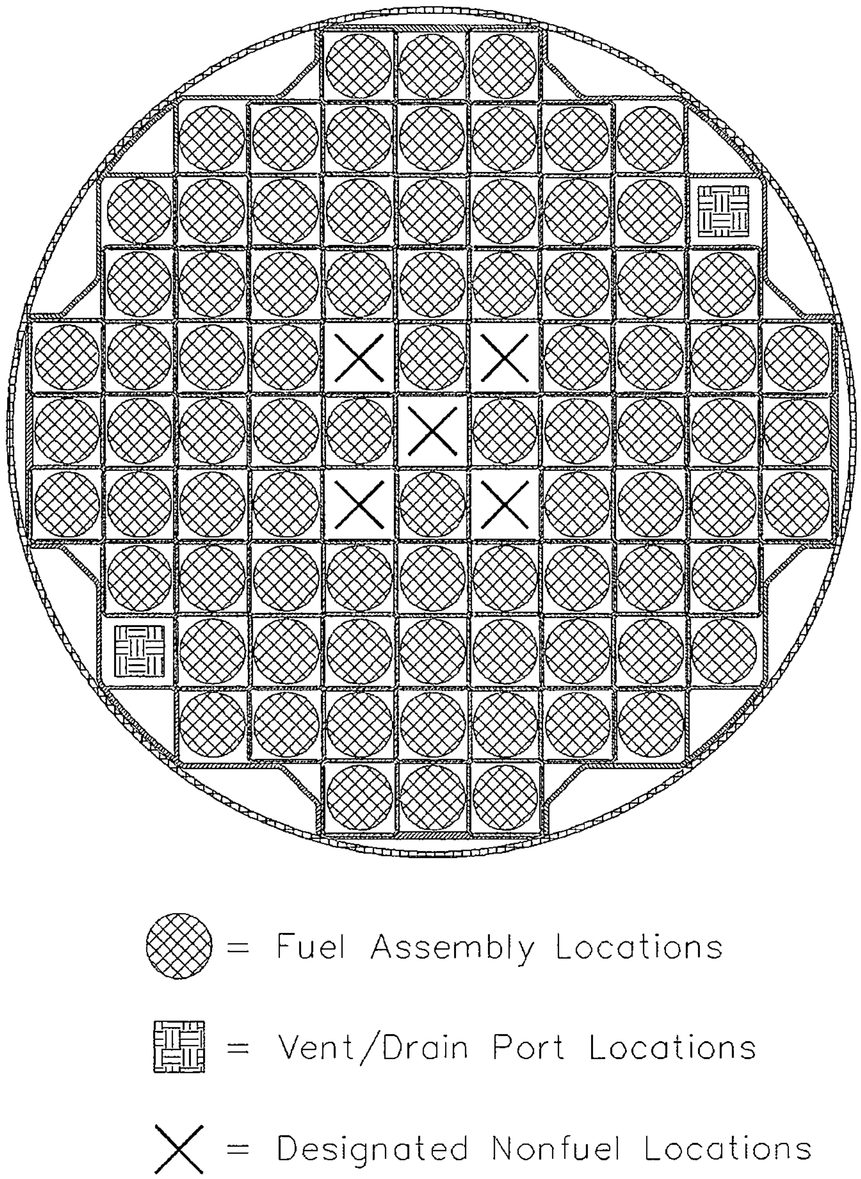
Three damaged fuel configurations are evaluated. Damaged fuel includes fuel debris. In the first configuration, undamaged fuel is loaded into a DFC to demonstrate the effect of the additional stainless steel from the DFC and the DFC corner weldments. In the second configuration, damaged fuel is postulated to lose its cladding and the array is modeled at an increased pitch. In the third configuration, mixtures of fuel and water simulate small fuel rubble inside the DFC.

Three moderator configurations are evaluated. Moderator density studies are performed on the preferentially flooded DFC, partially flooded cask, and mixture moderator density. In the preferentially flooded DFC scenario, the DFC is assumed to vary in moderator density with a wet and dry canister. A partial draindown of the TSC to the top of the active fuel is referred to as partial flooding. A study on the mixture moderator density is performed to ensure that the homogenized mixture remains undermoderated.

For each of the fuel types, with and without nonfuel inserts in the active fuel region of the undamaged assemblies, several combinations of minimum soluble boron and maximum initial enrichments are determined. The allowable loadings are documented in Table 6.1.1-6.

[a] Exterior moderator has been demonstrated in Section 6.7.3 to not affect system reactivity for a fully flooded TSC.

Figure 6.1.1-1 82-Assembly BWR Basket Configuration



9. Operating Procedures

Chapter 9
Operating Procedures

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9.1 Loading MAGNASTOR Using Standard MAGNASTOR Transfer Cask (MTC)

MAGNASTOR is used to load, transfer, and store spent fuel. The three principal components of the system are: the transportable storage canister (TSC), the MAGNASTOR transfer cask (MTC), and the concrete cask. The MTC contains and supports the TSC during fuel loading, lid welding and closure operations. The MTC, with the transfer adapter, is also used to move the 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 TSC (properly receipt inspected and accepted) is located in the MTC cavity
- an accepted concrete cask is available to receive the TSC when loading and preparation activities are complete

The TSC is filled with clean or pool water and the transfer cask containing the TSC is lowered into the spent fuel pool for fuel assembly loading and verification. The user must identify and select the fuel assemblies to be loaded and ensure that all loaded fuel assemblies comply with the Approved Content provisions of the CoC. Up to four damaged fuel cans (DFCs) containing damaged or undamaged PWR fuel assemblies or PWR fuel debris may be loaded in a TSC with a DF Basket Assembly, as authorized in the Approved Contents provisions of the CoC. Undamaged fuel assemblies may be loaded directly (i.e., without a DFC) into DFC locations in the DF Basket Assembly.

Following fuel loading, the closure lid is installed and the transfer cask containing the loaded TSC is lifted from the bottom of the spent fuel pool. The TSC is partially drained and the closure lid is welded to the TSC shell. The closure lid-to-shell weld is visual and progressive dye penetrant examined. The cavity is refilled and the TSC is subjected to a hydrostatic pressure test with no loss in pressure or observable leakage allowed. Following hydrostatic pressure test acceptance, the closure ring, which provides the redundant confinement closure barrier, is installed, welded and inspected. The TSC cavity water is then drained and volumetrically measured. 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 helium backfill.

The residual moisture in the TSC is then removed by vacuum drying techniques and the TSC dryness is verified. The TSC is then evacuated to ≤ 3 torr and backfilled with a known quantity of pressurized high-purity helium to provide an inert atmosphere and to establish the convective heat transfer flow for the safe long-term storage of the spent fuel 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 TSC closure lid, shell, closure ring and port covers complete the assembly of the confinement boundary and redundant closure.

The concrete cask is positioned for the transfer of the TSC and the transfer adapter is installed. The transfer cask containing the loaded TSC is positioned on the transfer adapter on the top of the concrete cask. The TSC is lowered into the concrete cask and the transfer cask and transfer adapter are removed. The concrete lid assembly 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.

9.1.1 Loading and Closing the TSC Using Standard MTC

This section describes the sequence of operations to load and close the TSC in preparation for transferring the TSC to the concrete cask. The empty TSC is assumed to be positioned inside the transfer cask located at the designated workstation.

1. Visually inspect the TSC and basket internals for foreign materials or debris.

   Note: When BWR enrichments require the use of the 82-assembly basket configuration, verify the basket design blocks the five center fuel tube cell locations to assure that assemblies cannot physically be loaded in the five designated nonfuel locations.
2. Visually inspect the top of the TSC shell and closure lid weld preps.
3. Inflate the upper MTC annulus seal with air or nitrogen gas. Disconnect the gas supply.

   Note: Either the top or bottom upper annulus seal is used based on the length of the TSC to be loaded.

   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 and approved site-specific TSC cooling methods to maintain TSC and fuel clad temperatures within FSAR limits.

   Note: Optional TSC annulus shims may be utilized at the discretion of the user to assist in centering the TSC in the MTC annulus.
4. Verify the three 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 TSC with clean or pool water. For PWR spent fuel contents, the soluble boron concentration in the TSC shall be verified and monitored in accordance with the LCO 3.2.1.
7. Attach the lift yoke to a crane suitable for handling the loaded TSC, MTC and yoke. Position the lift yoke over the MTC 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 TSC and move it to the spent fuel pool 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 pool water in-leakage.
10. Lower the MTC to the pool surface and turn on the clean water supply lines to the lower annulus fill ports to fill the MTC/TSC annulus.

    Note: Sequence on connection and filling/draining MTC/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 spent fuel pool and spraying the components leaving the pool 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 pool water in-leakage.
13. Lower the transfer cask to the bottom of the pool 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 spent fuel pool while spraying the yoke and crane cables with clean water.
15. Load the previously selected fuel assemblies into the TSC basket.

    Note: The fuel assemblies shall be selected in compliance with the requirements of the approved contents specified in Appendix B of the Technical Specifications and the boron concentration limits of the Technical Specifications, including limitations on fuel assembly positions within the basket. Assembly selection and placement within the basket shall be independently verified.

    Note: Up to four DFCs containing authorized PWR contents may be loaded in a TSC with a DF Basket Assembly. A DFC spacer is required to be positioned in the Designated

DF Basket Assembly corner locations for the shorter length DFCs. Independently, visually verify proper placement and correct orientation of each required DFC spacer.

Note: At the option of the user, install fuel assembly spacers for the axial positioning of the PWR fuel assembly types to be loaded. Verify spacer identification and install fuel spacers in each intended fuel loading location based on the fuel spacer plan prepared, which is based on the fuel assembly inventory and nonfuel hardware to be loaded. Independently, visually verify proper placement and correct orientation of each required fuel spacer.

16. Visually verify the fuel assembly (and DFC, as applicable) identifications to confirm the serial numbers match the approved fuel-loading pattern.
17. Install three swivel hoist rings hand tight in the three closure lid lifting holes or in three of the six 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.
18. Raise the closure lid. Adjust closure lid rigging to level the closure lid.
19. Move the closure lid over the spent fuel pool and align the lift yoke (if used) to the MTC trunnions and align the closure lid to the match marks of the TSC.
20. Lower the closure lid until it enters the TSC and seats in the top of the TSC. Visually verify closure lid alignment using the match marks (± ½ inch).

    Caution: Following closure lid installation, there is a thermal time limit of 18 hours to begin the Annulus Circulating Water System (ACWS), R-ACWS or approved alternative annulus flow system operation, and to begin temperature measurement of the MTC annulus outlet flow to verify MTC outlet temperature is maintained < 113°F. If ACWS or R-ACWS flow cannot be initiated in the time allowed, return the MTC to the spent fuel pool and remove the closure lid to allow cooling by the spent fuel pool water.

    Note: R-ACWS requires monitoring of inlet cooling water flow rates and maximum inlet water temperature, per Chapter 4, instead of monitoring outlet temperature.
21. 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.
22. Raise the MTC until its top clears the pool 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 pool.

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

    Note: At the option of the user, the TSC closure operations may be performed with the MTC partially submerged in the spent fuel pool, cask loading pit, or an equivalent structure. This operational alternative provides additional shielding for the cask operators.
26. 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.
27. 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.
28. Install the Annulus Circulating Water cooling System (ACWS), R-ACWS or alternative annulus flush/cooling system, to the lower and upper annulus fill lines. Unused fill lines are to be closed or capped.

    Note: For TSCs prepared with the MTC partially submerged on an in-pool shelf, partially drained cask loading pit or equivalent partial submerged condition, or in a ACWS catch basin, alternative ACWS operations (e.g., reverse flow ACWS [R-ACWS]) may be utilized to maintain TSC and fuel clad temperatures within normal operational limits.

    Note: ACWS or R-ACWS operation allows the vacuum drying and TSC transfer times in LCO 3.1.1 to be utilized.
29. Initiate clean water flow into the MTC lower fill lines with annulus water discharging through the upper fill lines. Ensure water flow is maintained to keep the outlet water temperature ≤ 113°F.

    Note: Analysis of alternative R-ACWS operations are detailed in Chapter 4, demonstrating that the fuel clad and TSC temperatures are bounded by standard ACWS cooling operations for the following reverse flow limits:

    - A maximum inlet water temperature of ≤ 100°F, which requires a minimum inlet flow rate of ≥ 60 GPM

- A minimum inlet flow rate of ≥ 40 GPM, which limits the maximum inlet water temperature of ≤ 70°F

Note: With the ACWS, R-ACWS, or site-approved alternative ACWS, operating, there is no time limit through initiation of the draining of the TSC. However, if the ACWS, R-ACWS, or site-approved alternative ACWS is not utilized, or becomes nonoperational, cavity water temperature measurements shall start within 19 hours of installation of the closure lid and repeated every 2 hours. If TSC preparation operations through draining are not completed prior to the cavity water temperature reaching 200°F, ACWS or R-ACWS cooling shall be re-established, or a cooling water flow will be established through the cavity to lower the water temperature to < 130°F prior to the start of draining, or the TSC shall be returned to the spent fuel pool within 2 hours and maintained with the TSC submerged for a minimum cooling period of 24 hours with the seals deflated, or until the ACWS operation is initiated.

30. Detorque and remove the lifting hoist rings from the closure lid.
31. Using a portable suction pump, remove any standing water from the closure lid weld groove, and the vent and drain ports.
32. Decontaminate the top of the MTC and TSC closure lid to allow installation of the welding equipment. Decontaminate external surfaces of the MTC and remove the bottom protective cover, if installed.
33. 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.
34. 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.
35. Install a venting device to the vent port quick-disconnect to prevent combustible gas or pressure buildup below the closure lid.
36. Verify that the top of the closure lid is level (flush) with, or slightly above, the top of the TSC shell.
37. At the discretion of the user, establish foreign material exclusion controls to prevent objects from being dropped into the annulus or TSC.
38. 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.
39. Connect a suction pump to the drain port quick-disconnect and verify venting through the vent port quick-disconnect.

40. Operate the suction pump to remove approximately 70 gallons of water from the TSC. Disconnect the suction pump.

    Note: The radiation level will increase as water is removed from the TSC cavity, as shielding material is being removed.

    Note: Fuel rods shall not be exposed to air during the 70-gallon pump-down.

41. Attach a hydrogen detector to the vent line. Ensure that the vent line does not interfere with the operation of the weld machine.

