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March 22, 2010

U.S. Nuclear Regulatory Commission
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Attn: Document Control Desk

Subject: Submittal of a Request to Amend the U.S. Nuclear Regulatory Commission Certificate of Compliance No. 1031 for the NAC International MAGNASTOR® Cask System

Docket No. 72-1031

References:
1. U.S. Nuclear Regulatory Commission (NRC) Certificate of Compliance (CoC) No. 1031 for the NAC International MAGNASTOR Cask System, Amendment No. 0, February 4, 2009
2. MAGNASTOR Cask System Final Safety Analysis Report (FSAR), Revision 0, NAC International, February 2009

NAC International (NAC) hereby submits a request to amend Reference 1 as follows:

- Addition of various ^{10}B areal densities for use with PWR and BWR baskets
- Correction of the code reference in Table 2.1-2, ASME Code Alternatives for MAGNASTOR Components
- Change of TSC surface contamination limits for loose contamination

This submittal includes eight copies of this transmittal letter and Revision 10A changed pages to the Reference 2 FSAR. The changed pages incorporate the requested amendment. Attachment 1 contains a brief summary of the changes to the FSAR for the amendment. Consistent with NAC administrative practice, this proposed FSAR revision is numbered to uniquely identify the applicable changed pages. Revision bars mark the FSAR text changes on the Revision 10A pages. The included List of Effective Pages identifies the current revision level of all pages in the Reference 2 FSAR.

In order to better facilitate the review process, NAC is providing the Revision 10A change pages as complete sections of the FSAR. Consequently, a number of Revision 10A pages with no revision bars are included. In accordance with NAC's administrative practices, upon final approval of this application, the Revision 10A changed pages will be reformatted and incorporated into the next revision of the NAC-MAGNASTOR FSAR.

The Revision 10A change pages of this application include a number of changes to the MAGNASTOR FSAR, Revision 0, that have been incorporated via the 10 CFR 72.48 process as of March 22, 2010. For clarity, these 72.48 changes are shaded.

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Changes implemented through 10 CFR 72.48 determination include the introduction of MTC1 and MTC2, which refer to two different configurations of the MAGNASTOR transfer cask. The difference is primarily limited to the structural materials (carbon steel versus stainless steel) and the overall length designed to accommodate different lengths of PWR and BWR Transportable Storage Canisters.

This amendment request affects Chapter 1, General Description; Chapter 2, Principal Design Criteria; Chapter 6, Criticality Evaluation; Chapter 10, Acceptance Criteria and Maintenance Program; and Chapter 13, Operating Controls and Limits, Appendix C, Technical Specification Bases for the MAGNASTOR SYSTEM, of the Reference 2 FSAR; and the Technical Specifications Appendix A, Technical Specifications and Design Features for the MAGNASTOR SYSTEM; and Appendix B, Approved Contents for the MAGNASTOR SYSTEM.

The amendment request also includes two revised license drawings associated with the requested changes. Drawing No. 71160-571, Details, Neutron Absorber, Retainer, MAGNASTOR – 37 PWR, and Drawing No. 71160-572, Details, Neutron Absorber, Retainer, MAGNASTOR – 87 BWR, have been revised to refer to the application for minimum effective areal density of the neutron absorber. These drawings also include other changes previously incorporated under 10 CFR 72.48 determination.

Approval of this amendment to Reference 1 and the issuance of the draft CoC/Safety Evaluation Report are requested by November 30, 2010, to support fabrication and equipment delivery schedules planned for 2010 - 2011. Applying the Direct Final Rulemaking process, the estimated/desired Direct Final Rule effective date is May 31, 2011.

If you have any comments or questions, please contact me on my direct line at 678-328-1274.

Sincerely,

Anthony L Patko

Anthony L. Patko
Director, Licensing
Engineering

Attachment 1: List of Changes, MAGNASTOR FSAR, Revision 10A and Technical Specifications, Appendix A and Appendix B

Enclosure

Attachment 1

List of Changes

MAGNASTOR FSAR, Revision 10A and Technical Specifications, Appendix A and Appendix B

March 2010

List of Changes,
MAGNASTOR® FSAR, Revision 10A
Technical Specifications, Appendix A and Appendix B

Proposed Technical Specifications, Appendix A, Changes

Note: The Table of Contents is revised accordingly to reflect the proposed changes

- Pages A3-14 & A3-15 – added new Section 3.3.2, TSC Surface Contamination
- Page A4-1, Section 4.1.1 a), Criticality Control – revised neutron absorber areal density table throughout
- Page A4-2, 1st line – changed "3.25 inches of lead gamma shielding" to "3.2 inches of lead gamma shielding"
- Page A5-1, Section 5.1, Radioactive Effluent Control Program – revised Subsection 5.1.2 throughout and added Subsection 5.1.3
- Page A5-3, Section 5.5, Radiation Protection Program – revised Subsection 5.5.4 adding new 2nd sentence
- Page A5-4, Section 5.8, Preoperational Testing and Training Exercises – revised last paragraph by adding new last sentence

Proposed Technical Specifications, Appendix B, Changes

Note: The Table of Contents is revised accordingly to reflect the proposed changes

- Page B2-2, Table B2-1 – revised I.A.1.b. throughout to add new table and revise other table numbers; revised I.C to change "Table B2-4" to "Table B2-5"
- Page B2-3, Table B2-1 – revised I.C to change table numbers in 2 places from "Tables B2-5 and B2-6" to "Tables B2-6 and B2-7"; revised I.F to change "Table B2-7" to "Table B2-8"
- Page B2-5, Table B2-3 – revised format throughout; former footnote 2 deleted, so former footnote 3 becomes footnote 2
- Page B2-6 – added new Table B2-4
- Page B2-7 – revised table number and table numbers listed in Note
- Page B2-8 – revised table numbers for 3 tables
- Page B2-10, Table B2-9 – revised I.A.1 table numbers; revised I.A.1.b. throughout to add new table and revise other table numbers
- Page B2-11 – revised I.E to change table number from "Table B2-10" to "Table B2-11"
- Page B2-12 – revised table number
- Page B2-13, Table B2-11 – revised format throughout
- Page B2-14 – added new Table B2-12
- Page B2-17 – revised table number for 2 tables

Proposed Technical Specifications, Appendix B, Changes (cont'd)

- Pages B2-18 thru B2-22 – changed "Table B2-13" to "Table B2-15"
- Pages B2-23 thru B2-30 – changed "Table B2-14" to "Table B2-16"
- Pages B2-31 thru B2-35 – changed "Table B2-15" to "Table B2-17"
- Pages B2-36 thru B2-43 – changed "Table B2-16" to "Table B2-18"
- Pages B2-44 thru B2-48 – changed "Table B2-17" to "Table B2-19"
- Pages B2-49 thru B2-56 – changed "Table B2-18" to "Table B2-20"
- Pages B2-57 thru B2-61 – changed "Table B2-19" to "Table B2-21"
- Pages B2-62 thru B2-69 – changed "Table B2-20" to "Table B2-22"
- Pages B2-70 thru B2-74 – changed "Table B2-21" to "Table B2-23"
- Pages B2-75 thru B2-82 – changed "Table B2-22" to "Table B2-24"

MAGNASTOR FSAR Changes

Note: The List of Effective Pages and the Chapter Tables of Contents, Lists of Figures and Lists of Tables were revised as needed to incorporate the following changes.

Chapter 1

- Page 1.8-1, Section 1.8 – revised revision numbers of License Drawings 71160-571 and 71160-572

Chapter 2

- Page 2.1-3, Table 2.1-2, 4th row, last column – added "and 24"; 5th row, last column – added "and 24"
- Page 2.1-4, Table 2.1-2, 1st row, last column – added "and 24"
- Page 2.2-1, Section 2.2.1, 2nd paragraph, 2nd sentence – added "effective neutron absorber sheet areal density of 0.036 ^{10}B g/cm^2 and"; 3rd sentence – added "absorber sheet areal densities and/or"; 5th sentence – added "with maximum initial enrichment/minimum soluble boron content as a function of absorber sheet loading listed in Table 6.4.3-2"
- Page 2.2-2, Section 2.2.2, 2nd paragraph, 3rd sentence – changed "Table 6.4.3-2" to "Table 6.4.3-3" and added ", with maximum initial enrichment as a function of absorber sheet loading listed in Table 6.4.3-4"
- Page 2.4-4, Section 2.4.6.1, 1st paragraph, 5th sentence – revised throughout

MAGNASTOR FSAR Changes (cont'd)

Chapter 6

- Pages 6.1-1 & 6.1-2, Section 6.1.1, 4th paragraph, 5th sentence – revised throughout
- Page 6.1-2, 3rd full paragraph – replaced existing 1st sentence with two new sentences; 4th paragraph – revised thoroughout; 6th paragraph, 1st sentence – revised throughout
- Page 6.1-5, Table 6.1.1-1 – revised throughout & deleted 2nd bullet
- Page 6.1-6, Table 6.1.1-2 – added new table
- Page 6.1-7, Table 6.1.1-3 – revised throughout
- Page 6.1-8, Table 6.1.1-4 – added new table
- Page 6.1-9, Table 6.1.1-5 – added new table
- Page 6.3-3, 1st full bullet, 1st sentence – revised throughout
- Page 6.3-9, Table 6.3.3-2, footnote – revised throughout
- Page 6.4-2, Section 6.4.2.1, 7th sentence – changed "design tolerance" to "thickness tolerance"
- Page 6.4-4, 7th paragraph, 2nd sentence – added "and Table 6.4.3-2"
- Page 6.4-6, 3rd paragraph, 2nd sentence – changed "Table 6.4.3-2" to "Table 6.4.3-3 and Table 6.4.3-4"
- Page 6.4-7, Table 6.4.3-1 – revised throughout & deleted 2nd bullet
- Page 6.4-8, Table 6.4.3-2 – added new table
- Page 6.4-9, Table 6.4.3-3 – added new table
- Page 6.4-10, Table 6.4.3-4 – added new table
- Page 6.7.3-1, Section 6.7.3.1, 3rd paragraph – added new item e.) and new last sentence
- Page 6.7.3-6, Section 6.7.3.2, 1st paragraph – revised throughout
- Page 6.7.3-20, Table 6.7.3-10 – added "and 0.036 ^{10}B g/cm^2 Absorber"
- Page 6.7.3-21, Table 6.7.3-11 – added "and 0.036 ^{10}B g/cm^2 Absorber"
- Page 6.7.3-22, Table 6.7.3-12 – added (0.036 ^{10}B g/cm^2 Absorber)"
- Page 6.7.3-23, Table 6.7.3-13 – added new table
- Page 6.7.6-1, Section 6.7.6.1, 4th paragraph – added new item e.) and new last sentence
- Page 6.7.6-5, 1st paragraph, 2nd sentence – changed "Table 6.7.6-10" to "Table 6.7.6-8"; Section 6.7.6.2, 1st paragraph – revised throughout
- Page 6.7.6-17 – changed "Table 6.7.6-10" to "Table 6.7.6-8"
- Page 6.7.6-18, Table 6.7.6-9 – revised throughout
- Page 6.7.6-19 – changed "Table 6.7.6-8" to "Table 6.7.6-10"
- Page 6.7.6-20, Table 6.7.6-11 – added new table