42. Sample the gas volume below the closure lid and observe hydrogen detector for H_2 concentration prior to commencing closure lid welding operations. Monitor H_2 concentration in the TSC until the root pass of the closure lid-to-shell weld is completed.

    Note: If H_2 concentration exceeds 2.4% prior to or during root pass welding operations, immediately stop welding operations. Evacuate the TSC gas volume or purge the gas volume with helium. Verify H_2 levels are <2.4% prior to restarting welding operations.

    Note: In place of continuous H_2 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_2 monitoring (upon termination of gas purging and prior to re-starting welding operations).

43. Install shims into the closure lid-to-TSC shell gap, as necessary, to establish a uniform gap for welding. Tack weld the closure lid and shims, as required.

44. Operate the welding equipment to complete the closure lid-to-TSC shell root pass weld in accordance with the approved weld procedure.

45. Perform visual and liquid penetrant (PT) examinations of the root pass and record the results.

46. Remove the H_2 detector from the vent line while ensuring the TSC cavity vent line remains installed and allows venting of gases from the cavity.

47. 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.

48. Complete welding through the completion of the final pass of the closure lid weld, perform final visual and PT examinations, and record the results.

49. Perform the hydrostatic test of the TSC as follows:

    a. Connect a drain line to the vent port and a pressure test system to the drain port.

    b. Refill the TSC with clean water (borated water for PWR) until water is observed flowing from the vent port drain line. Close the vent line isolation valve. Ensure continuing compliance with the boron concentration requirements of LCO 3.2.1.

    c. Pressurize the TSC to 150 (+10, -0) psig and isolate the TSC.

d. Maintain the TSC pressure for a minimum 10-minute hold period. At the end of the 10-minute hold period, visually examine the closure lid-to-TSC shell weld for leakage of water, while maintaining the test pressure. The test pressure shall be maintained until the completion of the visual inspection of the closure lid-to-TSC shell weld.
e. The hydrostatic test is acceptable if there is no visible water leakage from the closure lid-to-TSC shell weld based on a visual examination of the weld after a minimum 10-minute hold period, while maintaining the test pressure.
f. Vent the TSC cavity and remove the pressure test system from the drain port and the drain line from the vent line. Reinstall a vent line to the vent port to prevent pressurization of the TSC.

50. Install and tack the closure ring in position in the closure lid-to-TSC shell weld groove.

    Note: Depending on the operational loading procedure and intended minimum helium backfill time (per LCO 3.1.1) to be utilized, the closure ring installation, welding and NDE sequence can be performed following final helium mass backfill (i.e., after Step 60).

51. Weld the closure ring to the 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 and in order to facilitate the Maximum Transfer Time of Technical Specification LCO 3.1.1 the installation, welding, and NDE of the closure ring may be performed immediately after helium backfill (Step 61) or after completion of the welding, testing, and NDE of the vent and drain inner or outer port covers (Step 63 or 66).

52. Remove the water from the TSC using one of the following methods: drain down using a suction pump with a pressurized helium cover gas; or blow down using pressurized helium gas. Ensure the totalizer in the drain line is reset to zero prior to the start of draining.

    Note: Fuel rods shall not be exposed to air during canister draining operations. Record the start time of TSC draining operations. The maximum drying times of LCO 3.1.1 are based on the total time from start of the draining through completion of helium backfilling of the TSC cavity.

53. Connect a drain line with or without suction pump to the drain port connector.
54. Connect a regulated helium gas supply to the vent port connector.
55. Open gas supply valve and start suction pump, if used, and drain water from the TSC until water ceases to flow out of the drain line. Close gas supply valve and stop suction pump.
56. Record the time at the completion of the draining of the TSC. Record the volume of water drained from the TSC (V_{TSC}) as measured by the totalizer.

At the option of the user, disconnect suction pump, close discharge line isolation valve, and open helium gas supply line. Pressurize TSC to approximately 25 psig and open discharge line isolation valve to blow down the TSC. Repeat blow down operations until no significant water flows out of the drain line. Note that time used for system draining and blow down is considered part of the vacuum drying time.

57. Disconnect the drain line and gas supply line from the drain and vent port quick-disconnects.
58. Dry the TSC cavity using vacuum drying methods as follows.

    Note: Ensure heat load dependent vacuum drying time limits are not exceeded so that fuel cladding temperatures are maintained below 752°F. Vacuum drying cycle time limits in LCO 3.1.1 are based on utilizing the ACWS, reverse flow ACWS or equivalent annulus cooling/flush system.

    Note: At the option of the user, the drain and/or vent port quick-disconnects can be removed and replaced temporarily with suitable straight-through fittings to increase flow area cross-section and to reduce resistance to gas flow. The quick-disconnect fittings must be reinstalled and torqued prior to final helium backfill.

    a. Connect the vacuum drying system to the vent and drain port openings.
    b. Operate the vacuum pump until a vapor pressure of ≤ 10 torr is achieved in the TSC. The time durations of the first vacuum drying cycle shall be in accordance with the time limits of LCO 3.1.1.
    c. Isolate the vacuum pump from the TSC and turn off the vacuum pump. Observe the vacuum gauge connected to the TSC for an increase in pressure for a minimum period of 10 minutes. If the TSC pressure is ≤ 10 torr at the end of 10 minutes, the TSC is dry of free water in accordance with LCO 3.1.1.

    Note: [redacted] After the cooling period, subsequent drying cycle operations can continue for the times indicated in LCO 3.1.1. Drying cycles and cooling periods may be continued until the TSC cavity passes the dryness verification per LCO 3.1.1. For fuel burnup greater than 45 GWd/MTU, the total number of cooling cycles is limited to ten, with cladding temperature variations more than 65 °C (149 °F).

59. Upon satisfactory completion of the dryness verification, evacuate the TSC cavity to a pressure of ≤ 3 torr. Isolate and turn off the vacuum pump, and backfill and pressurize the TSC cavity with 99.995% (minimum) pure helium as follows:
    a. Determine the free volume of the TSC (V_{TSC}) per Step 56.

b. Multiply the V_{TSC} free volume by the helium loading value per unit volume (L_{helium}) to determine required helium mass (M_{helium}) to be backfilled into the cavity.
c. Set the helium bottle regulator to 90 (+5,-0) psig.
d. Connect the helium backfill system to the vent port and reset the mass-flow meter to zero.
e. Slowly open the helium supply valve and backfill the TSC with the required helium mass (M_{helium}) in accordance with LCO 3.1.1.

60. Disconnect the vacuum drying helium backfill system from the vent and drain openings. Note the time the helium backfill is completed.

    Note: At the option of the user, Steps 50 and 51 can alternatively be performed at this point or immediately following Steps 63 or 67. The user to establish appropriate radiological controls to maintain operator dose ALARA.

61. Install and weld the inner port cover on the drain port opening.
62. Install and weld the inner port cover on the vent port opening.
63. Perform visual and PT examinations of the final surface of the port cover welds and record the results.
64. Perform helium leak test on each of the inner port cover welds to verify the absence of helium leakage past the inner port cover welds.
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. The ACWS, R-ACWS or equivalent annulus cooling/flush system will be utilized throughout the TSC closing operations until the helium backfill time is satisfied (see LCO 3.1.1). Drain the 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. Note the time the MTC/TSC annulus cooling flow is terminated. Remove the temporary plugs or ensure that a minimum of four annulus fill lines are open in the base of the transfer cask.

    Note: The time duration of the sequence of operations from stopping the MTC/TSC annulus cooling, or completing the helium backfill if the ACWS or R-ACWS is not used, through completion of TSC transfer into the concrete cask shall not exceed the transfer time limits in LCO 3.1.1. If the TSC transfer to the concrete cask cannot be completed in the defined time period, the transfer operation will be suspended and the TSC shall be cooled by the ACWS, R-ACWS or site-approved alternative cooling system for a

minimum of 30 hours after steaming ceases prior to restarting TSC transfer operations. The second, and subsequent, minimum helium backfill time and maximum TSC transfer time shall be limited to the heat load specific cooling and specific transfer times in the maximum TSC transfer Tables 1.B and 1.D of LCO 3.1.1.

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 six swivel hoist rings into the six threaded holes in the closure lid if TSC transfer is to be performed by two sets of redundant slings. Torque the hoist rings to the manufacturer's recommended value.

    Note: Utilize high temperature-resistant slings (≤ 350°F).

    Note: Alternative site-specific TSC lifting systems and equipment may be used for lowering and lifting the TSC in the MTC. The lifting system design must comply with the user's heavy load program and the applicable requirements of ANSI N14.6, NUREG-0612, and/or ASME/ANSI B30.9, as appropriate.
71. Complete final decontamination of the MTC exterior surfaces. Final TSC contamination surveys may be performed after TSC transfer following Step 21 in Section 9.1.2 when TSC surfaces are more accessible.
72. Proceed to Section 9.1.2.

9.1.2 Transferring the TSC to the Concrete Cask Using a Standard MTC

This section describes the sequence of operations required to complete the transfer of a loaded 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 lid assembly removed in the designated 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 in a truck/rail bay 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; install supplemental shielding in four outlets.

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 lift yoke 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°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. Raise the MTC and move it into position over the empty concrete cask.
9. 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.
10. Following set down, remove the lock pins from the shield door lock tabs.
11. Install a stabilization system for the MTC, if required by the facility heavy load handling or seismic analysis programs.
12. Disengage the lift yoke from the transfer cask trunnions and move the lift yoke from the area.
13. As appropriate to the TSC lifting system being used, move the lifting system to a position above the MTC. If redundant sling sets are being used, connect the sling sets to the crane hook.
14. Using the TSC lifting system, lift the TSC slightly (approximately ½-1 inch) to remove the TSC weight from the shield doors.

    Note: The lifting system operator must take care to ensure that the TSC is not lifted such that the retaining blocks (MTC1/MTC2) or the retaining ring (MTC2) is engaged by the top of the TSC.
15. Open the MTC shield doors with the hydraulic system to provide access to the concrete cask cavity.
16. Using the cask handling crane in slow speed (or other approved site-specific handling system), slowly lower the TSC into the concrete cask cavity until the TSC is seated on the pedestal.

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

Note: The completion of the transfer of the TSC to the concrete cask (i.e., the top of the TSC is in the concrete cask cavity) completes the TSC transfer evolution time from Step 69 in Section 9.1.1.

17. When the TSC is seated, disconnect the slings (or other handling system) from the lifting system, and lower the sling sets through the MTC until they rest on top of the TSC.
18. Retrieve the lift yoke and engage the lift yoke to the MTC trunnions.
19. Remove the seismic/heavy load restraints from the MTC, if installed.
20. Close the shield doors using the hydraulic system and reinstall the lock pins into the shield door lock tabs.
21. Lift the MTC from the top of the concrete cask and return it to the cask preparation area for next fuel loading sequence or to its designated storage location.
22. Disconnect hydraulic supply system from the transfer adapter hydraulic cylinders.
23. Remove redundant sling sets, swivel hoist rings, or other lifting system components from the top of the TSC, if installed.
24. Verify all equipment and tools have been removed from the top of the TSC and transfer adapter.
25. 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. Remove supplemental shielding from outlets.

    Note: If the optional low profile concrete cask is used, proceed to Step 26. If the standard concrete cask is provided, proceed to Step 40.
26. Install three swivel hoist rings and the three-legged sling set on the concrete cask shield ring.
27. Using the crane, lift the shield ring and place it into position inside of the concrete cask top flange.
28. Remove the three-legged sling and swivel hoist rings.
29. Using the designated transport equipment, move the loaded concrete cask out of the low clearance work area or truck/rail bay.
30. Install the three swivel hoist rings into the three threaded holes and attach the three-legged sling set to the shield ring.
31. Using an external or mobile crane, lift and remove the shield ring. Place the shield ring in position for the next loading sequence or return it to its designated storage location.
32. Install four swivel hoist rings in the threaded holes of the concrete cask extension using the manufacturer-specified torque.
33. Install the four-legged sling set and attach to the crane hook.

    Note: A mobile crane of sufficient capacity may be required for concrete cask extension and lid installations performed outside the building.

34. 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 shine from the TSC.

35. Lift the concrete cask extension and move it into position over the concrete cask, ensuring alignment of the two anchor cavities with their mating lift anchor embedment.
36. Lower the concrete cask extension into position and remove the sling set from the crane hook.
37. Remove the four swivel hoist rings and cables from the concrete cask extension.

    Note: If concrete cask transport is to be performed by a vertical cask transporter, proceed to Step 38. If transport is to be performed using air pads in conjunction with a flat-bed transporter, proceed to Step 40.

38. Install the lift lugs into the anchor cavities of the concrete cask extension, or directly on top of the lifting embedment for the standard concrete cask, if applicable to the concrete cask design utilized.
39. Install the lift lug bolts through each 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.
40. Install three swivel hoist rings into the concrete cask lid and attach the three-legged sling set. Attach the lifting sling set to the crane hook.
41. At the option of the user, install the weather seal on the concrete cask lid flange. Lift the concrete cask lid and place it in position on the top of the flange.
42. Remove the sling set and swivel hoist rings and install the concrete cask lid bolts. Torque to the value specified in Table 9.1-2.
43. Move the loaded concrete cask into position for access to the site-specific transport equipment.
44. Proceed to Section 9.1.3.

9.1.3 Transporting and Placing the Loaded Concrete Cask

The section describes the general procedures for moving a loaded concrete cask to the ISFSI pad using either a vertical cask transporter (Step 1 through Step 9) or a flat-bed transport vehicle (Steps 10 through 17). Steps following Step 17 are performed for all concrete casks.

Vertical Cask Transporter

1. Using the vertical cask transporter lift fixture or device, engage the two concrete cask lifting lugs.
2. 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.

3. 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.

   Note: The spacing between adjacent loaded concrete casks must be at least 15 feet minimum.
4. Using the vertical transporter, slowly lower the concrete cask into position.
5. Disengage the vertical transporter lift connections from the two concrete cask lifting lugs. Move the cask transporter from the area.
6. Detorque and remove the lift lug bolts from each lifting lug, if the lugs are to be reused.

   Note: At the option of the user, the lift lugs may be left installed during storage operations.
7. Lift out and remove the concrete cask lift lugs. Store the lift lugs for the next concrete cask movement.
8. Install the lug bolts through the extension base (or through the cover plate for the standard concrete cask) and into the threaded holes. Torque each bolt to the value specified in Table 9.1-2.
9. 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.