Chapter 10

- Page 10.1-2, item h) – changed "Articles 1 and 6" to "Articles 1, 6 and 24" in 2 places; item i) – changed "Articles 1 and 7" to "Articles 1, 7 and 25"; item k) – changed "Articles 1 and 6 for PT and Articles 1 and 7 to MT" to "Articles 1, 6 and 24 for PT and Articles 1, 7 and 25 for MT"
- Page 10.1-4, Section 10.1.2.2, 2nd paragraph, last sentence – revised throughout

Chapter 13

In accordance with the proposed Appendix A and Appendix B Technical Specification changes, Appendix C, Technical Specification Bases for the MAGNASTOR SYSTEM, Chapter 13 of the MAGNASTOR FSAR (including the Table of Contents), is being revised as follows:

- Page 13C-2, Section 2.0, Approved Contents, Subsection 2.1, Fuel Specifications and Loading Conditions – Background, 3rd paragraph – changed "Table 2-1 and 2-8" to "Tables 2-1 and 2-9"; Approved Contents, 1st sentence – changed "Tables 2-1 and 2-8" to "Tables 2-1 and 2-9"; 3rd sentence – changed "Tables 2-2 through 2-7 and Tables 2-9 through 2-12" to "Tables 2-2 through 2-8 and Tables 2-10 through 2-14"
- Pages 13C-24 thru 13C-26 – added new Section 3.3.2, TSC Surface Contamination

Proposed MAGNASTOR$^{®}$ CoC Change(s) – Technical Specifications, Appendix A

Appendix A
Table of Contents

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		0.334	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		0.334	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 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. 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 orthogonal (x, y) pitch

PWR basket — 9.249 inches
BWR basket — 6.166 inches

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

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minimum radiation shield equivalent to 2 inches of 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.

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:

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

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

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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.

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, 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 flammable liquid.

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.

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.

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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)(2)(i)(C), 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.

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.

Proposed MAGNASTOR® CoC Change(s) – Technical Specifications, Appendix B

Appendix B
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List of Figures

List of Tables

Table B2-1 PWR Fuel Assembly Limits

I. PWR Fuel

A. Allowable Contents

1. Uranium PWR UNDAMAGED FUEL ASSEMBLIES listed in Tables 2-2 and 2-3 *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 fuel 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 fuel assemblies, maximum enrichments represent peak rod enrichments. Combined minimum enrichment, maximum assembly average burnup and minimum cool time limits are shown in Tables B2-15 through B2-22. For assembly average burnup levels below those shown in Tables B2-15 through B2-22, an assembly minimum cool time is specified in Table B2-13, provided that the minimum initial assembly average enrichment limits are applied.
c. Decay Heat Per Assembly (Preferential Loading):	≤1,200 watts
d. Nominal Fresh Fuel Assembly Length (in.):	≤178.3
e. Nominal Fresh Fuel Assembly Width (in.):	≤ 8.54
f. Fuel Assembly Weight (lbs.):	≤1,680, including nonfuel-bearing components

B. Quantity per TSC: Up to 37 PWR UNDAMAGED FUEL ASSEMBLIES. Fuel storage locations not containing a fuel assembly shall have an empty fuel cell insert installed.

C. PWR UNDAMAGED FUEL ASSEMBLIES may contain a flow mixer (thimble plug), instrument thimble, a burnable poison rod assembly, or a control element assembly consistent with Table B2-2. Nonfuel hardware may be located within the active fuel elevation of either the guide tubes or the instrument tube. Nonfuel hardware must not be located in the active fuel elevation of the guide tubes and the instrument tube simultaneously. 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. Assemblies may have stainless steel rods inserted to displace guide tube "dashpot" water. Loading activated nonfuel hardware requires extended fuel assembly cool times, and Table B2-5 presents the additional fuel assembly cool times required. Minimum BPRA

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Table B2-1 PWR Fuel Assembly Limits (continued)

and thimble plug cool times as a function of burnup (exposure) are shown in Tables 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 fuel assemblies to facilitate handling.

E. Unenriched 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.

F. Fuel may be loaded uniformly at a maximum heat load of 959 watts/assembly. Alternatively, a preferential loading pattern may be applied as described in Table B2-8 and Figure B2-1.

G. CEAs are restricted to the center 9 basket locations. Minimum CEA cool time is 10 years with a maximum equivalent exposure of 180,000 MWd/MTU.

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	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

- 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.
- Maximum uniform heat load is 959 watts per storage location.

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.

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

	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%	4.0%	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%	4.0%	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%	4.0%	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%	4.0%	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%	4.0%	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%

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

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

Table B2-5 Additional Fuel Assembly Cool Time Required to Load PWR Nonfuel Hardware

Core (Assembly)	Cool Time (years)		
	BPRA	TP	CEA
CE 14×14	--	--	0.1
WE 14×14	0.5	0.1	0.5
WE 15×15	0.5	0.1	0.7
B&W 15×15	0.1	0.1	0.1
CE 16×16	--	--	0.1
WE 17×17	0.5	0.1	0.7
B&W 17×17	0.1	0.1	0.1

Note: Additional fuel assembly cooling time to be added to the minimum fuel assembly cool time based on assembly initial enrichment and assembly average burnup listed in Table 2-15 through 2-22.

Table B2-6 Allowed BPRA 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 Thimble Plug 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 Definition

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

Figure B2-1 Schematic of PWR Fuel Preferential Loading Pattern

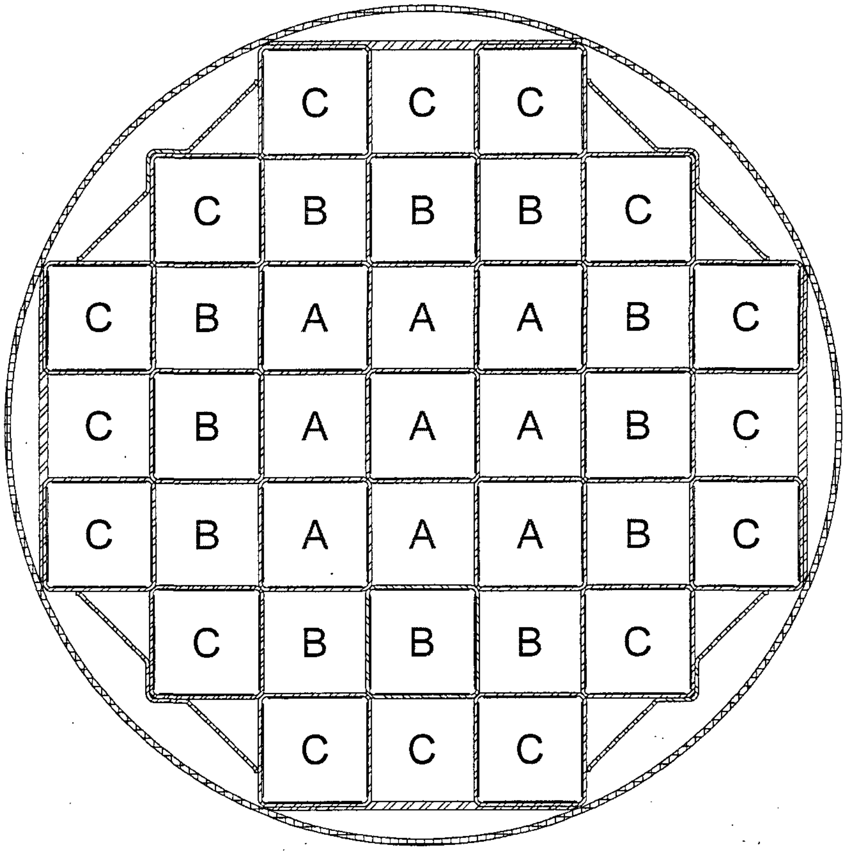

Table B2-9 BWR Fuel Assembly Limits

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 fuel 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 assembly average burnup and minimum cool time limits are shown in Table B2-23 and Table B2-24. For assembly average burnup levels below those shown in Table B2-23 and Table B2-24, an assembly minimum cool time is specified in Table B2-14, provided that the minimum initial assembly average enrichment limits are applied.
c. Decay Heat per Assembly:	≤ 379 watts
d. Nominal Fresh Fuel Design Assembly Length (in.):	≤ 176.2
e. Nominal Fresh Fuel Design Assembly Width (in.):	≤ 5.52
f. Fuel Assembly Weight (lb):	≤ 704, including channels

B. Quantity per TSC: Up to 87 BWR UNDAMAGED FUEL 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 82-assembly configuration, the center cell weldment and upper weldments with blocking strap must be in place to physically block the designated nonfuel locations.

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.

(continued)

E. Assembly lattices not containing the assembly type-specific nominal number of 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 fuel assemblies to facilitate handling.

G. Unenriched 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 fuel assembly locations for the 82-assembly fuel basket configuration are shown in Figure B2-2.

Table B2-10 BWR Fuel 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)	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 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.

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

Table B2-11 BWR Fuel 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 2-3.
[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.

Table B2-12 BWR Fuel 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%	3.6%	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%	4.3%	3.4%	4.1%	3.4%	4.0%
B9_76A	3.5%	4.2%	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%	3.6%	4.3%	3.5%	4.1%
B10_92A	3.8%	4.5%	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%

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[a] Maximum planar average.