Flat-bed Transport Vehicle Loaded with the Closed Concrete Cask

10. Move the transport vehicle with the closed concrete cask to a position adjacent to the ISFSI pad.
11. If required, install a bridging plate to cover the gap between the vehicle and the ISFSI pad.
12. If not already installed, insert four deflated air pads into the four inlets.
13. Attach a restraining device around the concrete cask and connect to a tow vehicle suitable for pushing or pulling the concrete cask off of the transport vehicle.
14. Using an air supply and an air pad controller, inflate the air pads.
15. Verify the ISFSI pad surface in the storage location is free of foreign objects and debris.
16. Using the tow vehicle, move the concrete cask into its position on the storage pad.

    Note: The center-to-center spacing of loaded concrete casks shall be 15 feet minimum.
17. Lower the concrete cask into position by deflating and removing the four air pads.

    Note: Ensure that air pads are not installed longer than eight hours to complete the concrete cask transfer.

All Concrete Casks

18. If optional temperature monitoring is implemented, install the temperature monitoring devices in each of the four outlets of the concrete cask and connect to the site's temperature monitoring system.
19. Install inlet and outlet screens to prevent access by debris and small animals.

    Note: Screens may be installed on the concrete cask prior to TSC loading to minimize operations personnel exposure.
20. Scribe and/or stamp the concrete cask nameplate to indicate the loading date. If not already done, scribe or stamp any other required information.
21. 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.
22. Initiate a daily temperature monitoring program or daily inspection program of the inlet and outlet screens to verify continuing effectiveness of the heat removal system.

Table 9.1-1 Major Auxiliary Equipment

Item	Description
Air Pad Rig Set	A device consisting of four air pads, a controller, and an air supply source that lifts the concrete cask using air supplied at a high volume.
Annulus Fill System	System that supplies clean/filtered spent fuel pool water through the transfer cask/TSC annulus using the lower and upper transfer cask fill lines. The system maintains a positive clean water flow to minimize the exposure of the TSC external surfaces to contaminated spent fuel pool water.
Annulus Circulating Water Cooling System (ACWS) or Reverse Flow ACWS (R-ACWS)	The system provides a circulating or once through water flow through the annulus to maintain the TSC shell temperature during TSC preparation and drying evolutions. The system includes appropriate circulating pump, pressure gauges, and inlet and outlet water thermometer.
Annulus Seals	Inflatable seals provided at the top and bottom of the transfer cask/TSC annulus for use with the annulus fill, ACWS and R-ACWS.
Bottom Protective Cover	Optional plate(s) temporarily attached to the base of the transfer cask to prevent particulate contamination of the transfer cask shield doors and rails.
Canister Upender	Lifting device used to upright a TSC from the horizontal position to a vertical orientation to allow vertical handling.
Cask Transporter	A heavy-haul trailer, a rail car, a vertical cask transporter, or other specially designed equipment used onsite to move the concrete cask. The loaded concrete cask is transported vertically resting on its base (requiring a flat-bed transporter) or it is transported vertically suspended from its lifting lugs (requiring a vertical cask transporter).
Closure Lid Lifting Sling System	Sling system used to install the closure lid into the TSC in the spent fuel pool. At the user's option, the sling system can be suspended from the lift yoke and used to install the lid and engage the yoke with one crane sequence.
Cooldown System (CDS)	Introduces nitrogen, helium, and cooling water to the TSC cavity to cooldown the TSC internals and stored spent fuel to allow the return of the TSC to the spent fuel pool for the unloading of the fuel assemblies. This system would only be required in the highly unlikely event that a loaded TSC had to be unloaded.

Table 9.1-1 Major Auxiliary Equipment (continued)

Drain and Blow Down System (DBS)	System used to pump out and/or blow down the water from the TSC cavity prior to the start of drying operations, and to refill the cavity and hydrostatic test the closure lid weld. The system includes the appropriate suction pump, piping/hoses, flow meter/totalizer, helium cover gas supply, pressure gauges, and valves to connect to the TSC vent and drain port connections to complete the draining and hydrostatic testing of the cavity.
Hydrogen Detection System	System that detects increased concentration of H_2 in the cavity resulting from material reactions during closure lid root pass welding operations and for closure lid weld removal operations.
Helium Mass Spectrometer Leak Detector (MSLD)	A system utilized to perform the helium leakage testing of the inner vent and drain port cover welds.
Lid Retention System	An optional component installed on top of the TSC closure lid to secure the lid during cask handling operations between the spent fuel pool and the workstation used to close the TSC.
Lift Yoke (with Crane Hook Extension, if required)	Device for lifting and moving MAGNASTOR transfer cask by engaging the lifting trunnions.
Loaded TSC Sling System	Redundant sling system (two 3-legged slings) used to transfer a TSC into a concrete cask or a transfer cask and meeting the requirements of ANSI N14.6 and the facility crane. Alternative TSC handling systems that meet site-specific or client requirements and comply with the facility's heavy lift program developed per NUREG-0612 may be utilized.
Lower Inlet Plugs	Lower inlet plugs are used to partially block the lower inlets of the PMTC during in-pool operations to limit potential incursion of spent fuel pool water into the PMTC to TSC annulus during R-ACWS operation in the spent fuel pool. The lower inlet plugs are removed after R-ACWS is terminated to allow establishment of passive convective cooling of the TSC in the PMTC.
Remote/Robotic Welding System	System that completes the closure lid and port cover welds with minimal operator assistance. The system may include video cameras and a recording device to remotely observe the welding activities and to videotape the results of the closure lid PT examinations.
Shield/Seal Insert Ring	A device used to shield and seal the top of the annulus to the TSC in the Passive MAGNASTOR Transfer Cask (PMTC) to facilitate R-ACWS cooling of the TSC during in-pool operations. The shield/seal insert ring is removed following termination of R-ACWS cooling to allow establishment of passive convective cooling of the TSC in the PMTC.

Table 9.1-1 Major Auxiliary Equipment (continued)

Supplemental Weld Shield	Optional steel plate installed on the closure lid to provide additional shielding to the cask operators during TSC welding, preparation, and test activities. The supplemental weld shield may be installed separately or as the base plate for the welding system.
Vacuum Drying and Helium Backfill System	The system used to vaporize and remove residual water, water vapor, and oxidizing gases from the TSC cavity prior to backfilling with helium. The system includes the appropriate vacuum pump(s), vacuum and pressure gauges, helium supply connections and valves, and hoses to connect the system to the vent and drain connections.
Weld Removal System and Port Cover Drill Fixture	Semiautomatic mechanical weld and/or TSC shell cutting system used to remove the closure lid and port cover welds in the unlikely event that a TSC needs to be unloaded. The Port Cover Drill Fixture is used to access the outer and inner vent port covers prior to TSC cavity gas sampling and venting in order to prevent an uncontrolled release of pressurized gas during the vent port cover removal process.
Gas Sampling and Pressure Measurement System	A system connected to the Port Cover Drill Fixture that allows the TSC cavity gas to be sampled and its pressure determined prior to venting of the TSC cavity gas without exposing operations personnel to any high pressure and temperature gas releases.

Table 9.1-2 Threaded Component Torque Values

Threaded Component	Torque Value (ft-lb)
Concrete Cask Lid Bolts	40 ± 5
Concrete Cask Body Extension	100 ± 10
Closure Lid Lifting Hoist Rings • Lid Handling Only • Loaded TSC Handling	 100, + 50, -0[1] 100, + 50, -0[1]
Drain Tube Connector • Viton, EDPM, or Elastomer Seal • Metallic Seal	 200 ± 25 200 ± 25
Vent Port Connector • Viton, EDPM, or Elastomer Seal • Metallic Seal	 200 ± 25 200 ± 25
Cover Plate Bolts	40 ± 5
Concrete Cask Lift Lug Bolts	115 ± 10 ft-lb
Concrete Cask Lid Lifting Hoist Rings	100, + 50, -0
Retaining Ring Bolts (MTC2 only)	30 (+0, -10) ft-lb
Retaining Ring Bolts (PMTC)	40 (+0, -10) ft-lb
Shield/Seal Ring Insert Retainer Bolts	40 (+0, -10) ft-lb

[1] For Jergens hoist rings only

9.2 Removing the Loaded 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 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 9.1.2 and Section 9.1.3, the procedural steps are only summarized here.

1. Remove inlet and outlet screens and temperature measuring equipment (if installed).
   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 the use of the concrete cask, per Section 4.3.1.g. of the Technical Specifications.
2. For concrete casks to be transported by a vertical cask transporter, remove anchor cavity cover plates, remove the lid assembly 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.
3. For concrete casks to be transported on a flat-bed vehicle, install an air pad rig set in the inlets. Inflate the air pads and move concrete cask onto the vehicle deck.
   Note: Ensure that air pads are not installed longer than eight hours to complete concrete cask transfer.
4. Move the loaded concrete cask to the facility.
5. Remove the concrete cask lid. Install concrete cask shield ring, if required.
6. Install the six hoist rings into the canister closure lid threaded holes. Remove shield ring, if installed.
   Note: Utilize high temperature-resistant slings (≤ 350°F)
7. Install transfer adapter on top of the concrete cask.
8. Place MTC onto the transfer adapter and engage the shield door connectors.
   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 the use of the carbon steel MTC, per Section 4.3.1.f. of the Technical Specifications (not applicable to stainless steel MTCs).
9. Open the shield doors, retrieve the lifting slings, and install the slings on the lifting system.

10. Slowly withdraw the TSC from the concrete cask. The chamfer on the underside of the transfer adapter assists in the alignment into the MTC.
11. Bring the 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.
12. Lift MTC off the concrete cask and move to the designated workstation.

After the MTC with the loaded TSC is in, or adjacent to, the facility, the operational sequence to load another concrete cask is performed in accordance with the procedures in Section 9.1.2. Note that the amount of time that a loaded TSC can remain in the MTC without cooling is limited to 11 hours from the time the TSC is removed from the concrete cask. Internal or external cooling of the TSC is required to be initiated within 11 hours as described in Section 9.3.

9.3 Wet Unloading a TSC Using a Standard MTC

This section provides the basic operational sequence to prepare, open, and unload a TSC in a spent fuel pool. Due to the rugged design and fabrication of the 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 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 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 TSC cavity gas and reduce 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 in order to satisfy the 11-hour maximum transfer time without cooling operations.
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: Cooling of the TSC using the ACWS, R-ACWS or equivalent annulus cooling/flush system may be required to assure cavity water boiling will not occur during closure lid weld removal operations per Section 9.1.1.
18. Initiate nitrogen gas flow through the 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 TSC with clean water through the drain connector under controlled temperature (minimum 70°F) and pressure conditions (25 +10/-0 psig). Borated water shall be used as required for the PWR fuel contents in accordance with LCO 3.2.1.
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.

    Note: Cooling of the TSC using the annulus circulating water system may be required to ensure cavity water boiling will not occur during closure lid weld removal operations per Section 9.1.1.
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 remove cavity gas using a vacuum pump.
26. Install the weld removal system on the closure lid. Operate the weld removal system to remove the closure ring-to-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 spent fuel pool.
32. Install lower annulus fill lines and fill the annulus with clean water while lowering the MTC.

33. When the trunnions are near the pool surface, install upper annulus fill lines and start clean water flow.
34. Lower the MTC to the bottom of the pool. 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. Following fuel unloading, reengage the lift yoke to the MTC trunnions and remove the MTC from the pool.
37. While the MTC is over the pool, 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 pool.
38. Place MTC and empty TSC in the cask decontamination area or other workstation.
39. Using a suction pump, remove the water from the TSC and pump to radwaste drains or return the water to the spent fuel pool.
40. Remove and store the contaminated TSC until a determination is made regarding reuse or disposition of the closure lid and TSC.
41. As appropriate, the user may proceed with the loading of the removed fuel assemblies in a new TSC in accordance with the procedures in Section 9.1.

9.4 Loading MAGNASTOR Using Passive MAGNASTOR Transfer Cask (PMTC)

MAGNASTOR is used to load, transfer, and store spent fuel. The three principal components of the system are: the transportable storage canister (TSC), the stainless steel Passive MAGNASTOR Transfer Cask (PMTC), and the concrete cask. The PMTC contains and supports the TSC during fuel loading, lid welding and closure operations, and allows passive air cooling of the TSC and its contents during operations outside of the spent fuel pool. The PMTC, with the transfer adapter, is also used to move the TSC into position for placement in the concrete cask.

These loading procedures are based on three initial conditions.

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

The TSC is filled with clean or pool water and the PMTC containing the TSC is lowered into the spent fuel pool for fuel assembly loading and verification. The user must identify and select the fuel assemblies to be loaded and ensure that all loaded fuel assemblies comply with the Approved Content provisions of the CoC.

Following fuel loading, the closure lid is installed and the transfer cask containing the loaded TSC is lifted from the bottom of the spent fuel pool, or the cask loading pit (CLP) water level is lowered. The TSC is partially drained and the closure lid is welded to the TSC shell. The closure lid-to-shell weld is visual and progressive dye penetrant examined. The cavity is refilled and the TSC is subjected to a hydrostatic pressure test with no observable leakage allowed. Following hydrostatic pressure test acceptance, the closure ring, which provides the redundant confinement closure barrier, is installed, welded and inspected. The TSC cavity water is then drained and volumetrically measured.

The residual moisture in the TSC is then removed by vacuum drying techniques and the TSC dryness is verified. The TSC is then evacuated to ≤ 3 torr and backfilled with a known quantity of pressurized high-purity helium to provide an inert atmosphere and to establish the convective heat transfer flow for the safe long-term storage of the spent fuel 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 TSC closure lid, shell, closure ring and port covers complete the assembly of the confinement boundary and redundant closure.

The concrete cask is positioned for the transfer of the TSC and the transfer adapter is installed. The PMTC containing the loaded TSC is positioned on the transfer adapter on the top of the concrete cask. Based on the passive air cooling of the TSC provided by the design of the PMTC, the TSC transfer time is essentially unlimited (limited by TS to 600 hours even at increased plant temperatures of ≤ 104°F). The TSC is lowered into the concrete cask and the PMTC and transfer adapter are removed. The concrete lid assembly 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.