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

Figure B2-2 82-Assembly BWR Basket Pattern

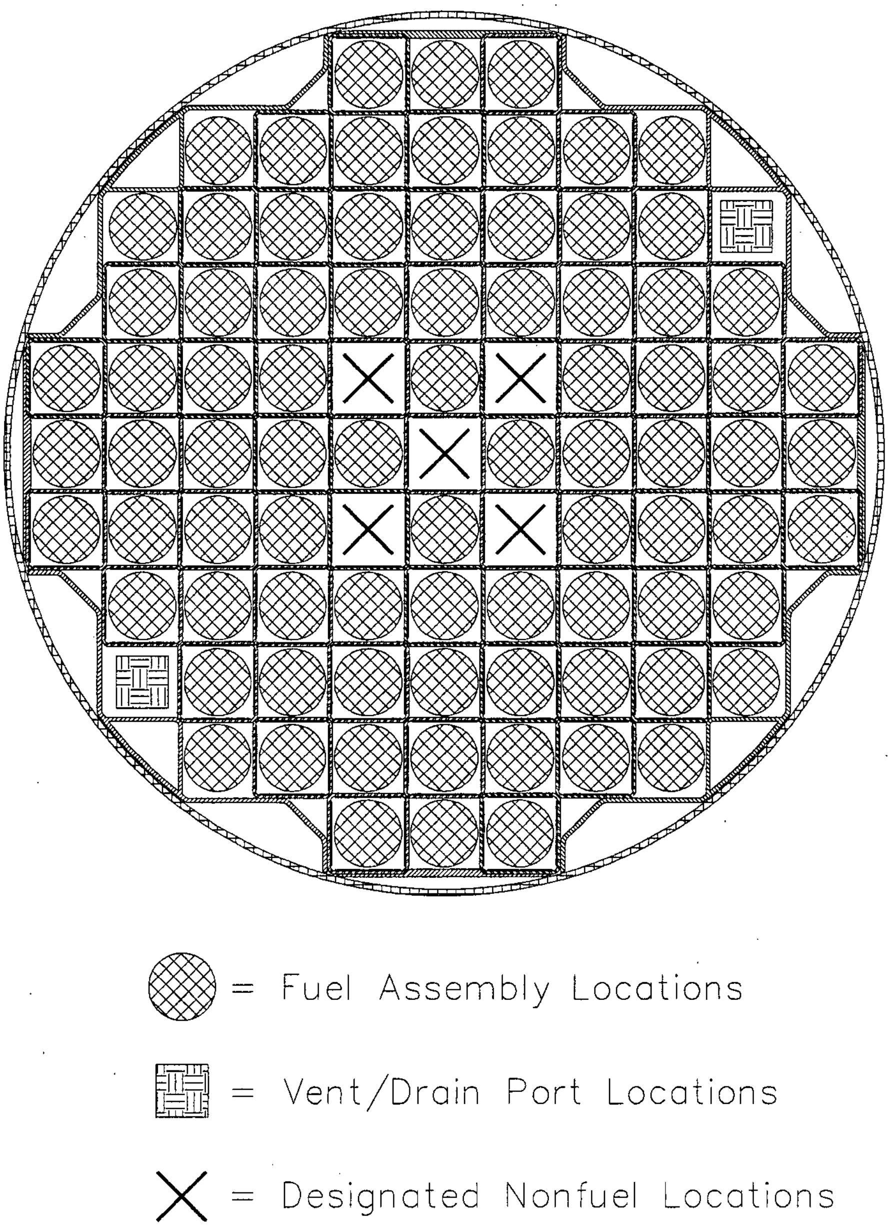
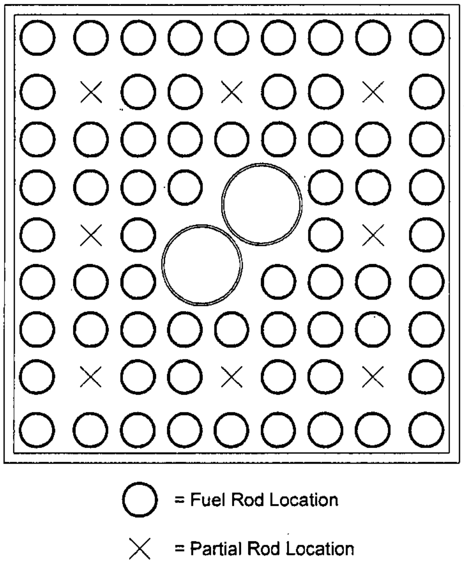
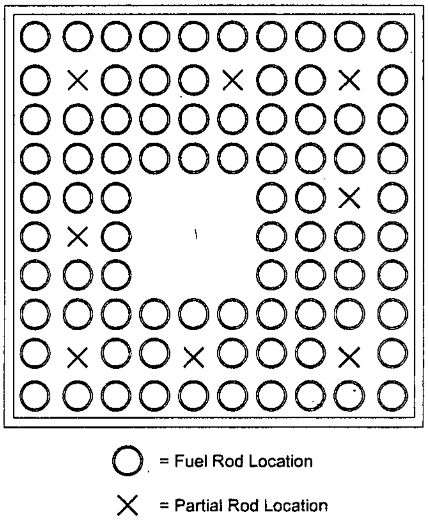


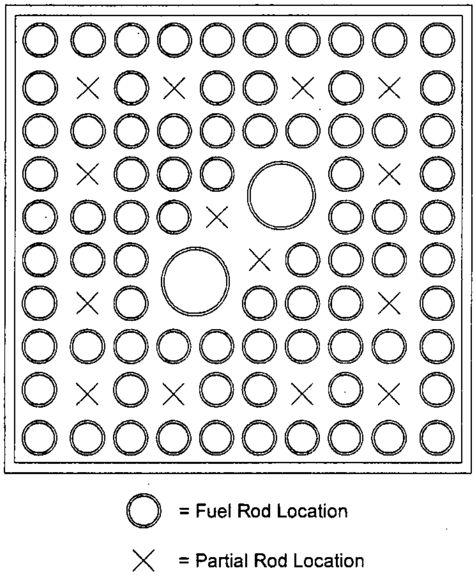
Figure B2-3 BWR Partial Length Fuel Rod Location Sketches



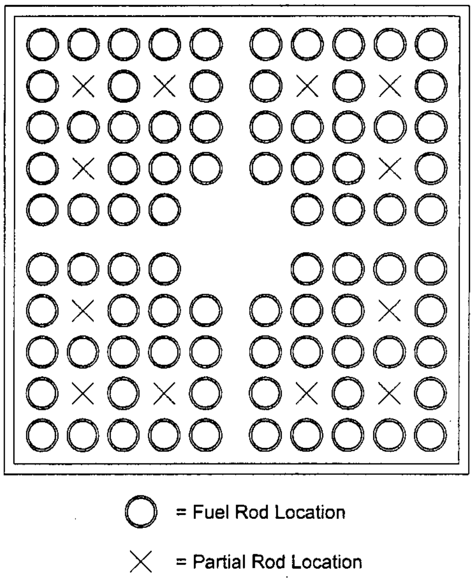
B9_74A 8 Partial Length Rods



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 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 Assembly Average Burnup Enrichment Limits

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	4.0
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	4.1	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

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 B2-16 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

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	12.9	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
$2.1 \leq E < 2.3$	-	-	-	-	-	-	-
$2.3 \leq E < 2.5$	4.0	4.0	4.3	4.4	4.2	4.4	4.4
$2.5 \leq E < 2.7$	4.0	4.0	4.3	4.4	4.1	4.4	4.4
$2.7 \leq E < 2.9$	4.0	4.0	4.2	4.3	4.1	4.3	4.3
$2.9 \leq E < 3.1$	4.0	4.0	4.2	4.3	4.0	4.3	4.3
$3.1 \leq E < 3.3$	4.0	4.0	4.1	4.2	4.0	4.2	4.2
$3.3 \leq E < 3.5$	4.0	4.0	4.1	4.2	4.0	4.2	4.2
$3.5 \leq E < 3.7$	4.0	4.0	4.0	4.2	4.0	4.2	4.2
$3.7 \leq E < 3.9$	4.0	4.0	4.0	4.1	4.0	4.1	4.1
$3.9 \leq E < 4.1$	4.0	4.0	4.0	4.1	4.0	4.1	4.1
$4.1 \leq E < 4.3$	4.0	4.0	4.0	4.0	4.0	4.0	4.0
$4.3 \leq E < 4.5$	4.0	4.0	4.0	4.0	4.0	4.0	4.0
$4.5 \leq E < 4.7$	4.0	4.0	4.0	4.0	4.0	4.0	4.0
$4.7 \leq E < 4.9$	4.0	4.0	4.0	4.0	4.0	4.0	4.0
$E \geq 4.9$	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
$2.1 \leq E < 2.3$	-	-	-	-	-	-	-
$2.3 \leq E < 2.5$	-	-	-	-	-	-	-
$2.5 \leq E < 2.7$	4.0	4.1	4.6	4.8	4.4	4.7	4.7
$2.7 \leq E < 2.9$	4.0	4.0	4.6	4.7	4.4	4.7	4.7
$2.9 \leq E < 3.1$	4.0	4.0	4.5	4.6	4.3	4.6	4.6
$3.1 \leq E < 3.3$	4.0	4.0	4.5	4.6	4.3	4.5	4.5
$3.3 \leq E < 3.5$	4.0	4.0	4.4	4.5	4.2	4.5	4.5
$3.5 \leq E < 3.7$	4.0	4.0	4.4	4.5	4.2	4.5	4.4
$3.7 \leq E < 3.9$	4.0	4.0	4.3	4.4	4.1	4.4	4.4
$3.9 \leq E < 4.1$	4.0	4.0	4.3	4.4	4.1	4.4	4.4
$4.1 \leq E < 4.3$	4.0	4.0	4.2	4.3	4.1	4.3	4.3
$4.3 \leq E < 4.5$	4.0	4.0	4.2	4.3	4.0	4.3	4.3
$4.5 \leq E < 4.7$	4.0	4.0	4.2	4.3	4.0	4.3	4.3
$4.7 \leq E < 4.9$	4.0	4.0	4.1	4.3	4.0	4.3	4.3
$E \geq 4.9$	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