9.4.1 Loading and Closing the TSC Using PMTC

This section describes the sequence of operations to load and close the TSC in preparation for transferring the TSC to the concrete cask. The empty TSC is assumed to be positioned inside the PMTC located at the designated workstation.

1. Visually inspect the TSC and basket internals for foreign materials or debris.
2. Note: Removable TSC centering shims may be used to assist in centering the TSC in the PMTC cavity. After TSC positioning in the PMTC, the TSC centering shims are removed prior to installation of the shield/seal insert.
3. Visually inspect the top of the TSC shell and closure lid weld preps.
4. Verify filled or fill the Shield Tank and Expansion Tanks as follows:
    a. Remove the threaded plugs from the two "Fill To" ports in the two expansion tanks.
    b. Remove the treaded plugs from the two shield tank manifolds.
    c. Fill the shield tank and expansion tanks with demineralized water until water flows out of the two "Fill To" ports in the expansion tanks.
    d. Stop filling operation and install threaded plugs in the two "Fill To" ports.
    e. Remove demineralized water supply from the two fill manifolds and install threaded plugs in the manifold fill lines.
5. Install the shield/seal insert in the TSC/PMTC annulus. Install the shield/seal retainer and retainer bolts and torque to the value per Table 9.1-2.
6. Install the lower inlet plugs in the lower forging.
7. Inflate the inner and outer seals of the shield/seal retainer with air or nitrogen gas to close the gaps between the TSC and the PMTC. At the option of the user either disconnect the gas supply or leave supply line connected to prevent inadvertent seal deflation.

8. Verify that at least one lock pin is installed on each transfer cask shield door.
9. Fill the TSC with clean or pool water. For PWR spent fuel contents, the soluble boron concentration in the TSC shall be verified and monitored in accordance with the LCO 3.2.1.
10. Attach the lift yoke to a crane suitable for handling the loaded TSC, PMTC and yoke. Position the lift yoke over the PMTC and engage it with the two PMTC trunnions.
11. Lift the PMTC containing the empty TSC and move it to the spent fuel pool following the prescribed load path.

    Note: An optional bottom protective cover may be used to prevent imbedding contaminated particles in the shield doors and door rails.
12. Connect the clean or filtered borated water line to the upper Reverse Annulus Circulating Water System (R-ACWS) fill port of PMTC.

    Note: The single upper R-ACWS fill port provides inlet water to the 8 inlet lines to the PMTC/TSC annulus, discharging out of the PMTC through the partially plugged air inlet openings in the PMTC bottom forging.
13. Lower the PMTC to the pool surface and turn on the clean or filtered borated water supply lines to the PMTC fill port to fill the PMTC/TSC annulus. Maintain R-ACWS operation at a minimum flow rate of 100 gpm and at a water inlet temperature of ≤ 125°F until completion of TSC loading, closure and processing, and the PMTC and loaded TSC are removed from the CLP or spent fuel pool.

    Note: Sequence on connection and filling/draining PMTC/TSC annulus is at the discretion of the user based on approved site-specific procedures.
14. Spray the PMTC and lift yoke with clean water to wet the exposed surfaces.

    Note: Wetting the components that enter the spent fuel pool and spraying the components leaving the pool will reduce the effort required to decontaminate the components.
15. Lower the PMTC to the bottom of the CLP in the cask loading area, or to the bottom of the spent fuel pool.
16. Disengage the lift yoke and visually verify that the lift yoke is fully disengaged. Remove the lift yoke from the spent fuel pool while spraying the yoke and crane cables with clean water.
17. Fill the CLP and open gate to spent fuel pool to allow movement of spent fuel assemblies from the storage racks to the CLP for loading into the TSC.
18. Load the previously selected fuel assemblies into the TSC basket.

    Note: The fuel assemblies shall be selected in compliance with the requirements of the approved contents specified in Appendix B of the Technical Specifications including limitations on fuel assembly positions within the basket, and the boron concentration limits of LCO 3.2.1. Specific fuel assembly positions for preferential and zoned loading patterns shall be in full compliance with the requirements of

Appendix B of the Technical Specifications. Assembly selection, placement and compliance with preferential zone loading patterns within the basket shall be independently verified.

Note: At the option of the user, install fuel assembly spacers for the axial positioning of the PWR fuel assembly types to be loaded. Verify spacer identification and install fuel spacers in each intended fuel loading location based on the fuel spacer plan prepared, which is based on the fuel assembly inventory and nonfuel hardware to be loaded. Independently, visually verify proper placement and correct orientation of each required fuel spacer.

19. Visually verify the fuel assembly identifications to confirm the serial numbers match the approved fuel loading pattern.
20. Install three swivel hoist rings hand tight in the three closure lid lifting holes or in three of the six 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.
21. Raise the closure lid. Adjust closure lid rigging to level the closure lid.
22. Move the closure lid over the spent fuel pool and align the lift yoke (if used) to the PMTC trunnions and align the closure lid to the match marks of the TSC.
23. Lower the closure lid until it enters the TSC and seats in the top of the TSC. Visually verify closure lid alignment using the match marks (± ½ inch).
24. Allow sling cables to go slack and move the lift yoke into position to engage the PMTC trunnions. Engage the lift yoke to the trunnions, apply a slight tension, and visually verify engagement.
25. Raise the PMTC until the top clears the pool surface and place the PMTC on the spent fuel shelf, or lower the water level in the CLP. 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 PMTC with clean water as the equipment is raised above the pool surface.
26. Rinse and flush the top of the PMTC and TSC with clean water as necessary to remove any radioactive particles. Survey the top of the TSC closure lid and the top of the PMTC to check for radioactive particles.
27. Maintain R-ACWS operation at a minimum flow rate of 100 gpm and at a water inlet temperature of ≤ 125°F through completion of closure lid welding, hydrostatic testing, cavity water draining, vacuum drying and minimum helium backfill time.

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

28. Install a cask work platform to provide access to the top of the TSC and closure lid.
29. Disengage the three-legged sling set from the closure lid and the lift yoke from the PMTC trunnions. Place lift yoke and sling set in storage/lay-down area.

    Note: R-ACWS operation allows the vacuum drying and TSC transfer times for the PMTC in LCO 3.1.1 to be utilized.

    Note: With the R-ACWS operating there is no time limit through initiation of the draining of the TSC.
30. Detorque and remove the lifting hoist rings from the closure lid.
31. Using a portable suction pump, remove any standing water from the closure lid weld groove, and the vent and drain ports.
32. Decontaminate the top of the PMTC and TSC closure lid to allow installation of the welding equipment.
33. Insert the drain line with a quick-connector attached through the drain port opening and into the basket drain port sleeve, as applicable. Remove the quick-disconnect and any contaminated water displaced from the cavity.
34. 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.
35. Install a venting device to the vent port quick-disconnect to prevent combustible gas or pressure buildup below the closure lid.
36. Verify that the top of the closure lid is level (flush) with, or slightly above, the top of the TSC shell.
37. At the discretion of the user, establish foreign material exclusion controls to prevent objects from being dropped into the annulus or TSC.
38. 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.
39. Connect a suction pump to the drain port quick-disconnect and verify venting through the vent port quick-disconnect.
40. Operate the suction pump to remove approximately 70 gallons of water from the TSC. Disconnect the suction pump.

Note: The radiation level will increase as water is removed from the TSC cavity, as shielding material is being removed.

Note: Fuel rods shall not be exposed to air during the 70-gallon pump-down.

41. Attach a hydrogen detector to the vent line. Ensure that the vent line does not interfere with the operation of the weld machine.
42. Sample the gas volume below the closure lid and observe hydrogen detector for H_2 concentration prior to commencing closure lid welding operations. Monitor H_2 concentration in the TSC until the root pass of the closure lid-to-shell weld is completed.

    Note: If H_2 concentration exceeds 2.4% prior to or during root pass welding operations, immediately stop welding operations. Evacuate the TSC gas volume or purge the gas volume with helium. Verify H_2 levels are <2.4% prior to restarting welding operations.

    Note: In place of continuous H_2 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_2 monitoring (upon termination of gas purging and prior to re-starting welding operations).
43. Install shims into the closure lid-to-TSC shell gap, as necessary, to establish a uniform gap for welding. Tack weld the closure lid and shims, as required.
44. Operate the welding equipment to complete the closure lid-to-TSC shell root pass weld in accordance with the approved weld procedure.
45. Perform visual and liquid penetrant (PT) examinations of the root pass and record the results.
46. Remove the H_2 detector from the vent line while ensuring the TSC cavity vent line remains installed and allows venting of gases from the cavity.
47. 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.
48. Complete welding through the completion of the final pass of the closure lid weld, perform final visual and PT examinations, and record the results.
49. Perform the hydrostatic test of the TSC as follows:
    a. Connect a drain line to the vent port and a pressure test system to the drain port.
    b. Refill the TSC with clean borated water until water is observed flowing from the vent port drain line. Close the vent line isolation valve. Ensure continuing compliance with the boron concentration requirements of LCO 3.2.1.
    c. Pressurize the TSC to 150 (+10, -0) psig and isolate the TSC.
    d. Maintain the TSC pressure for a minimum 10-minute hold period. At the end of the 10-minute hold period, visually examine the closure lid-to-TSC shell weld for leakage of water, while maintaining the test pressure. The test pressure shall be

maintained until the completion of the visual inspection of the closure lid-to-TSC shell weld.

e. The hydrostatic test is acceptable if there is no visible water leakage from the closure lid-to-TSC shell weld based on a visual examination of the weld after a minimum 10-minute hold period, while maintaining the test pressure.

g. Vent the TSC cavity and remove the pressure test system from the drain port and the drain line from the vent line. Reinstall a vent line to the vent port to prevent pressurization of the TSC.

50. Install and tack the closure ring in position in the closure lid-to-TSC shell weld groove.
51. Weld the closure ring to the TSC shell and to the closure lid. Perform visual and PT examinations of the final surfaces of the welds and record the results.
52. Remove the water from the TSC using one of the following methods: drain down using a suction pump with a pressurized helium cover gas; or blow down using pressurized helium gas. Ensure the totalizer in the drain line is reset to zero prior to the start of draining.

    Note: Fuel rods shall not be exposed to air during canister draining operations. Record the start time of TSC draining operations. The PMTC maximum drying times of LCO 3.1.1 are based on the total time from start of the draining through completion of helium backfilling of the TSC cavity.
53. Connect a drain line with or without suction pump to the drain port connector. Connect a regulated helium gas supply to the vent port connector.
54. Open gas supply valve and start suction pump, if used, and drain water from the TSC until water ceases to flow out of the drain line. Close gas supply valve and stop suction pump.
55. Record the time at the completion of the draining of the TSC. Record the volume of water drained from the TSC (V_{TSC}) as measured by the totalizer.

    Note: At the option of the user, disconnect suction pump, close discharge line isolation valve, and open helium gas supply line. Pressurize TSC to approximately 25 psig and open discharge line isolation valve to blow down the TSC. Repeat blow down operations until no significant water flows out of the drain line. Note that time used for system draining and blow down is considered part of the vacuum drying time.
56. Disconnect the drain line and gas supply line from the drain and vent port quick-disconnects.
57. Dry the TSC cavity using vacuum drying methods as follows.

    Note: Ensure heat load dependent vacuum drying time limits are not exceeded so that fuel cladding temperatures are maintained below 752°F. Vacuum drying cycle time limits in LCO 3.1.1 are based on utilizing the R-ACWS.

    a. Connect the vacuum drying system to the vent and drain port openings.

b. Operate the vacuum pump until a vapor pressure of ≤ 10 torr is achieved in the TSC. The time durations of the first vacuum drying cycle shall be in accordance with the time limits of LCO 3.1.1.

d. Isolate the vacuum pump from the TSC and turn off the vacuum pump. Observe the vacuum gauge connected to the TSC for an increase in pressure for a minimum period of 10 minutes. If the TSC pressure is ≤ 10 torr at the end of 10 minutes, the TSC is dry of free water in accordance with LCO 3.1.1.

Note: If the dryness verification is not met within the first vacuum drying cycle time as defined in LCO 3.1.1 for TSC's having a decay heat of > 20 kW, the TSC shall be backfilled with helium to 86 psig, +10, -0 psig and cooled by R-ACWS for a minimum of 24 hours. After the cooling period, subsequent drying cycle operations can continue for the times indicated in LCO 3.1.1. Drying cycles and cooling periods may be continued until the TSC cavity passes the dryness verification per LCO 3.1.1. For fuel burnup greater than 45 GWd/MTU, the total number of cooling cycles is limited to ten, with cladding temperature variations more than 65 °C (149 °F).

58. Upon satisfactory completion of the dryness verification, evacuate the TSC cavity to a pressure of ≤ 3 torr. Isolate and turn off the vacuum pump, and backfill and pressurize the TSC cavity with 99.995% (minimum) pure helium as follows:
    a. Determine the free volume of the TSC (V_{TSC}) per Step 55.
    b. Multiply the V_{TSC} free volume by the helium loading value per unit volume (L_{helium}) to determine required helium mass (M_{helium}) to be backfilled into the cavity.
    c. Set the helium bottle regulator to 90 (+5,-0) psig.
    d. Connect the helium backfill system to the vent port and reset the mass-flow meter to zero.
    e. Slowly open the helium supply valve and backfill the TSC with the required helium mass (M_{helium}) in accordance with LCO 3.1.1, Table A3-1.
59. Disconnect the vacuum drying helium backfill system from the vent and drain openings. Note the time the helium backfill is completed.
60. Install and weld the inner port cover on the drain port opening.
61. Install and weld the inner port cover on the vent port opening.
62. Perform visual and PT examinations of the final surface of the port cover welds and record the results.
63. Perform helium leak test on each of the inner port cover welds to verify the absence of helium leakage past the inner port cover welds.