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 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	5.2	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 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	5.4	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
$2.1 \le E < 2.3$	-	-	-	-	-	-	-
$2.3 \le E < 2.5$	-	-	-	-	-	-	-
$2.5 \le E < 2.7$	-	-	-	-	-	-	-
$2.7 \le E < 2.9$	5.6	5.8	6.8	7.0	6.3	6.9	6.9
$2.9 \le E < 3.1$	5.5	5.7	6.7	6.9	6.1	6.8	6.7
$3.1 \le E < 3.3$	5.4	5.6	6.5	6.8	6.0	6.6	6.6
$3.3 \le E < 3.5$	5.3	5.5	6.4	6.7	5.9	6.5	6.5
$3.5 \le E < 3.7$	5.2	5.4	6.3	6.6	5.9	6.4	6.4
$3.7 \le E < 3.9$	5.2	5.3	6.2	6.5	5.8	6.3	6.3
$3.9 \le E < 4.1$	5.1	5.2	6.1	6.4	5.7	6.2	6.2
$4.1 \le E < 4.3$	5.0	5.2	6.0	6.3	5.7	6.1	6.1
$4.3 \le E < 4.5$	5.0	5.1	5.9	6.2	5.6	6.0	6.0
$4.5 \le E < 4.7$	4.9	5.0	5.9	6.1	5.5	6.0	6.0
$4.7 \le E < 4.9$	4.8	5.0	5.8	6.0	5.5	5.9	5.9
$E \ge 4.9$	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
$2.1 \le E < 2.3$	-	-	-	-	-	-	-
$2.3 \le E < 2.5$	-	-	-	-	-	-	-
$2.5 \le E < 2.7$	-	-	-	-	-	-	-
$2.7 \le E < 2.9$	-	-	-	-	-	-	-
$2.9 \le E < 3.1$	5.7	5.8	6.9	7.3	6.4	7.0	7.0
$3.1 \le E < 3.3$	5.6	5.7	6.8	7.1	6.3	6.9	6.9
$3.3 \le E < 3.5$	5.5	5.6	6.7	7.0	6.2	6.8	6.8
$3.5 \le E < 3.7$	5.4	5.5	6.6	6.9	6.0	6.7	6.7
$3.7 \le E < 3.9$	5.4	5.5	6.5	6.8	6.0	6.6	6.6
$3.9 \le E < 4.1$	5.3	5.4	6.4	6.7	5.9	6.5	6.5
$4.1 \le E < 4.3$	5.2	5.3	6.3	6.6	5.8	6.4	6.4
$4.3 \le E < 4.5$	5.1	5.2	6.2	6.5	5.8	6.3	6.3
$4.5 \le E < 4.7$	5.0	5.2	6.1	6.4	5.7	6.2	6.2
$4.7 \le E < 4.9$	5.0	5.1	6.0	6.3	5.7	6.2	6.2
$E \ge 4.9$	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 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	7.9	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	8.7	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 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	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 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	4.9	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 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	6.5	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	-	-	-	-	-	-	-
2.3 ≤ E < 2.5	-	-	-	-	-	-	-
2.5 ≤ E < 2.7	6.2	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

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 B2-20 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	8.7	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 % ^{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	7.5	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	8.1	8.7	7.4	8.3	8.3

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	7.9	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

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 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	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	9.1	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 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	8.7	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
$2.1 \le E < 2.3$	-	-	-	-	-	-	-
$2.3 \le E < 2.5$	-	-	-	-	-	-	-
$2.5 \le E < 2.7$	-	-	-	-	-	-	-
$2.7 \le E < 2.9$	-	-	-	-	-	-	-
$2.9 \le E < 3.1$	8.9	9.5	12.6	13.7	11.0	12.8	12.8
$3.1 \le E < 3.3$	8.7	9.3	12.2	13.3	10.7	12.5	12.4
$3.3 \le E < 3.5$	8.5	9.0	11.9	13.0	10.5	12.1	12.1
$3.5 \le E < 3.7$	8.4	8.8	11.7	12.7	10.2	11.9	11.9
$3.7 \le E < 3.9$	8.2	8.7	11.5	12.4	10.0	11.7	11.6
$3.9 \le E < 4.1$	8.0	8.5	11.2	12.2	9.8	11.5	11.4
$4.1 \le E < 4.3$	7.9	8.4	11.0	11.9	9.6	11.3	11.2
$4.3 \le E < 4.5$	7.8	8.2	10.9	11.8	9.5	11.1	11.0
$4.5 \le E < 4.7$	7.7	8.1	10.7	11.6	9.3	10.9	10.9
$4.7 \le E < 4.9$	7.6	8.0	10.5	11.4	9.2	10.8	10.7
$E \ge 4.9$	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
$2.1 \le E < 2.3$	-	-	-	-	-	-	-
$2.3 \le E < 2.5$	-	-	-	-	-	-	-
$2.5 \le E < 2.7$	-	-	-	-	-	-	-
$2.7 \le E < 2.9$	-	-	-	-	-	-	-
$2.9 \le E < 3.1$	9.5	10.1	13.5	14.3	11.7	13.7	13.7
$3.1 \le E < 3.3$	9.2	9.8	13.2	13.9	11.5	13.4	13.4
$3.3 \le E < 3.5$	9.0	9.6	12.8	13.6	11.2	13.1	13.0
$3.5 \le E < 3.7$	8.8	9.4	12.5	13.3	10.9	12.8	12.7
$3.7 \le E < 3.9$	8.7	9.2	12.2	13.0	10.7	12.5	12.4
$3.9 \le E < 4.1$	8.5	9.0	12.0	12.8	10.4	12.2	12.2
$4.1 \le E < 4.3$	8.3	8.9	11.8	12.5	10.2	12.0	11.9
$4.3 \le E < 4.5$	8.2	8.7	11.6	12.3	10.0	11.8	11.8
$4.5 \le E < 4.7$	8.1	8.6	11.4	12.1	9.9	11.6	11.6
$4.7 \le E < 4.9$	8.0	8.5	11.2	11.9	9.8	11.5	11.5
$E \ge 4.9$	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 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	11.2	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 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	11.9	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 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	12.6	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 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	13.5	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	19.1	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	18.4	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
$2.1 \le E < 2.3$	4.8	4.9	5.6	5.7	5.2	5.6	5.6
$2.3 \le E < 2.5$	4.7	4.8	5.5	5.7	5.2	5.6	5.6
$2.5 \le E < 2.7$	4.7	4.8	5.4	5.6	5.1	5.5	5.5
$2.7 \le E < 2.9$	4.6	4.7	5.4	5.5	5.0	5.5	5.5
$2.9 \le E < 3.1$	4.6	4.7	5.3	5.5	5.0	5.4	5.4
$3.1 \le E < 3.3$	4.5	4.6	5.3	5.4	5.0	5.3	5.3
$3.3 \le E < 3.5$	4.5	4.6	5.2	5.4	4.9	5.3	5.3
$3.5 \le E < 3.7$	4.5	4.5	5.1	5.3	4.9	5.2	5.2
$3.7 \le E < 3.9$	4.4	4.5	5.1	5.3	4.8	5.2	5.2
$3.9 \le E < 4.1$	4.4	4.5	5.0	5.2	4.8	5.2	5.1
$4.1 \le E < 4.3$	4.4	4.4	5.0	5.2	4.8	5.1	5.1
$4.3 \le E < 4.5$	4.3	4.4	5.0	5.1	4.8	5.1	5.1
$4.5 \le E < 4.7$	4.3	4.4	5.0	5.1	4.7	5.0	5.0
$4.7 \le E < 4.9$	4.3	4.4	4.9	5.1	4.7	5.0	5.0
$E \ge 4.9$	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
$2.1 \le E < 2.3$	-	-	-	-	-	-	-
$2.3 \le E < 2.5$	5.2	5.3	6.0	6.3	5.7	6.1	6.1
$2.5 \le E < 2.7$	5.1	5.2	6.0	6.2	5.7	6.0	6.0
$2.7 \le E < 2.9$	5.0	5.2	5.9	6.1	5.6	6.0	6.0
$2.9 \le E < 3.1$	5.0	5.1	5.9	6.0	5.5	5.9	5.9
$3.1 \le E < 3.3$	4.9	5.0	5.8	6.0	5.5	5.9	5.9
$3.3 \le E < 3.5$	4.9	5.0	5.8	5.9	5.4	5.8	5.8
$3.5 \le E < 3.7$	4.9	4.9	5.7	5.9	5.4	5.8	5.8
$3.7 \le E < 3.9$	4.8	4.9	5.7	5.8	5.3	5.8	5.8
$3.9 \le E < 4.1$	4.8	4.9	5.6	5.8	5.3	5.7	5.7
$4.1 \le E < 4.3$	4.7	4.8	5.6	5.8	5.2	5.7	5.7
$4.3 \le E < 4.5$	4.7	4.8	5.5	5.7	5.2	5.6	5.6
$4.5 \le E < 4.7$	4.7	4.8	5.5	5.7	5.2	5.6	5.6
$4.7 \le E < 4.9$	4.6	4.7	5.5	5.7	5.1	5.6	5.6
$E \ge 4.9$	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

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
$2.1 \le E < 2.3$	-	-	-	-	-	-	-
$2.3 \le E < 2.5$	-	-	-	-	-	-	-
$2.5 \le E < 2.7$	-	-	-	-	-	-	-
$2.7 \le E < 2.9$	9.9	10.6	13.8	15.0	12.0	13.9	13.9
$2.9 \le E < 3.1$	9.7	10.3	13.5	14.7	11.7	13.7	13.7
$3.1 \le E < 3.3$	9.4	10.0	13.2	14.4	11.4	13.4	13.4
$3.3 \le E < 3.5$	9.2	9.8	12.9	14.0	11.2	13.1	13.1
$3.5 \le E < 3.7$	9.0	9.6	12.7	13.8	11.0	12.9	12.8
$3.7 \le E < 3.9$	8.9	9.4	12.4	13.6	10.8	12.6	12.6
$3.9 \le E < 4.1$	8.8	9.3	12.2	13.4	10.6	12.5	12.4
$4.1 \le E < 4.3$	8.6	9.1	12.0	13.2	10.4	12.2	12.2
$4.3 \le E < 4.5$	8.5	9.0	11.8	13.0	10.3	12.1	12.0
$4.5 \le E < 4.7$	8.4	8.9	11.7	12.8	10.1	11.9	11.9
$4.7 \le E < 4.9$	8.3	8.8	11.6	12.7	10.0	11.8	11.8
$E \ge 4.9$	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
$2.1 \le E < 2.3$	-	-	-	-	-	-	-
$2.3 \le E < 2.5$	-	-	-	-	-	-	-
$2.5 \le E < 2.7$	-	-	-	-	-	-	-
$2.7 \le E < 2.9$	10.6	11.4	14.9	16.1	12.9	15.1	15.1
$2.9 \le E < 3.1$	10.4	11.1	14.5	15.8	12.5	14.7	14.7
$3.1 \le E < 3.3$	10.0	10.8	14.1	15.5	12.2	14.4	14.4
$3.3 \le E < 3.5$	9.9	10.5	13.9	15.2	12.0	14.1	14.0
$3.5 \le E < 3.7$	9.6	10.3	13.6	14.9	11.8	13.8	13.8
$3.7 \le E < 3.9$	9.5	10.1	13.4	14.6	11.6	13.6	13.6
$3.9 \le E < 4.1$	9.3	9.9	13.2	14.4	11.4	13.4	13.4
$4.1 \le E < 4.3$	9.1	9.8	13.0	14.1	11.2	13.2	13.2
$4.3 \le E < 4.5$	9.0	9.6	12.8	14.0	11.1	13.0	13.0
$4.5 \le E < 4.7$	8.9	9.5	12.6	13.8	10.9	12.9	12.8
$4.7 \le E < 4.9$	8.8	9.3	12.4	13.6	10.8	12.7	12.7
$E \ge 4.9$	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	12.7	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

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 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	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 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	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	16.7	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	19.1	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	18.5	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 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	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	20.7	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 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	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	23.0	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 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	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	22.7	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	25.3	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 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	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
$2.1 \le E < 2.3$	-	-	-	-	-	-	-
$2.3 \le E < 2.5$	5.2	5.6	4.7	5.4	4.4	5.4	5.2
$2.5 \le E < 2.7$	5.1	5.5	4.7	5.3	4.3	5.3	5.2
$2.7 \le E < 2.9$	5.0	5.4	4.6	5.3	4.3	5.2	5.1
$2.9 \le E < 3.1$	4.9	5.4	4.5	5.2	4.2	5.1	5.0
$3.1 \le E < 3.3$	4.9	5.3	4.5	5.1	4.1	5.1	4.9
$3.3 \le E < 3.5$	4.8	5.2	4.4	5.0	4.1	5.0	4.9
$3.5 \le E < 3.7$	4.8	5.1	4.4	5.0	4.0	4.9	4.8
$3.7 \le E < 3.9$	4.7	5.1	4.3	4.9	4.0	4.9	4.8
$3.9 \le E < 4.1$	4.6	5.0	4.3	4.9	4.0	4.9	4.7
$4.1 \le E < 4.3$	4.6	5.0	4.3	4.9	4.0	4.8	4.7
$4.3 \le E < 4.5$	4.6	4.9	4.2	4.8	4.0	4.8	4.7
$4.5 \le E < 4.7$	4.5	4.9	4.2	4.8	4.0	4.7	4.6
$4.7 \le E < 4.9$	4.5	4.9	4.1	4.7	4.0	4.7	4.6
$E \ge 4.9$	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
$2.1 \le E < 2.3$	-	-	-	-	-	-	-
$2.3 \le E < 2.5$	-	-	-	-	-	-	-
$2.5 \le E < 2.7$	5.7	6.1	5.2	5.9	4.7	5.9	5.7
$2.7 \le E < 2.9$	5.6	6.0	5.1	5.8	4.6	5.8	5.7
$2.9 \le E < 3.1$	5.5	5.9	5.0	5.8	4.6	5.7	5.6
$3.1 \le E < 3.3$	5.5	5.9	4.9	5.7	4.5	5.6	5.5
$3.3 \le E < 3.5$	5.4	5.8	4.9	5.6	4.4	5.6	5.4
$3.5 \le E < 3.7$	5.3	5.7	4.8	5.6	4.4	5.5	5.4
$3.7 \le E < 3.9$	5.2	5.7	4.7	5.5	4.3	5.4	5.3
$3.9 \le E < 4.1$	5.2	5.6	4.7	5.4	4.3	5.4	5.2
$4.1 \le E < 4.3$	5.1	5.6	4.6	5.4	4.3	5.3	5.2
$4.3 \le E < 4.5$	5.0	5.5	4.6	5.3	4.2	5.3	5.1
$4.5 \le E < 4.7$	5.0	5.5	4.5	5.3	4.2	5.2	5.0
$4.7 \le E < 4.9$	5.0	5.4	4.5	5.2	4.1	5.2	5.0
$E \ge 4.9$	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	7.6	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
$2.1 \le E < 2.3$	-	-	-	-	-	-	-
$2.3 \le E < 2.5$	-	-	-	-	-	-	-
$2.5 \le E < 2.7$	-	-	-	-	-	-	-
$2.7 \le E < 2.9$	-	-	-	-	-	-	-
$2.9 \le E < 3.1$	11.8	12.9	9.6	12.0	8.0	11.8	11.1
$3.1 \le E < 3.3$	11.5	12.6	9.4	11.7	7.8	11.5	10.9
$3.3 \le E < 3.5$	11.2	12.3	9.1	11.5	7.6	11.2	10.6
$3.5 \le E < 3.7$	10.9	11.9	8.9	11.1	7.5	11.0	10.3
$3.7 \le E < 3.9$	10.7	11.8	8.7	10.9	7.3	10.7	10.0
$3.9 \le E < 4.1$	10.4	11.6	8.6	10.7	7.2	10.5	9.9
$4.1 \le E < 4.3$	10.3	11.3	8.4	10.5	7.0	10.3	9.7
$4.3 \le E < 4.5$	10.0	11.2	8.3	10.4	7.0	10.1	9.6
$4.5 \le E < 4.7$	9.9	11.0	8.1	10.1	6.8	9.9	9.4
$4.7 \le E < 4.9$	9.8	10.9	8.0	10.0	6.8	9.8	9.3
$E \ge 4.9$	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
$2.1 \le E < 2.3$	-	-	-	-	-	-	-
$2.3 \le E < 2.5$	-	-	-	-	-	-	-
$2.5 \le E < 2.7$	-	-	-	-	-	-	-
$2.7 \le E < 2.9$	-	-	-	-	-	-	-
$2.9 \le E < 3.1$	12.7	13.9	10.3	12.9	8.4	12.6	11.9
$3.1 \le E < 3.3$	12.3	13.4	10.0	12.5	8.2	12.3	11.6
$3.3 \le E < 3.5$	11.9	13.2	9.8	12.1	8.0	11.9	11.3
$3.5 \le E < 3.7$	11.7	12.9	9.5	11.9	7.9	11.7	11.0
$3.7 \le E < 3.9$	11.5	12.6	9.3	11.7	7.7	11.4	10.8
$3.9 \le E < 4.1$	11.2	12.4	9.1	11.5	7.6	11.3	10.5
$4.1 \le E < 4.3$	11.0	12.1	8.9	11.3	7.4	11.0	10.3
$4.3 \le E < 4.5$	10.8	11.8	8.8	11.1	7.3	10.9	10.2
$4.5 \le E < 4.7$	10.6	11.7	8.7	10.9	7.2	10.7	10.0
$4.7 \le E < 4.9$	10.5	11.6	8.5	10.7	7.1	10.5	9.9
$E \ge 4.9$	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
$2.1 \le E < 2.3$	-	-	-	-	-	-	-
$2.3 \le E < 2.5$	-	-	-	-	-	-	-
$2.5 \le E < 2.7$	-	-	-	-	-	-	-
$2.7 \le E < 2.9$	-	-	-	-	-	-	-
$2.9 \le E < 3.1$	-	-	-	-	-	-	-
$3.1 \le E < 3.3$	16.8	18.4	13.8	17.2	11.1	16.9	16.0
$3.3 \le E < 3.5$	16.5	18.1	13.5	16.8	10.9	16.4	15.5
$3.5 \le E < 3.7$	16.0	17.7	13.1	16.4	10.5	16.2	15.2
$3.7 \le E < 3.9$	15.7	17.3	12.9	16.1	10.2	15.7	14.8
$3.9 \le E < 4.1$	15.4	17.1	12.5	15.8	10.0	15.4	14.5
$4.1 \le E < 4.3$	15.1	16.8	12.2	15.4	9.8	15.2	14.3
$4.3 \le E < 4.5$	14.8	16.4	12.0	15.2	9.6	14.8	14.0
$4.5 \le E < 4.7$	14.6	16.2	11.8	15.0	9.4	14.7	13.8
$4.7 \le E < 4.9$	14.3	15.9	11.6	14.7	9.2	14.4	13.5
$E \ge 4.9$	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
$2.1 \le E < 2.3$	-	-	-	-	-	-	-
$2.3 \le E < 2.5$	-	-	-	-	-	-	-
$2.5 \le E < 2.7$	-	-	-	-	-	-	-
$2.7 \le E < 2.9$	-	-	-	-	-	-	-
$2.9 \le E < 3.1$	-	-	-	-	-	-	-
$3.1 \le E < 3.3$	17.8	19.5	14.8	18.2	11.8	17.8	16.8
$3.3 \le E < 3.5$	17.3	19.1	14.4	17.7	11.5	17.5	16.5
$3.5 \le E < 3.7$	17.0	18.7	14.0	17.4	11.2	17.1	16.1
$3.7 \le E < 3.9$	16.6	18.3	13.6	17.0	10.9	16.8	15.7
$3.9 \le E < 4.1$	16.3	17.9	13.3	16.7	10.6	16.4	15.4
$4.1 \le E < 4.3$	15.9	17.7	13.1	16.3	10.3	16.1	15.1
$4.3 \le E < 4.5$	15.7	17.4	12.8	16.1	10.1	15.8	14.8
$4.5 \le E < 4.7$	15.5	17.1	12.5	15.9	9.9	15.5	14.6
$4.7 \le E < 4.9$	15.2	16.9	12.3	15.6	9.8	15.3	14.4
$E \ge 4.9$	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

March 2010

Revision 10A

MAGNASTOR®

(Modular Advanced Generation
Nuclear All-purpose STORage)

FINAL SAFETY ANALYSIS REPORT

Docket No. 72-1031

NAC
INTERNATIONAL

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Chapter 1

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	5
71160-556	Assembly, MAGNASTOR Transfer Cask (MTC), Stainless Steel	1
71160-560	Assembly, Standard Transfer Cask, MAGNASTOR	1
71160-561	Structure, Weldment, Concrete Cask, MAGNASTOR	5
71160-562	Reinforcing Bar and Concrete Placement, Concrete Cask, MAGNASTOR	3
71160-571	Details, Neutron Absorber, Retainer, MAGNASTOR – 37 PWR	7
71160-572	Details, Neutron Absorber, Retainer, MAGNASTOR – 87 BWR	6
71160-574	Basket Support Weldments, MAGNASTOR – 37 PWR	4
71160-575	Basket Assembly, MAGNASTOR – 37 PWR	7
71160-581	Shell Weldment, Canister, MAGNASTOR	3
71160-584	Details, Canister, MAGNASTOR	3
71160-585	TSC Assembly, MAGNASTOR	6
71160-590	Loaded Concrete Cask, MAGNASTOR	4
71160-591	Fuel Tube Assembly, MAGNASTOR – 87 BWR	5
71160-598	Basket Support Weldments, MAGNASTOR – 87 BWR	4
71160-599	Basket Assembly, MAGNASTOR – 87 BWR	5
71160-600	Basket Assembly, MAGNASTOR – 82 BWR	3

Figure Withheld Under 10 CFR 2.390

NAC INTERNATIONAL

DETAILS,
NEUTRON ABSORBER, RETAINER,
MAGNASTOR – 37 PWR

PROJECT 71160		DRAWING 571	REV 7
		SH 1 OF 1	7:45AM 1-15-2010

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1

Figure Withheld Under 10 CFR 2.390

NAC INTERNATIONAL

DETAILS,
NEUTRON ABSORBER, RETAINER,
MAGNASTOR – 87 BWR

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PROJECT 71160		DRAWING 572	REV 6
		SH 1 OF 1	4:31PM 3-1-2010

1

Chapter 2

2.1 MAGNASTOR System Design Criteria

The design of MAGNASTOR ensures that the stored spent fuel is maintained subcritical in an inert environment, within allowable temperature limits, and is retrievable. The acceptance testing and maintenance program specified in Chapter 10 ensures that the system is, and remains, suitable for the intended purpose. The MAGNASTOR design criteria appear in Table 2.1-1.