64. 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.
65. 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.
66. Using an appropriate crane, remove the weld machine and supplemental shield.
67. Perform final decontamination of the top of the TSC and PMTC.
68. Engage the lift yoke to the cask handling crane hook.
69. Engage the lift yoke to the PMTC trunnions.
70. When the PMTC bottom forging breaks pool surface, terminate water flow to the R-ACWS and drain the annulus.
71. Rinse and flush the PMTC and lift yoke with clean water as necessary to remove any radioactive particles.
72. Move PMTC to the decontamination area and disengage lift yoke.
73. Move auxiliary crane above PMTC, install lifting hoist rings in shield/insert retainer ring lift holes, remove retainer bolts (3) and attach rigging to crane.
74. Using auxiliary crane move the shield/insert retainer ring to storage area.
75. Remove slings and hoist rings from shield/insert retainer ring.
76. Move auxiliary crane above PMTC, install lifting hoist rings in insert lift holes deflate seals and attach rigging to crane.
77. Using auxiliary crane remove the shield/seal inset from PMTC annulus and move to storage.
78. Remove the lower inlet plugs and store.
79. There is an administrative time limit of 4 hours for decay heat loads of > 20 kW and 10 hours for decay heat loads of ≤ 20 kW to complete removal of the shield/seal insert ring and lower inlet plugs to allow establishment of passive air cooling of the TSC. If these time limits are not met, TSC annulus cooling is to be provided by the R-ACWS for a minimum of 8 hours before resuming the effort for shield/seal insert and lower inlet plug removal (with the same time limit).
80. The annulus is now clear for normal convective air cooling.
81. Move auxiliary crane above retaining ring, install lifting hoist rings in retaining ring, and attach rigging to crane.
82. Using auxiliary crane move the retaining ring to above the PMTC and lower to install on upper forging.
83. Remove slings and hoist rings from retaining ring and move auxiliary crane from the area.
84. Install the 18 retaining ring bolts and torque to the value specified in Table 9.1-2.

85. Complete final decontamination of the transfer cask exterior surfaces. Final TSC contamination surveys may be performed after TSC transfer following Step 21 in Section 9.4.2 when TSC surfaces are more accessible.
86. Install the six swivel hoist rings into the six threaded holes in the closure lid if TSC transfer is to be performed by two sets of redundant slings. Torque the hoist rings to the value specified in Table 9.1-2.

    Note: Utilize high temperature-resistant slings (≤ 350°F).

    Note: Alternative site-specific TSC lifting systems and equipment may be used for lowering and lifting the TSC in the PMTC. The lifting system design must comply with the user's heavy load program and the applicable requirements of ANSI N14.6, NUREG-0612, and/or ASME/ANSI B30.9, as appropriate.
87. Engage the lift yoke to the cask handling crane hook.
88. Engage the lift yoke to the PMTC trunnions.
89. Raise the PMTC until the bottom forging clears the decontamination area.
90. Proceed to Section 9.4.2.

9.4.2 Transferring the TSC to the Concrete Cask Using the PMTC

This section describes the sequence of operations required to complete the transfer of a loaded TSC from the PMTC into a concrete cask, and preparation of the concrete cask for movement to the ISFSI pad. In accordance with the requirements of LCO 3.1.1, there is a time limit on the completion of TSC transfer from termination of R-ACWS cooling to placement of the TSC on the concrete cask pedestal of 600 hours.

1. Position an empty concrete cask with the lid assembly removed in the designated TSC transfer location.

    Note: The concrete cask can be positioned on the ground, or on a de-energized air pad set, roller skid, heavy-haul trailer, rail car, or transfer cart. The transfer location can be in a truck/rail bay 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 the lifting of the concrete cask with the lifting lugs, 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 lift yoke to the crane and engage the lift yoke to the PMTC trunnions. Ensure all lines, temporary shielding and work platforms are removed to allow for the vertical lift of the transfer cask.
8. Raise the PMTC and move it into position over the empty concrete cask.
9. Slowly lower the PNTC into the engagement position on top of the transfer adapter to align with the door rails and engage the connector tees.
10. Following set down, remove the lock pins from the shield door lock tabs.
11. Install a stabilization system for the PMTC, if required by the facility heavy load handling or seismic analysis programs.
12. Disengage the lift yoke from the PMTC trunnions and move the lift yoke from the area.
13. As appropriate to the TSC lifting system being used, move the lifting system to a position above the PMTC. If redundant sling sets are being used, connect the sling sets to the crane hook.
14. Using the TSC lifting system, lift the TSC slightly (approximately ½-1 inch) to remove the TSC weight from the shield doors.

    Note: The lifting system operator must take care to ensure that the TSC is not lifted such that the retaining ring is engaged by the top of the TSC.
15. Open the PMTC shield doors with the hydraulic system to provide access to the concrete cask cavity.
16. Using the cask handling crane in slow speed (or other approved site-specific handling system), slowly lower the TSC into the concrete cask cavity until the TSC is seated on the pedestal.

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

    Note: The completion of the transfer of the TSC to the concrete cask (i.e., the top of the TSC is in the concrete cask cavity) completes the TSC transfer evolution.
17. When the TSC is seated, disconnect the slings (or other handling system) from the lifting system, and lower the sling sets through the transfer cask until they rest on top of the TSC.
18. Retrieve the lift yoke and engage the lift yoke to the PMTC trunnions.
19. Remove the seismic/heavy load restraints from the PMTC, if installed.

20. Close the shield doors using the hydraulic system and reinstall the lock pins into the shield door lock tabs.
21. Lift the PMTC from the top of the concrete cask and return it to the cask preparation area for next fuel loading sequence or to its designated storage location.
22. Disconnect hydraulic supply system from the transfer adapter hydraulic cylinders.
23. Remove redundant sling sets, swivel hoist rings, or other lifting system components from the top of the TSC, if installed.
24. Verify all equipment and tools have been removed from the top of the TSC and transfer adapter.
25. 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.
26. Perform visual inspection of the top of the concrete cask and verify all equipment and tools have been removed.
27. Install three swivel hoist rings into the concrete cask lid and attach the three-legged sling set. Attach the lifting sling set to the crane hook.
28. At the option of the user, install the weather seal on the concrete cask lid flange. Lift the concrete cask lid and place it in position on the top of the flange.
29. Remove the sling set and swivel hoist rings and install the concrete cask lid bolts. Torque to the value specified in Table 9.1-2.
30. Move the loaded concrete cask into position for access to the site-specific transport equipment.
31. Proceed to Section 9.4.3.

9.4.3 Transporting and Placing the Loaded Concrete Cask

The section describes the general procedures for moving a loaded concrete cask to the ISFSI pad using either a vertical cask transporter (Step 1 through Step 9) or a flat-bed transport vehicle (Steps 10 through 17). Steps following Step 17 are performed for all concrete casks.

Vertical Cask Transporter

1. Using the vertical cask transporter lift fixture or device, engage the two concrete cask lifting lugs.
2. 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.

3. 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.

   Note: The spacing between adjacent loaded concrete casks must be 15 feet minimum.
4. Using the vertical transporter, slowly lower the concrete cask into position.
5. Disengage the vertical transporter lift connections from the two concrete cask lifting lugs. Move the cask transporter from the area.
6. Detorque and remove the lift lug bolts from each lifting lug, if the lugs are to be reused.

   Note: At the option of the user, the lift lugs may be left installed during storage operations.
7. Lift out and remove the concrete cask lift lugs. Store the lift lugs for the next concrete cask movement.
8. Install the lug bolts through the extension base (or through the cover plate for the standard concrete cask) and into the threaded holes. Torque each bolt to the value specified in Table 9.1-2.
9. 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.

Flat-bed Transport Vehicle Loaded with the Closed Concrete Cask

10. Move the transport vehicle with the closed concrete cask to a position adjacent to the ISFSI pad.
11. If required, install a bridging plate to cover the gap between the vehicle and the ISFSI pad.
12. If not already installed, insert four deflated air pads into the four inlets.
13. Attach a restraining device around the concrete cask and connect to a tow vehicle suitable for pushing or pulling the concrete cask off of the transport vehicle.
14. Using an air supply and an air pad controller, inflate the air pads.
15. Verify the ISFSI pad surface in the storage location is free of foreign objects and debris.
16. Using the tow vehicle, move the concrete cask into its position on the storage pad.

    Note: The center-to-center spacing of loaded concrete casks shall be 15 feet minimum.
17. Lower the concrete cask into position by deflating and removing the four air pads.

    Note: Ensure that air pads are not installed longer than eight hours to complete the concrete cask transfer.

All Concrete Casks

18. If optional temperature monitoring is implemented, install the temperature monitoring devices in each of the four outlets of the concrete cask and connect to the site's temperature monitoring system.

19. Install inlet and outlet screens to prevent access by debris and small animals.

    Note: Screens may be installed on the concrete cask prior to TSC loading to minimize operations personnel exposure.

20. Scribe and/or stamp the concrete cask nameplate to indicate the loading date. If not already done, scribe or stamp any other required information.
21. 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.
22. Initiate a daily temperature monitoring program or daily inspection program of the inlet and outlet screens to verify continuing effectiveness of the heat removal system.

9.5 Removing the Loaded TSC from a Concrete Cask Using a PMTC

This procedure assumes the loaded concrete cask is returned to the reactor loading facility for unloading. However, transfer of the 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 9.4.2 and Section 9.4.3, the procedural steps are only summarized here.

1. Remove inlet and outlet screens and temperature measuring equipment (if installed).
   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 the lifting of the concrete cask using lifting lugs, per Section 4.3.1.g. of the Technical Specifications.
2. For concrete casks to be transported by a vertical cask transporter, remove anchor cavity cover plates or fill 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.
3. For concrete casks to be transported on a flat-bed vehicle, install an air pad rig set in the inlets. Inflate the air pads and move concrete cask onto the vehicle deck.
   Note: Ensure that air pads are not installed longer than eight hours to complete concrete cask transfer.
4. Move the loaded concrete cask to the facility.
5. Remove the concrete cask lid. Install concrete cask shield ring, if required.
6. Install the six hoist rings into the canister closure lid threaded holes. Remove shield ring, if installed.
   Note: Utilize high temperature-resistant slings (≤ 350°F)
7. Install transfer adapter on top of the concrete cask.
8. Place PMTC with the retaining ring installed onto the transfer adapter and engage the shield door connectors.
9. Open the shield doors, retrieve the lifting slings or other site-specific handling equipment, and install on the lifting system.
10. Slowly withdraw the TSC from the concrete cask. The chamfer on the underside of the transfer adapter assists in the alignment into the PMTC.

Note: There is an administrative time limit of 600 hours from the lifting of the TSC into the PMTC from the concrete cask pedestal until the start of TSC cooldown operations following removal of the vent and drain port covers and installation of the cooldown system.

11. Bring the TSC up to just below the retaining ring and close the PMTC shield doors and install the shield door lock pins.
12. Lift PMTC off the concrete cask and move to the designated workstation.

After the PMTC loaded with a TSC is in, or adjacent to, the facility, the operational sequence to load another concrete cask is performed in accordance with the procedures in Section 9.4.2.

9.6 Wet Unloading a TSC Using a PMTC

This section provides the basic operational sequence to prepare, open, and unload a TSC in a spent fuel pool. Due to the rugged design and fabrication of the 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 TSC is in a PMTC in the appropriate workstation.

1. Remove the 18 retaining ring bolts and the retaining ring.
2. Survey the TSC and PMTC to establish radiological boundaries.
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 TSC cavity gas and reduce 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.
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 ports.
18. Initiate nitrogen gas flow through the 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 TSC with clean water through the drain connector under controlled temperature (minimum 70°F) and pressure conditions (25 +10/-0

psig). Borated water shall be used as required for the PWR fuel contents in accordance with LCO 3.2.1.

20. Monitor steam/water temperature of the discharge from the vent connection.
21. Continue cooldown operations until the discharge water temperature is < 150°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.

    Note: Monitor TSC cavity water temperature on a 2 hour frequency to verify temperature below boiling. Cooling of the TSC cavity water or of TSC using R-ACWS may be required to ensure cavity water boiling will not occur during closure lid weld removal operations.
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 remove cavity gas using a vacuum pump.
26. Install the weld removal system on the closure lid. Operate the weld removal system to remove the closure ring-to-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.
30. Install the shield/seal ring insert and insert retainer in the PMTC to TSC annulus, and install the 3 bolts and torque to value specified in Table 9.1-2.
31. Install the lower inlet plugs into the lower forging.
32. Install three swivel hoist rings into the closure lid threaded holes and torque per Table 9.1-2. Attach three-legged sling set to the hoist rings and the lifting system (or, alternately, the lifting yoke).
33. Engage the lift yoke to the PMTC trunnions and bring the PMTC over the CLP or spent fuel pool.
34. Install the water supply line to the R-ACWS connection and start R-ACWS water flow as the PMTC enters the CLP or spent fuel pool water. Maintain R-ACWS operation at a minimum flow rate of 100 gpm and at a water inlet temperature of ≤ 125°F until completion of TSC fuel unloading operations or until empty TSC is removed from the CLP or spent fuel pool.
35. Lower the PMTC to the bottom of the CLP or pool. Disengage the lift yoke.

36. Slowly remove the closure lid and move the lid to an appropriate storage area.
    Note: The closure lid will be contaminated and slightly activated.
37. Using standard fuel handling procedures, unload spent fuel assemblies from the TSC until the basket is empty.
38. Following fuel unloading, reengage the lift yoke to the PMTC trunnions and remove the PMTC from the pool.
39. While the bottom of the PMTC breaks the pool water surface, stop the flow of water to the annulus, disconnect the R-ACWS fill lines and allow the water in the annulus to drain back into the pool.
40. Place PMTC and empty TSC in the cask decontamination area or other workstation.
41. Using a suction pump, remove the water from the TSC and pump to radwaste drains or return the water to the spent fuel pool.
42. Remove and store the contaminated TSC until a determination is made regarding reuse or disposition of the closure lid and TSC.
43. As appropriate, the user may proceed with the loading of the removed fuel assemblies in a new TSC in accordance with the procedures in Section 9.4.

10. Acceptance Criteria/
Maintenance Program

Chapter 10
Acceptance Criteria and Maintenance Program

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10.1.2.3 Pressure Testing of the TSC

Following completion of the closure lid-to-TSC shell weld during the TSC preparation operations after fuel loading, the TSC shall be hydrostatically pressure tested at not less than 125% of the design pressure of 110 psig in accordance with ASME Code, Section III, Subsection NB, NB-6000 requirements as described in Section 9.1.1. A bounding minimum test pressure of 150 psig shall be applied to the drain port connection for a minimum 10-minute hold period. There shall be no visible water leakage from the closure lid-to-TSC shell weld based on visual examination of the weld after a minimum 10-minute hold period, while maintaining the test pressure. Test pressure shall be maintained until the completion of the visual weld examination. The design pressure and minimum test pressure are identical for both PWR and BWR TSCs. The minimum test pressure conservatively exceeds the hydrostatic test pressure commitment stated in Table 2.1-2 (125% of MNOP).

10.1.2.4 Load Testing of Damaged Fuel Can (DFC)

To qualify the design of the MAGNASTOR DFC, the first DFC to be provided to a user shall be load tested to 150% of the total weight of the DFC plus the heaviest contents to be loaded in the DFC. The test load on the DFC shall be applied and held for a minimum of 10 minutes. Following completion of the load test, all load bearing welds and surfaces shall be visually inspected for permanent deformation, galling or cracking. Load bearing welds shall be inspected using liquid penetrant examination in accordance with ASME Code, Section V, Article 6. Acceptance criteria shall be in accordance with ASME Code, Section III, NG-5350.

Any evidence of permanent deformation, cracking or galling of load bearing surfaces, or unacceptable liquid penetrant examination results shall be cause for rejection, repair, reperformance of the load test and reexamination of the DFC.

10.1.2.5 Pressure Testing of the Passive MAGNASTOR Transfer Cask (PMTC)

Following completion of the load testing of the PMTC, the neutron shield tank and the expansion tanks shall be hydrostatically tested simultaneously, since they are joined by siphon tubes. The hydrostatic test shall be performed at a pressure of 30 (+5, -0) psig (125% of maximum operating pressure of 23.7 psig) for a minimum hold period of 10 minutes in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1. All tank weld seams and joints shall be visually inspected for evidence of leakage while the test pressure is maintained following the minimum hold period. Any evidence of leakage, seam failure or deformation is cause for rejection. Following neutron shield tank and expansion tank depressurization, all accessible welds on the neutron shield structure shall be visually examined in accordance with ASME Code, Section V, Articles 1 and 9 with acceptance per Section III, Subsection NF, Article NF-5360, and

dye penetrant examined in accordance with ASME Code, Section V, Articles 1, 6 and 24, with acceptance criteria per Section III, Subsection NF, Article NF-5350.

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

Hydrostatic testing of the PMTC neutron shield and expansion tanks shall be performed in accordance with written and approved procedures, and the test results documented.

10.1.3 Leakage Tests

The confinement boundary is defined as the TSC shell weldment, closure lid assembly, and vent and drain port covers. As described in Section 10.1.1, the confinement boundary is designed, fabricated, examined, and tested in accordance with the requirements of the ASME Code, Section III, Subsection NB, except for the code alternatives listed in Table 2.1-2.

At the completion of the TSC shell weldment confinement boundary welds (e.g., TSC shell seam and shell to bottom plate), the TSC shell weldment shall be leakage tested. 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 [20] to confirm the total leakage rate is less than, or equal to, 1×10^{-7} ref. cm^3/s (i.e., leaktight). The sensitivity of the test shall be one-half of the acceptance test criteria as specified in ANSI N14.5-1997.

The TSC shell weldment will be closed using a test lid installed over the top of the shell and the cavity evacuated. A test envelope will be installed around the TSC enclosing all of the TSC shell confinement welds and base metal plates, and filled with 99.995% (minimum) pure helium to an acceptable test concentration. The percentage of helium gas in the test envelope shall be accounted for in the determination of the test sensitivity. A mass spectrometer leak detector (MSLD) will be used to sample the evacuated volume for helium.

If helium leakage is detected, the area of leakage shall be identified, repaired and re-examined in accordance with the ASME Code, Section III, Subsection NB, NB-4450 or NB-4130, as appropriate. Following repair, the complete helium leakage test shall be re-performed to the original test acceptance criteria.

Leakage testing of the TSC shell weldment shall be performed in accordance with written and approved procedures, and the test results documented.

Based on the confinement system materials, welding requirements and inspection methods, shop helium leakage testing of the 9-inch thick closure lid is not required. However, due to the 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. 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, 1 ± 10^{-7} cm^3/s (i.e., leaktight).. 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 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^3/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^3/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 fabrication of the neutron absorber material is controlled to provide a uniform boron carbide distribution and the specified ^{10}B areal density.

10.1.6.1 Design/Performance Requirements

The MAGNASTOR system utilizes sheets of neutron absorber material that are attached to the sides of the spent fuel storage locations in the fuel baskets. The materials and dimensions of the neutron absorber sheets are defined on license drawings 71160-571 and 71160-572. The material is called out as a metallic composite (includes borated aluminum alloy, borated MMC, and Boral, which are available under various commercial trade names). Incorporating optional neutron absorber materials in the design provides fabrication flexibility for the use of the most economical and available neutron absorber material that meets the critical characteristics necessary to assure criticality safety. The critical design characteristics of the neutron absorber material are:

- A minimum "effective" areal density of 0.036 g/cm^2 ^{10}B for the PWR basket and 0.027 g/cm^2 ^{10}B for the BWR basket; and
- A uniform distribution of boron carbide; and
- A yield strength greater than or equal to that used in Section 10.1.6.4.4; and
- An effective thermal conductivity greater than or equal to that used in Section 10.1.6.4.4.

The required minimum actual ^{10}B loading in a neutron absorber sheet is determined based on the effectiveness of the material, i.e., 75% for Boral and 90% for borated aluminum alloys and for borated metal matrix composites. Testing will be used to verify the areal density and the uniform distribution of ^{10}B in the neutron absorber materials. Section 8.8 presents a tabulation of the types of neutron absorber materials, the required minimum effective areal density of ^{10}B, and the required minimum as-fabricated areal density of ^{10}B.

The positions of the neutron absorber sheets with their attachments and retainers to the fuel tubes are shown on license drawings 71160-551 and 71160-591. The attachments and retainers ensure that the neutron absorber remains in place for all loading conditions for the lifetime of the canister.

10.1.6.2 Terminology

Applicable terminology definitions for the neutron absorber materials:

acceptance –	tests conducted to determine whether a specific production lot meets selected material properties and characteristics, or both, so that the lot can be accepted for commercial use.
areal density –	for sheets with flat parallel surfaces, the density of the neutron absorber times the thickness of the material.

designer –	the organization responsible for the design or the license holder for the dry cask storage system or transport packaging. The designer is usually the purchaser of the neutron absorber material, either directly or indirectly (through a fabrication subcontractor).
lot –	a quantity of a product or material accumulated under conditions that are considered uniform for sampling purposes.
neutron absorber –	a nuclide that has a large thermal or epithermal neutron absorption cross-section, or both.
neutron absorber material –	a compound, alloy, composite or other material that contains a neutron absorber.
neutron attenuation test –	a process in which a material is placed in a thermal neutron beam, and the number of neutrons transmitted through the material in a specified period of time is counted. The observed neutron counting rate may be converted to areal density by performing the same test on a series of calibration standards.
neutron cross-section –	a measure of the probability that a neutron will interact with a nucleus; a function of the neutron energy and the structure of the interacting nucleus.
packaging –	in transport of radioactive material, the assembly of components necessary to enclose the radioactive contents completely.
qualification –	the process of evaluating and testing, or both, a material produced by a specific manufacturing process to demonstrate uniformity and durability for a specific application.

10.1.6.3 Inspections

After manufacturing, each sheet of neutron absorber material will be visually and dimensionally inspected for damage, embedded foreign material, and dimensional compliance. The neutron absorber sheets are intended to be defect/damage free, but limited defects/damages are acceptable. Allowed defects are discussed in each material specification section that follows.

Standard industrial inspections will be performed on the neutron absorber sheets to verify the acceptability of physical characteristics such as dimensions, flatness, straightness, tensile properties (if structural considerations are applicable) or other mechanical properties as appropriate, surface quality and finish. Inspection and testing of the neutron absorber materials will be performed in accordance with written procedures, by appropriately certified personnel, and the inspection and test results will be documented.

10.1.6.4 Specification

Three types of neutron absorber materials are permitted to augment criticality control in the MAGNASTOR fuel baskets – (1) Boral, a clad composite of aluminum and boron carbide, as specified in Section 10.1.6.4.1; (2) borated metal matrix composites (MMC), as specified in Section 10.1.6.4.2; and (3) borated aluminum alloy, as specified in Section 10.1.6.4.3. The required minimum "effective" areal density of ^{10}B in a neutron absorber is defined on license drawings 71160-571 and 71160-572, in Section 1.8, and is based on the fuel basket geometry and on the fuel assembly type and reactivity. The analyses of the fuel baskets do not consider the tensile strength of the neutron absorber material other than that it be sufficient to maintain its form, i.e., at least equivalent to the yield strength listed in Section 8.3. Environmental conditions encountered by the neutron absorber material may include:

- Immersion in water with the associated chemical, temperature and pressure concerns
- Dissimilar materials
- Gamma and neutron radiation fluence
- Dry heat-up rates
- Maximum temperatures

Except for materials for which validation has been completed, the durability of the neutron absorber materials is validated to demonstrate the following results:

- Neutron absorber materials will not incur significant damage due to the pressure, temperature, radiation, or corrosion environments that may be present in the loading and storage of spent fuel;
- Aluminum and boron carbide do not react with each other in the range of the maximum temperatures present in the fuel baskets;
- There are no significant changes in mechanical properties of the neutron absorber materials due to the fast neutron fluences experienced in spent fuel storage;

- General corrosion does not have time to affect the integrity of the neutron absorber material due to the very short time of immersion in spent fuel pool water.

Individual material types and process lots are tested to verify the presence, uniform distribution and minimum areal density (effectiveness) of ^{10}B specific to each type of neutron absorber material.

All neutron absorber materials are procured and qualified under a Quality Assurance/Quality Control program in conformance with the requirements of 10 CFR 72, Subpart G.

10.1.6.4.1 Boral

Boral is a composite core of blended boron carbide and aluminum powders between outer layers of aluminum. The core is slightly porous. Sheets of Boral are formed and mechanically bonded by hot-rolling ingots of the core material between aluminum sheets. Boral is credited with an effectiveness of 75% of the specified minimum areal density of ^{10}B in Boral based on testing of the material as described in Section 10.1.6.4.8.

Visual inspections of the Boral sheets will verify the presence of a full core and will identify any cladding damage, cracks or discontinuities, embedded foreign material, or peeled cladding. Evidence of less than a full core, embedded foreign material, cracks or sharp burrs in the cladding shall be identified as nonconforming. Nonconforming items are segregated and evaluated within the NAC International Quality Assurance Program, and assigned one of the following dispositions: "Use-As-Is," "Rework/Repair" or "Reject." Only material that is determined to meet all applicable conditions of the license will be accepted. Embedded pieces of B_4C matrix material are not considered foreign material, but such material shall be removed from the surface of the Boral. Scratches, creases or other surface indications are acceptable on the cladding of the Boral, but exposure of the core through the cladding surface of the sheet is not acceptable.

10.1.6.4.2 Borated Metal Matrix Composites - MMC

Borated metal matrix composite (MMC) material can be produced by powder metallurgy, casting or thermal spray methods and consists of fine boron carbide particles in a matrix of aluminum. Borated MMC material is a metallurgically bonded matrix, low porosity product. Borated metal matrix composites rely on a fine (average 10-40 micron) boron carbide particle size to achieve a uniform boron distribution. Specifications on the boron carbide particle size in MMCs are included in Section 10.1.6.4.7. MMCs are credited with an effectiveness of 90% of the specified minimum areal density of ^{10}B in the borated MMC material based on acceptance and

qualification testing of the material as described in the Sections 10.1.6.4.4, 10.1.6.4.5 and 10.1.6.4.6. Visual inspections of the sheets of borated MMC material will be based on Aluminum Association recommendations, as applicable—i.e., blisters and/or widespread rough surface conditions such as die chatter or porosity shall be identified as nonconforming. Nonconforming items are segregated and evaluated within the NAC International Quality Assurance Program, and assigned one of the following dispositions: "Use-As-Is," "Rework/Repair" or "Reject." Only material that is determined to meet all applicable conditions of the license will be accepted. Local or cosmetic conditions such as scratches, nicks, die lines, inclusions, abrasion, isolated pores or discoloration are acceptable based on material neutron attenuation and thermal performance not being impacted by minor fabrication anomalies.

10.1.6.4.3 Borated Aluminum

Borated aluminum material is a direct chill cast metallurgy product with a uniform fine dispersion of discrete boron particles in a matrix of aluminum. Borated aluminum material is a metallurgically bonded matrix, low porosity product. Borated aluminum is credited with an effectiveness of 90% of the specified minimum areal density of ^{10}B in the borated aluminum material based on acceptance and qualification testing of the material as described in Sections 10.1.6.4.4, 10.1.6.4.5 and 10.1.6.4.6. Visual inspections of the sheets of borated aluminum material will be based on Aluminum Association recommendations, as applicable—i.e., blisters and/or widespread rough surface conditions such as die chatter or porosity shall be identified as nonconforming. Nonconforming items are segregated and evaluated within the NAC International Quality Assurance Program, and assigned one of the following dispositions: "Use-As-Is," "Rework/Repair" or "Reject." Only material that is determined to meet all applicable conditions of the license will be accepted. Local or cosmetic conditions such as scratches, nicks, die lines, inclusions, abrasion, isolated pores or discoloration are acceptable based on material neutron attenuation and thermal performance not being impacted by minor fabrication anomalies.

10.1.6.4.4 Thermal Conductivity and Yield Strength Testing of Metal Matrix and Borated Aluminum Neutron Absorber Material

Thermal Conductivity Testing

Thermal conductivity qualification testing of the neutron absorber materials shall conform to ASTM E1225 [15], ASTM E1461 [16], or an equivalent method. The testing shall be performed on test coupons taken from production material. Note that thermal conductivity increases slightly with temperature increases.

- Sampling will initially be one test per lot and may be reduced if the first five tests meet the specified minimum thermal conductivity. Additional tests may be performed on the

- material from a lot whose test result does not meet the required minimum value, but the lot will be rejected if the mean value of the tests does not meet the required minimum value.
- Upon completion of 25 tests of a single type of neutron absorber material having the same aluminum alloy matrix and boron content (in the same compound), further testing may be terminated if the mean value of all of the test results minus two standard deviations meets the specified minimum thermal conductivity. Similarly, testing may be terminated if the matrix of the material changes to an alloy with a larger coefficient of thermal conductivity, or if the boron compound remains the same, but the boron content is reduced.

In the Chapter 4 thermal analyses, the neutron absorber is conservatively evaluated as a 0.125-in nominal thickness sheet~~ for the PWR fuel basket~~ and a 0.10-in nominal thickness sheet for the BWR fuel basket. The required minimum thermal conductivities for the MAGNASTOR absorbers are as follows.