Approved alternatives to the ASME Code for the design procurement, fabrication, inspection, and testing of MAGNASTOR TSCs and spent fuel baskets are listed in Table 2.1-2.

Proposed alternatives to ASME Code, Section III, 2001 Edition with Addenda through 2003, including alternatives listed in Table 2.1-2, 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 the following.

- The proposed alternatives would provide an acceptable level of quality and safety, or 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.

Table 2.1-1 MAGNASTOR System Design Criteria

Parameter	Criteria
Design Life	50 years
Design Code – Confinement	
TSC	ASME Code, Section III, Subsection NB [1] for confinement boundary
TSC Cavity Atmosphere	Helium
Gas Pressure	7.0 atmospheres gauge (103 psig)
Design Code - Nonconfinement	
Fuel Basket	ASME Code, Section III, Subsection NG [2] and NUREG/CR-6322 [3]
Concrete Cask	ACI-349 [4], ACI-318 [5]
Transfer Cask	ANSI N14.6 [6], NUREG-0612 [15]
Thermal	
Maximum Fuel Cladding Temperature	752°F (400°C) for Normal and Transfer [7] 1058°F (570°C) for Off-Normal and Accident [8]
Ambient Temperature	
Normal (average annual ambient)	76°F
Off-Normal (extreme cold; extreme hot)	-40°F; 106°F
Accident	133°F
Concrete Temperature	
Normal Conditions	≤150°F (bulk) [4]; ≤200°F (local) [9]
Off-Normal/Accident Conditions	≤350°F local/ surface [4]
Radiation Protection/Shielding	
Owner-Controlled Area Boundary Dose [10]	
Normal/Off-Normal Conditions	25 mrem (Annual Whole Body) [10]
Accident Whole Body Dose	5 rem (Whole Body) [10]

Table 2.1-2 ASME Code Alternatives for MAGNASTOR Components

Component	Reference ASME Code Section/Article	Code Requirement	Exception, Justification and Compensatory Measures
TSC and Fuel Basket	NCA-1000, NCA-2000, NCA-3000, NCA-4000, NCA-5000, NCA-8000, NB-1110, and NG-1110	Requirements for Code stamping of NB components and preparation of Code Design Specifications, Design Reports, Overpressure Protection Report (TSC only), and Data Reports, and Quality Assurance requirements in accordance with Code requirements.	Code stamping is not required for the TSC or fuel baskets. Code Design Specifications, Design Reports, Overpressure Protection Report, and Data Reports are not required. The TSC and Fuel Basket are designed, procured, fabricated, inspected and tested in accordance with a QA Program meeting 10 CFR 72, Subpart G. Authorized Nuclear Inspection Agency Services are not required.
TSC Pressure-Retaining Materials	NB-2000	Pressure-retaining material to be provided by ASME-approved Material Organization.	Materials will be supplied with Certified Material Test Reports by NAC approved suppliers.
TSC Closure Lid-to-Shell Weld	NB-4243	Full penetration welds required for Category C joints.	The closure lid-to-shell weld is not a full penetration weld. The design and analysis of the closure lid weld utilizes a 0.8 stress reduction factor in accordance with ISG-15 [23].
Port Cover-to-Closure Lid Weld	NB-5230	Radiographic (RT) examination required.	Final surface liquid penetrant examination to be performed per ASME Code Section V, Articles 6 and 24. PT acceptance criteria is to be in accordance with NB-5350.
TSC Closure Lid-to-Shell Weld	NB-5230	Radiographic (RT) examination required.	In accordance with ISG-15, the TSC closure lid-to-shell weld is to be inspected by progressive surface liquid penetrant (PT) examination of the root, midplane and final surface layers. The progressive PT examination of the weld will be performed in accordance with ASME Code, Section V, Articles 6 and 24, and acceptance criteria per NB-5350.

Table 2.1-2 ASME Code Alternatives for MAGNASTOR Components

Component	Reference ASME Code Section/Article	Code Requirement	Exception, Justification and Compensatory Measures
TSC Closure Ring-to-TSC Shell & TSC Closure Ring-to-Closure Lid	NB-5230	Radiographic (RT) examination required.	Final surface liquid penetrant examination to be performed per ASME Code Section V, Articles 6 and 24. PT acceptance criteria is to be in accordance with NB-5350.
TSC	NB-6111	All completed pressure retaining systems shall be pressure tested.	Following closure lid to TSC shell welding, each TSC shall be hydrostatically pressure tested to 125% of MNOP. No observable pressure drop or water leakage from the closure lid to TSC shell weld is allowed. Since the shell welds of the TSC cannot be checked for leakage during this pressure test, as required by the Code, the shop leakage test to 10^{-7} ref cc/sec (as described in Section 10.1.3) provides reasonable assurance as to its leak tightness.
TSC	NB-7000	Pressure vessels shall be protected from the consequences of pressure conditions exceeding design pressure.	No overpressure protection is provided. The function of the TSC is to confine radioactive contents without release under normal conditions, or off-normal and accident events of storage. The TSC is designed to withstand the maximum internal pressure considering 100% fuel rod failure and maximum accident condition temperatures.
TSC	NB-8000	States requirements for nameplates, stamping and reports per NCA-8000.	The TSC is marked and identified to ensure proper identification of the contents. Code stamping is not required.
TSC Basket Assembly Structural Materials	NG-2000	Core support structural materials are to be provided by an ASME approved Material Organization.	Fuel basket structural materials with Certified Material Test Reports to be supplied by NAC approved suppliers.

Table 2.1-3 ASME Code Alternatives for MAGNASTOR Components

Component	Reference ASME Code Section/Article	Code Requirement	Exception, Justification and Compensatory Measures
TSC Basket Assembly Structural Components	NG-8000	Requirements for nameplates, stamping and reports per NCA-8000.	The TSC basket structural assembly is marked and identified to ensure component traceability in accordance with NAC's QA Program.

2.2 Spent Fuel To Be Stored

MAGNASTOR is designed to safely store up to 37 PWR or up to 87 BWR spent fuel assemblies, contained within a TSC. 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. For TSC spent fuel content loads less than a full basket, empty fuel positions shall include an empty fuel cell insert.

Undamaged 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.

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 unenriched 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. Each TSC may contain up to 37 undamaged PWR fuel assemblies.

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. 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 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. 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.

As noted in Table 2.2-1, the evaluation of PWR fuel assemblies includes thimble plugs (flow mixers), burnable poison rod assemblies (BPRAs), control element assemblies (CEAs), and/or solid filler rods. 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.

2.2.2 BWR Fuel Evaluation

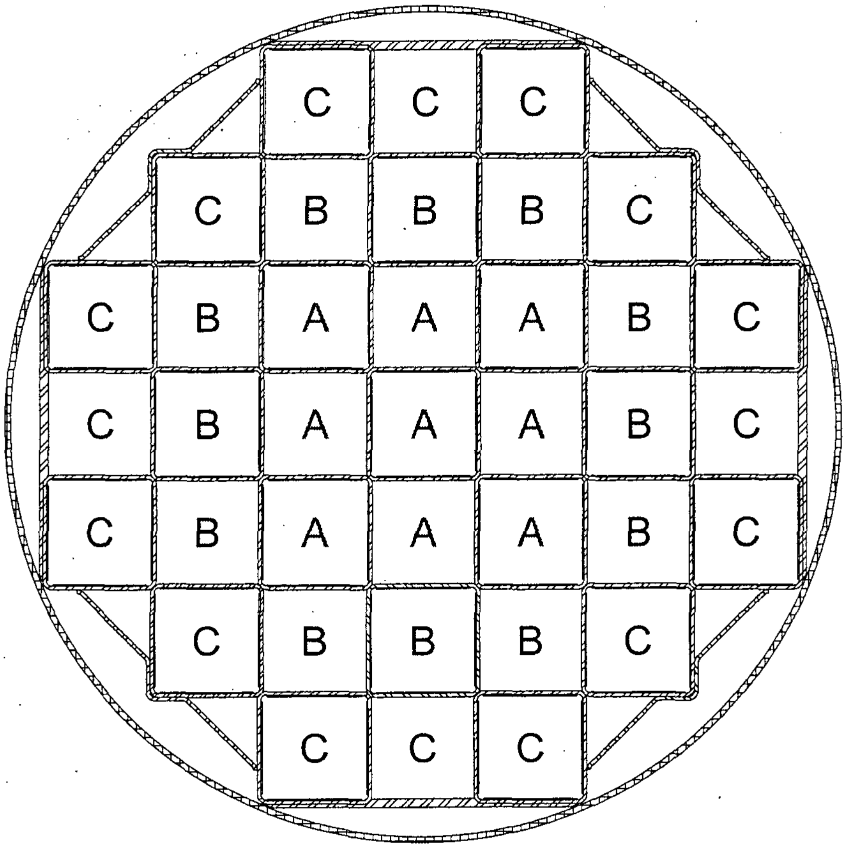
MAGNASTOR evaluations are based on bounding BWR fuel assembly parameters that maximize the source terms for the shielding evaluations, the reactivity for the criticality evaluations, the decay heat load for the thermal evaluations, and the fuel weight for the structural evaluations. These bounding parameters 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

Figure 2.2-2 82-Assembly-BWR Basket Pattern

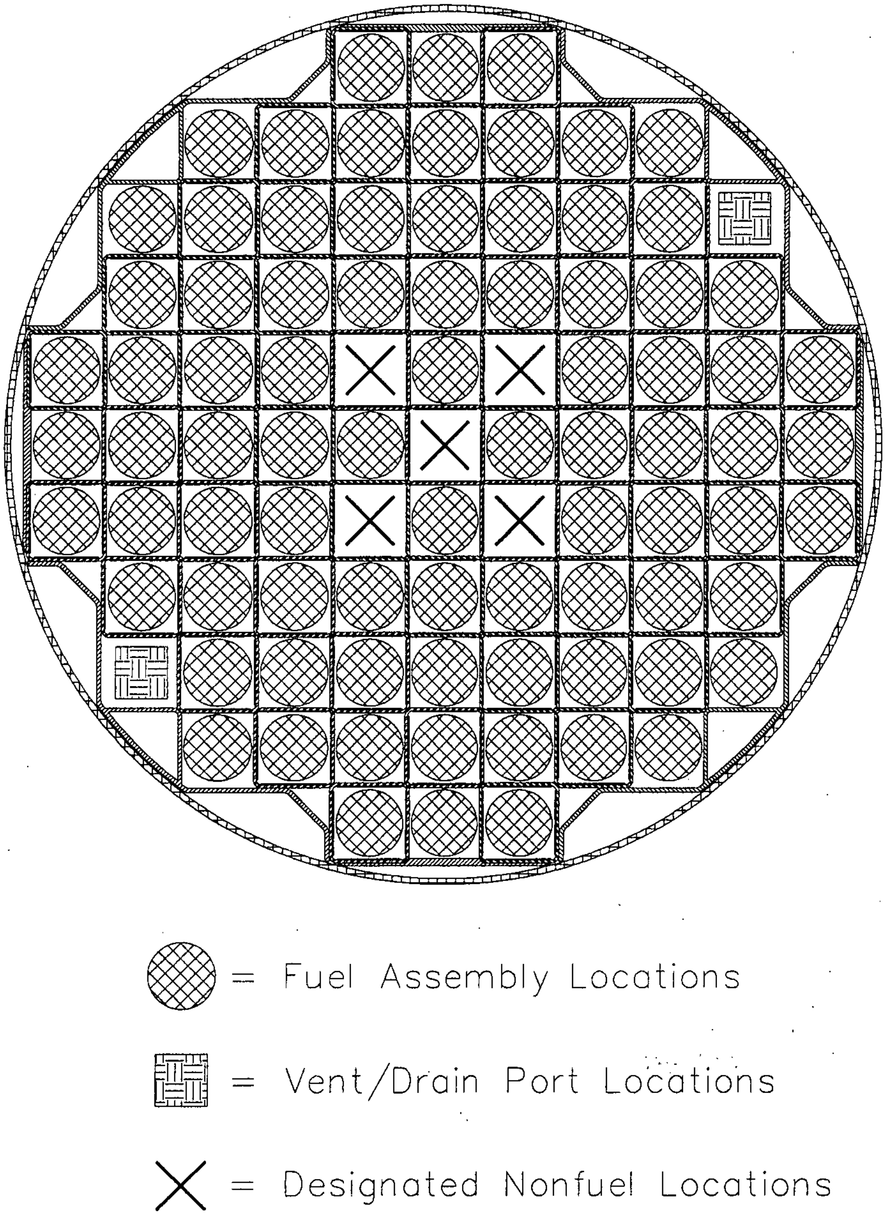


Table 2.2-1 PWR Fuel Assembly Characteristics

Characteristic	Fuel Class					
	14x14	14x14	15x15	15x15	16x16	17x17
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
Peak Average Rod Burnup (MWd/MTU)	62,500	62,500	62,500	62,500	62,500	62,500
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 a flow mixer (thimble plug), a burnable poison rod assembly, a control element assembly, and/or solid stainless steel or zirconium-based alloy filler rods.
- 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.
- Spacers may be used to axially position fuel assemblies to facilitate handling.
- Maximum uniform heat load is 959 watts per storage location.

---

[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			
	7x7	8x8	9x9	10x10
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
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)	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).

[b] May be composed of four subchannel clusters.

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

[d] Composed of four subchannel clusters.

2.4 Safety Protection Systems

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

2.4.1 General

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

- Continued radioactive material confinement in postulated accidents.
- Thick steel and concrete biological shield.
- Passive systems that ensure reliability.
- Pressurized inert helium atmosphere to provide corrosion protection for fuel cladding and enhanced heat transfer for the stored fuel.

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

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

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

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

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

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

2.4.2 Confinement Barriers and Systems

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

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

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

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

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

2.4.3 Concrete Cask Cooling

The loaded concrete cask is passively cooled. Ambient air enters at the bottom of the concrete cask through four air inlets and heated air exits through the four air outlets at the top of the cask due to natural convection heat transfer. Radiant heat transfer also occurs from the TSC to the concrete cask liner. Consequently, the liner also heats the convective airflow. This natural circulation of air inside the concrete cask, in conjunction with radiation from the TSC surface, maintains the fuel cladding and concrete cask component temperatures below their design limits. Conduction does not play a substantial role in heat removal from the TSC surface. Refer to Chapter 4 for details on the concrete cask thermal analyses.

2.4.4 Protection by Equipment

There is no important-to-safety equipment required for the safe storage operation of MAGNASTOR. The important-to-safety equipment employed in the handling of MAGNASTOR is the lifting yoke used to lift the transfer cask. The lifting yoke is designed, fabricated, and tested in accordance with ANSI N14.6 as a special lifting device as defined in NUREG-0612. The lifting yoke is proof load tested to 300% of its design load when fabricated. Following the load test, the bolted connections are disassembled, and the components are inspected for deformation. Permanent deformation of components is not acceptable. Engagement pins are examined by dye penetrant examination. The transfer cask and lifting yoke are inspected for visible defects prior to each use. Transfer cask annual maintenance requirements are defined in Chapter 10.

2.4.5 Protection by Instrumentation

No instrumentation is required for the safe storage operations of MAGNASTOR.

A remote temperature-monitoring system may be used to measure the outlet air temperature of the concrete casks in long-term storage. The outlet temperature can be monitored daily as a check of the continuing thermal performance of the concrete cask. Alternately, a daily visual inspection for blockage of the air inlet and air outlet screens of all concrete casks may be performed. Following any natural phenomena event, such as an earthquake or tornado, the concrete casks shall be inspected for damage and air inlet and air outlet blockage.

2.4.6 Nuclear Criticality Safety

MAGNASTOR design includes features to ensure that nuclear criticality safety is maintained (i.e., the cask remains subcritical under normal conditions and off-normal and accident events).

The design of the TSC and fuel basket is such that, under all conditions, the highest neutron multiplication factor (k_{eff}) is less than 0.95.

2.4.6.1 Control Methods for Prevention of Criticality

The principal design criterion is that k_{eff} remain less than 0.95 for all conditions. Criticality control for PWR spent fuel is achieved using neutron absorber material fixed in the basket and by maintaining a minimum boron concentration in the TSC during fuel loading. The fixed neutron absorber attracts thermal neutrons that are moderated in the water surrounding the fuel. Fast, high-energy neutrons escape the system. The minimum effective loading for neutron absorber sheets is 0.036, 0.030 or 0.027 ^{10}B g/cm^2 for PWR fuel baskets and 0.027, 0.0225 or 0.020 ^{10}B g/cm^2 for BWR fuel baskets. The required minimum boron loading in a neutron absorber sheet is determined based on the assumed boron effectiveness used in the criticality analysis, i.e., 75% for Boral (registered trademark of AAR Advanced Structures) and 90% for borated aluminum alloys and for borated metal matrix composites (MMCs). Neutron absorber sheets are mechanically attached to the fuel tube structure to ensure that the neutron absorber remains in place during the design basis normal conditions and off-normal and accident events.

The basket designs ensure that there is sufficient absorption of moderated neutrons by the neutron absorber (and by boron in the cavity water in some cases) to maintain criticality control in the basket ($k_{eff} < 0.95$). See Chapter 6 for the detailed criticality analyses.

2.4.6.2 Error Contingency Criteria

The standards and regulations of criticality safety require that k_{eff}, including uncertainties, be less than 0.95. The bias and 95/95 uncertainty are applied to the calculation using an upper subcritical limit (USL) approach [22]. The $k_{eff} + 2\sigma$ value must be less than the USL. Based on MCNP critical benchmarks, the USL as a function of fission neutron lethargy (eV) is shown as:

$$USL = 0.9364 + 8.4409 \times 10^{-3} \times x$$

where:

x = energy of average neutron lethargy causing fission

2.4.6.3 Verification Analyses

The MCNP criticality analysis code is benchmarked through a series of calculations based on critical experiments. These experiments span a range of fuel enrichments, fuel rod pitches, poison sheet characteristics, shielding materials, and geometries that are typical of light water reactor fuel in a cask. To achieve accurate results, three-dimensional models, as close to the actual experiment as possible, are used to evaluate the experiments.

2.4.7 Radiological Protection

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

2.4.7.1 Access Control

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

2.4.7.2 Shielding

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

2.4.7.3 Ventilation Off-Gas

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

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

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

2.4.7.4 Radiological Alarm Systems

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

2.4.8 Fire Protection

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

2.4.9 Explosion Protection

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

2.4.10 Auxiliary Structures

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

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

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

Table 2.4-1 Safety Classification of MAGNASTOR Components

Component Description	Reference Drawings	Safety Function	Safety Classification
TSC Assembly Shell and Base Plate Closure Lid Closure Ring Port Covers	71160-581 71160-584 71160-584 71160-585	Structural and Confinement	A
Fuel Basket Assembly Basket Support Weldments Fuel Tube Assemblies Neutron Absorbers	71160-551 71160-571 71160-572 71160-574 71160-575 71160-591 71160-598 71160-599	Criticality, Structural and Thermal	A
Transfer Cask Assembly Trunnions Inner and Outer Shells Shield Doors and Rails Lead Gamma Shield Neutron Shield	71160-560 71160-556	Structural, Shielding 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

Chapter 6

Chapter 6
Criticality Evaluation

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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 PWR fuel assemblies or up to 87 BWR fuel assemblies. 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. One-size concrete cask and one-size transfer cask accommodate all of the PWR and BWR TSCs.

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 basket design includes 21 fuel tubes forming 37 fuel-assembly-sized openings while 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 and Table 6.1.1-2 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.

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 0.9372 per Section 6.7.5. The results of the analyses are presented in detail in Sections 6.4.3 and 6.7, and are summarized as follows.

			Water Density (g/cc)		PWR	BWR
Cask Body	Gap Condition	Operating Condition	Interior	Exterior	$k_{eff} + 2\sigma$	$k_{eff} + 2\sigma$
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.