Minimum Effective Thermal Conductivity - BTU/(hr-in-°F)

Fuel Basket Type	Radial		Axial	
	100°F	500°F	100°F	500°F
[redacted]				
BWR	4.687	4.335	5.054	5.017

The neutron absorber thermal acceptance criterion will be based on the nominal sheet thickness. Surface anomalies increase radiation heat transfer and have insignificant influence on thermal conductivity, permitting acceptance of minor surface defects without additional material testing.

Additional thermal conductivity qualification testing of neutron absorber material is not required if certified quality-controlled test results (from an NAC approved supplier) that meet the specified minimum thermal conductivity are available as referenced documentation.

<u>**Yield Strength Testing**</u>

Yield strength qualification testing of the neutron absorber shall conform to ASTM Test Method B 557/B 557M, E 8 or E 21 [17, 18, 19].

Neutron absorber material yield strength must be equal to or greater than 1.6 ksi at 700°F. Per Section 8.3, a yield strength of 1.6 ksi is the material strength of the neutron absorber at 700°F and is applied as a temperature-independent value in the structural evaluations of the absorber. This yield strength assures that the material will maintain its form when subjected to normal, off-normal and accident condition loads.

The neutron absorber yield strength acceptance criterion will be based on the absorber meeting the specified nominal sheet thickness. Control and limitations on the neutron absorber boron content (primary driver to material structural performance) permits acceptance without additional material yield strength acceptance testing.

Additional yield strength qualification testing of neutron absorber material is not required if certified quality-controlled test results (from an NAC approved supplier) that meet the specified minimum yield strength are available as referenced documentation.

10.1.6.4.5 Acceptance Testing of Borated Aluminum Alloy and Borated MMC Neutron Absorber Material by Neutron Attenuation

NOTE
Section 10.1.6.4.5 is 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 this section is shown in bold to distinguish it from other sections.

Acceptance testing shall be performed to ensure that neutron absorber material properties for sheets in a given production run are in compliance with the materials requirements for the MAGNASTOR fuel baskets and that the process is operating in a satisfactory manner.

Statistical tests will be run to augment findings relating to isotopic content, impurity content or uniformity of the ^{10}B distribution.

- **Determination of neutron absorber material acceptance shall be performed by neutron attenuation testing. Neutron attenuation testing of the final product, or the coupons, shall compare the results with those for calibrated standards, which may be composed of homogeneous or heterogeneous materials. The heterogeneous standard will be calibrated to a recognized standard (e.g., homogeneous material such as ZrB_2 plate material or a NIST-produced standard) or by attenuation of a thermal neutron beam correlated to the known cross-section of ^{10}B at the beam energies. These tests shall include a statistical sample of finished product or test coupons taken from each lot of material to verify the presence, uniform distribution and the minimum areal density of ^{10}B.**
- **The ^{10}B areal density is measured using a collimated thermal neutron beam of up to 2.54 cm in diameter, with a tolerance of 10 percent.**
- **Based on the MAGNASTOR required ^{10}B minimum effective areal densities for the PWR basket of 0.036, 0.030 or 0.027 g/cm^2, the ^{10}B minimum effective areal densities**

for the BWR basket of 0.027, 0.0225 or 0.020 g/cm^2 and the 90% credit applied for borated aluminum alloys and for borated metal matrix composites, a required minimum areal density for the as-manufactured neutron absorber sheets is established.

- Test locations/coupons shall be well distributed throughout the lot of material, particularly in the areas most likely to contain variances in thickness, and shall not contain unacceptable defects that could inhibit accurate physical and test measurements.
- The sampling plan shall require that each of the first 50 sheets of neutron absorber material from a lot, or a coupon taken therefrom, be tested. Thereafter, coupons shall be taken from 10 randomly selected sheets from each set of 50 sheets. This 1 in 5 sampling plan shall continue until there is a change in lot or batch of constituent materials of the sheet (i.e., boron carbide powder or aluminum powder) or a process change. A measured value less than the required minimum areal density of ^{10}B during the reduced inspection is defined as nonconforming, along with other contiguous sheets, and mandates a return to 100% inspection for the next 50 sheets. The coupons are indelibly marked and recorded for identification. This identification will be used to document the neutron absorber material test results, which become part of the quality record documentation package.
- The minimum areal density specified shall be verified for each lot at the 95% probability, 95% confidence level (also expressed as 95/95 level) or better. The following illustrates one acceptable method.

  The acceptance criterion for individual plates is determined from a statistical analysis of the test results for that lot. The minimum ^{10}B areal densities determined by neutron attenuation are converted to volume density, i.e., the minimum ^{10}B areal density is divided by the thickness at the location of the neutron attenuation measurement or the maximum thickness of the coupon. The lower tolerance limit of ^{10}B volume density is then determined—defined as the mean value of ^{10}B volume density for the sample, less K times the standard deviation, where K is the one-sided tolerance limit factor for a normal distribution with 95% probability and 95% confidence.

  Finally, the minimum specified value of ^{10}B areal density is divided by the lower tolerance limit of ^{10}B volume density to arrive at the minimum plate thickness that provides the specified ^{10}B areal density.

Any plate that is thinner than this minimum or the minimum design thickness, whichever is greater, shall be treated as nonconforming, with the following exception. Local depressions are acceptable, as long as they total no more than 0.5% of the area on any given plate and the thickness at their location is not less than 90% of the minimum design thickness.

- **All neutron absorber material acceptance verification will be conducted in accordance with the NAC International Quality Assurance Program. The neutron absorber material supplier shall control manufacturing in accordance with the key process controls via a documented quality assurance system (approved by NAC or NAC's approved fabricator), and the designer shall verify conformance by reviewing the manufacturing records.**
- **Nonconforming material shall be evaluated within the NAC International Quality Assurance Program and shall be assigned one of the following dispositions: "Use-As-Is," "Rework/Repair" or "Reject." Only material that is determined to meet all applicable conditions of the license will be accepted.**

10.1.6.4.6 Qualification Testing of Metal Matrix and Borated Aluminum Neutron Absorber Material

NOTE

Section 10.1.6.4.6 is 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 this section is shown in bold to distinguish it from other sections.

Qualification tests for each MAGNASTOR System neutron absorber material and its set of manufacturing processes shall be performed at least once to demonstrate acceptability and durability based on the critical design characteristics, previously defined in this section.

The licensed service life will include a range of environmental conditions associated with short-term transfer operations, normal storage conditions, as well as off-normal and accident storage events. Additional qualification testing is not required for a neutron absorber material previously qualified, i.e., reference can be provided to prior testing with the same, or similar, materials for similar design functions and service conditions.

- **Qualification testing is required for: (1) neutron absorber material specifications not previously qualified; (2) neutron absorber material specifications previously qualified, but manufactured by a new supplier; and (3) neutron absorber material**

specifications previously qualified, but with changes in key process controls. Key process controls for producing the neutron absorber material used for qualification testing shall be the same as those to be used for commercial production.

- Qualification testing shall demonstrate consistency between lots (2 minimum).
- Environmental conditions qualification will be verified by direct testing or by validation by data on the same, or similar, material, i.e., the neutron absorber material is shown to not undergo physical changes that would preclude the performance of its design functions. Conditions encountered by the neutron absorber material may include: short-term immersion in water, exposure to chemical, temperature, pressure, and gamma and neutron radiation environments. Suppliers' testing will document the durability of neutron absorber materials that may be used in the MAGNASTOR system by demonstrating that the neutron absorber materials will not incur significant damage due to the pressure, temperature, radiation, or corrosion environments or the short-term water immersion that may occur in the loading and storage of spent fuel.
- Thermal conductivity and yield strength qualification testing shall be as previously described in Section 10.1.6.4.4.
- The uniformity of the boron carbide distribution in the material shall be verified by neutron attenuation testing of a statistically significant number of measurements of the areal density at locations distributed throughout the test material production run, i.e., at a minimum from the ends and the middle of the run. The sampling plan must be designed to demonstrate 95/95 compliance with the absorber content requirements. Details on acceptable neutron attenuation testing are previously provided in this section for Acceptance Testing. Alternate test methods may be employed provided they are validated (benchmarked) to neutron attenuation tests.
- One standard deviation of the neutron attenuation test sampling results shall be less than 10% of the sample mean. This requirement provides additional assurance that a consistent product is achieved by the manufacturing process.
- A material qualification report verifying that all design requirements are satisfied shall be prepared.
- Key manufacturing process controls in the form of a complete specification for materials and process controls shall be developed for the neutron absorber material by the supplier and approved by NAC to ensure that the product delivered for use is consistent with the qualified material in all respects that are important to the material's design function.

- **Major changes in key manufacturing processes for neutron absorber material shall be controlled by mutually agreed-upon process controls established by the certificate holder/purchaser and the neutron absorber supplier. These process controls will ensure that the neutron absorber delivered will always be consistent with the qualification test material in any and all respects that are important to the neutron absorber's safety characteristics. Changes in the agreed-upon process controls may require requalification of those parts of the qualification that could be affected by the process changes. Typical changes covered by the agreed-upon process controls include:**
  - **Changes that could adversely affect mechanical properties (e.g., change in thermal conductivity, porosity, material strength, change of matrix alloy, boron carbide content, increase in the B_4C content above that used in previously qualified material, etc.);**
  - **Changes that could affect the uniformity of boron (e.g., change to mixing process for aluminum and boron carbide powders, change in stirring of melt, change in boron precipitate phase, etc.).**
- **Minor neutron absorber material processing changes, i.e., roller machine hardware or final sheet cutting methods, water jet, shear cut, etc., may be determined to be acceptable on the basis of engineering review without additional qualification testing, if such changes do not adversely affect the particle bonding microstructure, i.e., the durability or the uniformity of the boron carbide particle distribution, which is the neutron absorber effectiveness.**
- **Nonconforming material shall be evaluated within the NAC International Quality Assurance Program and shall be assigned one of the following dispositions: "Use-As-Is," "Rework/Repair" or "Reject." Only material that is determined to meet all applicable conditions of the license will be accepted.**

10.1.6.4.7 Additional Material Specifications

NOTE
Section 10.1.6.4.7 is 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 this section is shown in bold to distinguish it from other sections.

Boron carbide particles for MMCs shall have an average size in the range 10-40 microns and no more than 10% of the particles shall be over 60 microns. The material shall have negligible interconnected porosity exposed at the surface or edges.

Open porosity for borated aluminum and borated MMC neutron absorber material must be no greater than 0.5% unless qualification tests are performed to ensure that blisters are not produced under submerging and subsequent vacuum drying conditions.

Chemical composition of the boron carbide powder must meet the requirements of Table 1 of ASTM C 750-03, Type 3. Additional chemical requirements, applicable to a particular absorber material, may be placed on the boron carbide powder as a result of the "key manufacturing process controls" invoked by Section 10.1.6.4.6. Additional requirements may include, but are not limited to, upper limits on fluorine and chlorine content.

10.1.6.4.8 Boral Neutron Absorber Tests

NOTE
Section 10.1.6.4.8 is 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 this section is shown in bold to distinguish it from other sections.

The Boral neutron absorbing material is an aluminum matrix material formed from aluminum and boron-carbide. The mixing of the aluminum and boron-carbide powder forming the neutron absorber material is controlled to assure the required ^{10}B areal density. The constituents of the neutron absorber material shall be verified by chemical testing and by dimensional measurement to ensure the quality of the finished plate or sheet. The results of all neutron absorber material tests and inspections, including the results of wet chemistry coupon testing, are documented and become part of the quality records documentation package for the fuel tube and basket assembly.

The manufacturing process of Boral consists of several steps. The initial step is the mixing of the aluminum and boron carbide powders that form the core of the finished material. The amount of each powder is a function of the desired ^{10}B areal density. The methods used to control the weight and blend the powders are proprietary processes of the manufacturer.

After manufacturing, test samples from each Boral batch of neutron absorber sheets shall be tested using wet chemistry techniques to verify the presence and minimum weight

percent of ^{10}B. The tests shall be performed in accordance with approved written procedures.

The neutron absorber sampling plan is selected to demonstrate a 95/95 statistical confidence level in the neutron absorber sheet material in compliance with the specification. In addition to the specified sampling plan, each sheet of material is visually and dimensionally inspected using at least six measurements on each sheet. The sampling plan is supported by written and approved procedures.

The sampling plan requires that a coupon sample be taken from each of the first 100 sheets of absorber material. Thereafter, coupon samples are taken from 20 randomly selected sheets from each set of 100 sheets. This 1 in 5 sampling plan continues until there is a change in lot or batch of constituent materials of the sheet (i.e., boron carbide powder, aluminum powder, or aluminum extrusion) or a process change. If either of these circumstances occurs, the sampling plan reverts back to a coupon sample being taken from each of the first 100 sheets of absorber material, followed by the 20 randomly selected sheets from each set of 100 sheets. The sheet samples are indelibly marked and recorded for identification. This identification is used to document neutron absorber test results, which become part of the quality record documentation package.

Neutron Absorber Wet Chemistry Testing

Wet chemistry testing of the test coupons obtained from the sampling plan is used to verify the ^{10}B content of the neutron absorber material. Wet chemistry testing is applied because it provides an accurate and practical direct measurement of the boron and B_4C content of metal materials.

An approved facility with chemical analysis capability, which could include the neutron absorber vendor's facility, shall be selected to perform the wet chemistry tests. Personnel performing the testing shall be trained and qualified in the process and in the test procedure.

Wet chemistry testing is performed by dissolving the aluminum in the matrix, including the powder and cladding, in a strong acid, leaving the B_4C material. A comparison of the amount of B_4C material remaining to the amount required to meet the ^{10}B content specification is made using a mass-balance calculation based on sample size.

A statistical conclusion about the neutron absorber sheet from which the sample was taken and that batch of neutron absorber sheets may then be drawn based on the test results and the controlled manufacturing processes.

The adequacy of the wet chemistry method is based on its use to qualify the standards employed in neutron blackness testing. The neutron absorption performance of a test material is validated based on its performance compared to a standard. The material properties of the standard are demonstrated by wet chemistry testing. Consequently, the specified test regimen provides adequate assurance that the neutron absorber sheet thus qualified is acceptable.

Acceptance Criteria

The wet chemistry test results shall be considered acceptable if the ^{10}B areal density is determined to be equal to, or greater than, that specified on the fuel tube License Drawings. Failure of any coupon wet chemistry test shall result in 100% sampling, as described in the sampling plan, until compliance with the acceptance criteria is demonstrated.

Yield Strength Testing

Yield strength qualification testing of the neutron absorber shall conform to ASTM Test Method B 557/B 557M, E 8 or E 21 [17, 18, 19]. For Boral, a laminated absorber, yield strength credited in the structural analysis was limited to the outer aluminum cover sheets. Therefore, only the cover sheet must be shown to meet the required strength.

10.1.7 Thermal Tests

Thermal acceptance testing of the MAGNASTOR system following fabrication and construction is not required. Continued effectiveness of the heat-rejection capabilities of the system may be monitored during system operation using a remote temperature-monitoring system.

The heat-rejection system consists of convection air cooling where air flow is established and maintained by a chimney effect, with air moving from the lower inlets to the upper outlets.

Since this system is passive, and air flow is established by the decay heat of the contents of the TSC, it is sufficient to ensure by inspection that the inlet and outlet screens are clear and free of debris that could impede air flow. Because of the passive design of the heat-rejection system, no thermal testing is required.

10.1.8 Cask Identification

Each TSC and concrete cask shall be marked with a model number and an identification number. Each concrete cask will additionally be marked for empty system weight and date of loading. Specific marking instructions are provided on the license drawings for these system components.

10.2 Maintenance Program

A generic maintenance program is defined in an operations manual, which will be provided to system users. The operations manual will provide instructions for the inspection, testing, and component replacements required to ensure continued safe and effective operation and handling of the MAGNASTOR system. System users will develop site-specific maintenance programs and documents.

The MAGNASTOR is totally passive by design. There are no active components or systems required to assure the continued performance of its safety functions during storage operations. This results in a minimal inspection and maintenance program for the lifetime of the system. The routine maintenance requirements and schedule are shown in Table 10.2-1. As shown in the table, the requirements include concrete surface condition inspections and repairs, and reapplication of corrosion-inhibiting coatings on accessible external carbon steel surfaces.

Maintenance activities for the MAGNASTOR shall be performed under the user's approved quality assurance (QA) program. Maintenance activities shall be administratively controlled and the results documented, as required by the QA program.

10.2.1 Structural and Pressure Tests

As described and analyzed in this document, there is no credible event leading to the structural failure of the TSC resulting in the loss of radioactive material confinement. Therefore, periodic structural or pressure tests on the TSC following initial acceptance and loading are not required.

The transfer cask shall be maintained, tested, and inspected in accordance with the routine inspection, maintenance, and annual testing requirements of ANSI N14.6. Prior to each use of the transfer cask, the trunnions and shield door assembly will be inspected for gross damage, adequate lubrication, and proper function. On a maintenance schedule established by the user, the transfer cask corrosion-inhibiting coating will be inspected and repaired in accordance with the coating supplier application procedures. Areas of minor scratching or damage to the coating of the transfer cask found during use may be temporarily repaired using a nuclear grade, pool-compatible grease.

Annually, or prior to the next use if period exceeds one year, the neutron shield tank and expansion tanks of the Passive MAGNASTOR Transfer Cask (PMTC) shall be visually examined in accordance with ASME Code, Section V, Articles 1 and 9 with acceptance per Section III, Subsection NF, Article NF-5360.

If weld defects exceeding acceptance criteria are detected, the area of weld defect(s) shall be identified, repaired and re-examined in accordance with ASME Code, Section III, Subsection

NF, NF-4130. Following repair and completion of required NDE, the hydrostatic test shall be re-performed to the original test acceptance criteria as specified in Section 10.1.2.5.

NDE and post-repair hydrostatic testing of the PMTC neutron shield and expansion tanks shall be performed in accordance with written and approved procedures, and the test results documented.

10.2.2 Leakage Tests

The TSC confinement boundary is provided by a welded vessel and, as described in Chapters 3 and 12, no credible normal conditions or off-normal or accident events result in a loss of confinement. Therefore, maintenance leakage testing of the TSC is not required.

10.2.3 Subsystem Maintenance

The MAGNASTOR does not include any active subsystems that provide safety functions during storage operations. Therefore, no subsystem maintenance is required.

Auxiliary systems used during operations, such as equipment, rigging, and instrumentation used to handle, prepare, and weld the TSC or concrete cask, are maintained and calibrated by the users in accordance with their QA program and the safety importance of the auxiliary system, equipment, instrument, or rigging.

10.2.4 Shielding Tests

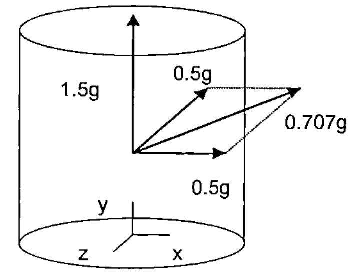
The shielding materials of the TSC, concrete cask, and transfer cask are designed for long-term use with negligible degradation over time as a result of normal operations. Chipping, spalling, or other defects of the concrete cask surface shall be identified by annual visual inspection. Repairs to defects larger than approximately one-inch deep or square shall be performed using grout repair materials applied in accordance with the manufacturer's instructions. Accessible external carbon steel surfaces are inspected annually to verify the integrity of corrosion-inhibiting coatings. Coatings are reapplied as necessary for the repair of the coating in accordance with manufacturer's instructions.

Table 10.2-1 MAGNASTOR Maintenance Program Schedule

Task	Frequency
Visual inspection and repair or recoating of concrete cask concrete and accessible coated carbon steel surfaces	Annually during storage operations
Visual inspection of concrete cask identification markings	Annually
Load testing and/or visual and dimensional inspection of the transfer cask	Annually while transfer cask is in operation, or prior to returning to service
Visual inspection and repair or recoating of MTC1 transfer cask exposed carbon steel surfaces, except on sliding surfaces (does not apply to MTC2 or PMTC)	Annually while transfer cask is in operation, or prior to returning the transfer cask to service
Visual inspection of MTC1 transfer cask exposed carbon steel surfaces and temporary repair of coating surfaces using site-approved materials (does not apply to MTC2 or PMTC)	Quarterly while transfer cask is in operation, or prior to returning the transfer cask to service
Visual examination of welds of PMTC neutron shield and expansion tanks	Annually while PMTC is in operation, or prior to returning the transfer cask to service
Functional check of transfer cask sliding parts to verify adequate lubrication	Each use
Functional check of transfer cask inflatable seals to confirm operability	Each use
Visual inspection of the concrete cask lift lug bolts – if applicable	Prior to each installation

12. Accident Analysis

The off-normal TSC handling loads are defined as 0.5g applied in all directions (i.e., in the global x, y, and z directions) in addition to a 1g lifting load applied in the vertical direction. The resulting off-normal handling accelerations are 0.707g in the lateral direction and 1.5g (0.5g + 1g) in the vertical direction.



The resulting maximum TSC stresses for combined off-normal handling, maximum internal pressure and thermal stress loads are summarized in Section 3.6.

The structural evaluation of the PWR and BWR fuel basket tubes and support weldments for off-normal events is also presented in Section 3.6.

The TSCs and fuel baskets are shown to be structurally adequate for the off-normal handling condition.

12.1.3.4 Corrective Actions

Operations should be halted until the cause of the misalignment, interference or faulty operation is identified and corrected. Since the radiation level of the TSC sides and bottom is high, extreme caution should be exercised if inspection of these surfaces is required.

12.1.3.5 Radiological Impact

There are no radiological consequences associated with this off-normal TSC handling event.

12.1.4 Failure of Instrumentation

MAGNASTOR may use a temperature-sensing system to measure the outlet air temperature at each of the four air outlets on each concrete cask. The air temperature at the outlets may be recorded and reviewed daily. A minimum of two outlet air temperatures must be measured to provide an average outlet temperature to comply with Technical Specifications SURVEILLANCE REQUIREMENT 3.1.2.1.

12.1.4.1 Cause of Instrumentation Failure Event

The temperature instrumentation failure event could occur as a result of instrumentation component failure, or as a result of any event that interrupted power or altered temperature sensor output.

12.1.4.2 Detection of Instrumentation Failure Event

The temperature instrumentation failure event may be identified by the lack of, or an inappropriate, reading at the temperature reader terminal. The event could also be identified by disparities between outlet temperatures in a cask or between similar casks.

12.1.4.3 Analysis of Instrumentation Failure Event

For concrete casks incorporating daily temperature-monitoring systems, the maximum time period during which an increase in the outlet air temperatures may go undetected is 24 hours. The principal condition that could cause an increase in temperature is the blockage of the air inlets. Section 12.2.13 shows that even if all of the air inlets of a single cask are blocked immediately after a temperature measurement, it would take longer than 24 hours before any component approaches its allowable temperature limit. Therefore, there will be sufficient time to identify and correct temperature instrumentation failure events prior to critical system components reaching the temperature limits. During the period of loss of instrumentation, no significant change in TSC temperature will occur under normal conditions. Therefore, instrument failure would be of no consequence when the affected storage cask continues to operate in a normal storage condition.

Because the TSC and the concrete cask are a large heat sink, and because there are few conditions that could result in an outlet temperature increase, the temporary loss of the optional remote sensing and monitoring of the outlet air temperature is not a major concern. No applicable regulatory criteria are violated by the failure of the temperature instrumentation system.

12.1.4.4 Corrective Actions

This event requires that the temperature-monitoring equipment be either replaced or repaired or otherwise returned to operable, or that the concrete cask air inlet screens be visually inspected daily for blockage.

12.1.4.5 Radiological Impact

There are no radiological consequences for this event.

12.1.5 Small Release of Radioactive Particulate From the TSC Exterior

The procedures for loading the TSC provide for operations and measures to minimize TSC exterior surface contact with contaminated spent fuel pool water, and the TSC external surfaces are surveyed, to the extent practical, to verify removable contamination is within allowable limits. The external surfaces of the TSC are rolled or flat stainless steel plates, and the presence of excessive removable contamination on the external surfaces is unlikely. Therefore, radioactive particulate release from the TSC exterior surface is not expected to occur during normal storage operations.

13. Operating Controls & Limits

BASES (continued)

BACKGROUND (cont.)

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 1.0×10^{-7} cm^3 / 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 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. Long-term integrity of the spent fuel 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.

LCO

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 in the TRANSFER CASK); and the Maximum TSC Transfer Time available to complete the transfer of the TSC to the CONCRETE CASK.

(continued)

BASES (continued)

LCO (cont.)

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 of 24 hours of either in-pool cooling or annulus circulating water system (ACWS) or reverse ACWS (R-ACWS) cooling with the TSC backfilled to 75 psig (+10, -0) for TSCs in a MTC and 84 psig (+10, -0) for TSCs in a PMTC 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 a standard MAGNASTOR Transfer Cask (MTC). A Note in Section 2 refers the Licensee to use Table 1.B and 1.D 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 Time in Tables 1.B and 1.D would also be applicable for a second cycle of TSC transfer to the CONCRETE CASK if the first transfer cycle was not completed in the allowed 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.

The table in Section 3 is applicable to PWR TSCs prepared in a Passive MAGNASTOR Transfer Cask (PMTC). 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 PMTC 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 PMTC 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.

APPLICABILITY

The sealed TSC with a dry measured helium mass cavity atmosphere 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.

(continued)

BASES (continued)

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 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 the helium backfill mass or purity requirements are not met prior to TRANSPORT OPERATIONS, an engineering evaluation shall be performed to establish the mass of helium 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. The Completion Time is sufficient to complete an engineering evaluation of the safety significance of the Condition.

AND

B.2

When the mass of helium 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.

(continued)

BASES (continued)

ACTIONS (cont.)	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.
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 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 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 during STORAGE OPERATIONS. 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.
REFERENCES	1. FSAR Sections 4.4 and 9.1.

ACTIONS (cont.)

Thermal analyses of a fully blocked CONCRETE CASK air inlet condition show that fuel cladding and critical basket material accident temperatures and internal pressure limits could be exceeded over time. As a result, requiring immediate verification, or restoration, of adequate heat removal capability will ensure that accident temperature and pressure limits are not exceeded. Once adequate heat removal has been reestablished or verified, the additional actions required to restore the CONCRETE CASK to OPERABLE status can be completed under A.2.

AND

A.2

In addition to Required Action A.1, efforts are required to be continued to restore the CONCRETE CASK heat removal system to OPERABLE.

As long as adequate heat removal capability has been verified to exist, restoring the CONCRETE CASK heat removal system to fully OPERABLE is not an immediate concern. Therefore, restoring it to OPERABLE within 30 days is a reasonable Completion Time.

SURVEILLANCE REQUIREMENTS

SR 3.1.2.1

The long-term integrity of the stored spent fuel is dependent on the continuing ability of the CONCRETE CASK to reject decay heat from the TSC to the ambient environment. Routine verification that the four air inlets and four air outlets are unobstructed and intact ensures that convective airflow through the CONCRETE CASK/TSC annulus is occurring and performing effective heat transfer. Alternatively, the Surveillance Requirement can be fulfilled by measuring the exit air temperature from the four air outlets and determining the temperature rise over the ISFSI ambient air temperature. A minimum of two outlet air temperatures must be measured to provide an average outlet temperature to comply with Technical Specifications SURVEILLANCE REQUIREMENT 3.1.2.1. As long as the temperature increase of the convective airflow is less than the surveillance limits, adequate heat transfer is occurring to maintain CONCRETE CASK, TSC, and spent fuel cladding temperatures below long-term limits.

If partial or complete blockage of the CONCRETE CASK air inlets occurs, the heat rejection system will be rendered inoperable and this LCO is not meet. Immediate corrective actions are to be taken to remove the obstructions from at least two air inlets and air outlets to restore partial air flow, and additional corrective actions are to be taken to remove all air inlet and outlet obstructions and return the CONCRETE CASK to OPERABLE status.

(continued)

BASES (continued)

SURVEILLANCE REQUIREMENTS (continued)	SR 3.1.2.1 (continued) The Frequency of 24 hours is reasonable based on the time necessary for the spent fuel cladding and CONCRETE CASK and TSC component temperatures to reach their short-term temperature limits and the internal pressure to increase to the accident condition pressure limit. The Frequency will allow appropriate corrective actions to be completed in a timely manner.
REFERENCES	FSAR Section 4.4.