Figure 6.1.1-1 82-Assembly BWR Basket Configuration

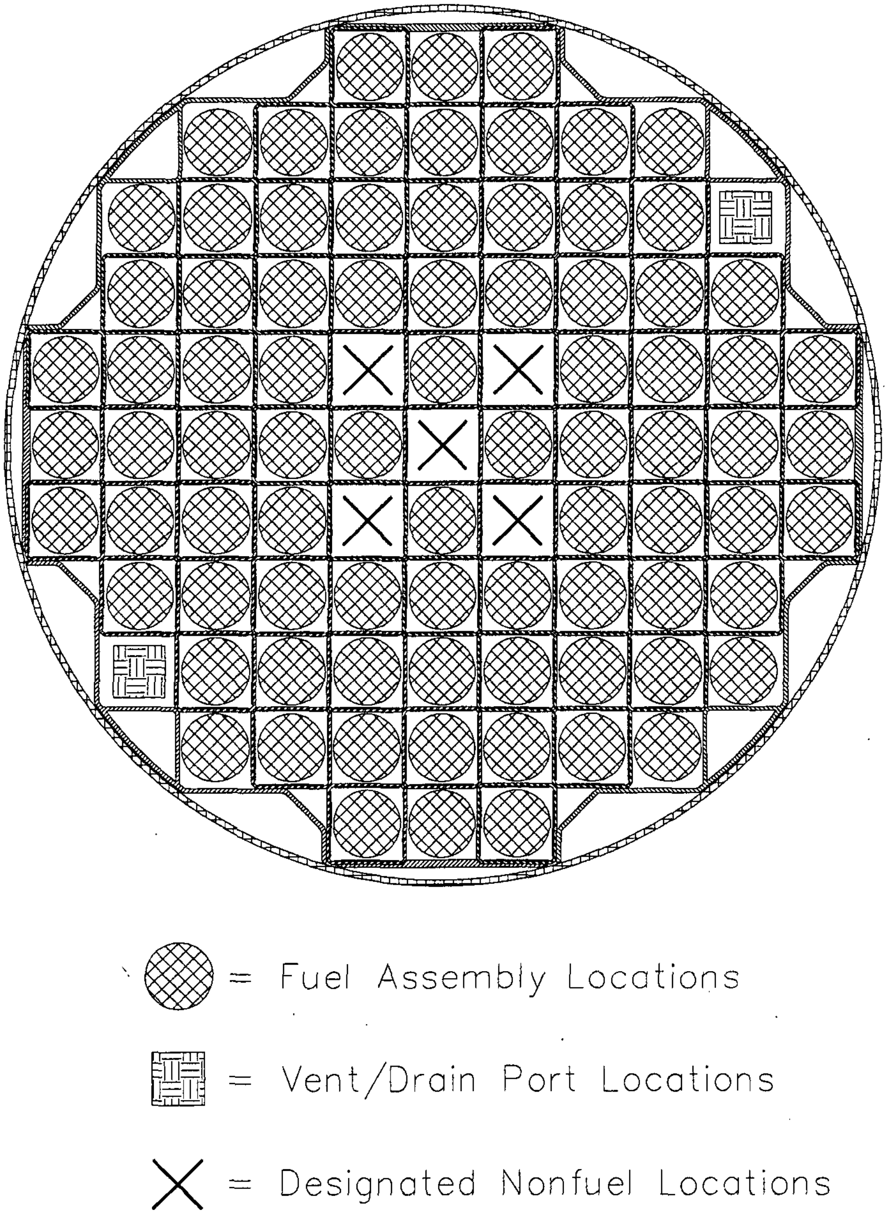

Table 6.1.1-1 Bounding PWR Fuel Assembly Loading Criteria (Assembly Description)

Assembly Type	No. of Fuel Rods	No. of Guide Tubes[a]	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

- Assembly characteristics represent cold, unirradiated, nominal configurations.

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[a] Combined number of guide and instrument tubes.

Table 6.1.1-2 Bounding PWR Fuel Assembly Loading Criteria (Enrichment/Soluble Boron Limits)

	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%	4.0%	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%	4.0%	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%	4.0%	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%	4.0%	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%	4.0%	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%

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

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

Table 6.1.1-3 BWR Fuel Assembly Loading Criteria (Assembly Description)

Assembly Type	Number of Fuel Rods	Number of Partial Length Rods	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	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[a]	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[a]	8	0.5100	0.3957	0.02385	0.3420	150.0	0.1906
B10_92A	92[a]	14	0.5100	0.4040	0.02600	0.3455	150.0	0.1966
B10_96A	96[a]	12	0.4880	0.3780	0.02430	0.3224	150.0	0.1787
B10_100A	100	N/A	0.4880	0.3780	0.02430	0.3224	150.0	0.1861

Note: Assembly characteristics represent cold, unirradiated, nominal configurations.

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[a] Assemblies may contain partial length fuel rods. Partial length rod assemblies are evaluated by removing partial length rods from the lattice. This configuration bounds an assembly with full length rods and combinations of full and partial length rods.

Table 6.1.1-4 BWR Fuel Assembly Loading Criteria (Enrichment Limits)

	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%	3.6%	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%	4.3%	3.4%	4.1%	3.4%	4.0%
B9_76A	3.5%	4.2%	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%	3.6%	4.3%	3.5%	4.1%
B10_92A	3.8%	4.5%	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%

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[a] Maximum planar average.

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

Table 6.1.1-5 Effective Areal Density as a Function of Absorber Credit

	Effective[a] ^{10}B g/cm^2	75% Credit ^{10}B g/cm^2	90% Credit ^{10}B g/cm^2
PWR	0.036	0.048	0.040
	0.030	0.040	0.0334
	0.027	0.036	0.30
BWR	0.027	0.036	0.030
	0.0225	0.030	0.025
	0.020	0.0267	0.0223

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[a] The effective areal density represents the value input into the criticality model and is, therefore, the "100% credit" value.

6.3 Model Specification

6.3.1 Description of Calculation Model

MCNP is used to model the PWR and BWR storage and transfer casks containing a full load of fuel assemblies. The PWR cask system contains up to 37 fuel assemblies, while the BWR system is capable of storing up to 87 fuel assemblies (89 assemblies are modeled). MCNP uses combinatorial geometry, with the option to divide the model into self-contained Universes. The self-contained Universe structure can be used to separate the TSC, concrete cask, and fuel into individual components that can be easily modified and checked.

The basic MCNP geometry package is comprised of a set of general surfaces. To reduce the required user input, MCNP includes simplified expressions for cylinders and planes perpendicular to system axes and "macrobodies" (cubes, finite cylinders, wedges, etc). Models are constructed by combining geometry components (surfaces) into cells. Cells may be embedded in individual Universes to simplify modeling. A given Universe may be included in different positions within the geometry by translation. Translation allows movement in the x, y, and z directions and rotation using direction cosines.

Finite concrete cask/TSC/basket/fuel models (termed cask model henceforth) are constructed for the storage and transfer system. The cask models are constructed in a set of distinct phases. In the first phase, a fuel assembly is constructed from the basic components of the fuel assembly, i.e., fuel rod, guide tube (PWR), instrument tube (PWR), water rods (BWR), and nozzles (end-fittings). Lattice elements are discretely modeled. Assembly material homogenization is limited to the end-fitting elevations where cuboids, containing a mixture of steel and TSC cavity material (either void or water at various densities), are included. Next the basket structure is placed within the TSC cavity. The basket structure is comprised of a set of carbon steel tubes and aluminum-based neutron absorber panels surrounded by corner and side weldments. After completing the basket model, fuel assemblies are explicitly placed into the TSC cavity, with the basket structure superimposed on the cavity surrounding the assemblies using the Universe structure. The TSC shell and lid are placed around the loaded basket. The complete TSC is then placed into either the transfer or storage cask overpack. Generic basket features and TSC and cask model details are included here. Detailed basket features unique to a specific payload configuration are discussed in Section 6.7.

The basket is composed of a set of corner-locking tubes and corner and side weldments. Twenty-one PWR tubes and 45 BWR tubes form the openings for 37 PWR assemblies and 89 BWR assemblies. Sketches of a generic tube and the developed cell are shown in Figure 6.3.3-1.

Refer to Sections 6.7.1 and 6.7.4 for detail on the PWR and BWR tube and basket layout and dimensions. Each of the baskets is placed into a matching TSC. PWR and BWR baskets are designed in two lengths each, with PWR and BWR TSC differences being limited to the location of the TSC ports. Ports are not included in the criticality model. Therefore, PWR and BWR TSC models are identical and are composed of a simple set of steel cylinders. Figure 6.3.3-2 contains a sketch of the TSC model. A single-length transfer cask and concrete cask design accommodates either length PWR or BWR basket. A model sketch of the transfer cask is shown in Figure 6.3.3-3, with the concrete cask model sketch shown in Figure 6.3.3-4.

An outer cylindrical body allows reflecting boundary conditions to be applied at specified distances surrounding each cask model. Due to the size of the transfer and storage radiation shields, cask surface neutron currents are low. This, in turn, results in baskets that are neutronically isolated from cask exterior conditions and from other casks in an array configuration.

6.3.2 Model Assumptions

Key assumptions for the analytical models are as follows.

- Assemblies are modeled as fresh, unburned fuel.
- The assembly is modeled at a fuel density of 96% theoretical ($0.96 \times 10.96 = 10.52$ g/cm^2).
- A homogenous, peak planar average enrichment is applied to the BWR models. The appropriateness of this assumption is validated in Section 6.7.5.
- With the exception of the fuel assembly channels in the BWR case, no fuel assembly structural materials (i.e., spacer or mixing grids) are included in the PWR and BWR active fuel region elevations. Nonfuel components placed into guide tubes are specifically addressed in the analysis. As demonstrated in the moderator density and fuel characteristics evaluation, the fuel rod lattices are undermoderated, therefore, making this assumption conservative.
- Integral fuel assembly neutron absorbers (e.g., BWR gadolinium rods, PWR erbium or boron IFBAs) are excluded from the analysis, thereby substantially increasing assembly reactivity of the unburned assembly.
- Fuel assembly cladding for baseline cases is intact. In-core failure rates indicate that the vast majority of fuel loaded will not have cladding damage, allowing access to the pellet-to-clad gap. Flooding of this void space is addressed in Sections 6.7.3 and 6.7.6.
- The moderator is assumed to be water at various densities. Baseline for the analysis is water at a temperature of 293K and a density of 0.9982 g/cm^3. PWR analyses include soluble boron at various concentrations, effectively increasing water density. For a consistent presentation, water densities are expressed at the unborated levels throughout

this document unless specifically noted. The fuel, cladding, and other structural materials are assumed to be at 293K.

- Fixed neutron absorber sheets are evaluated at effective ^{10}B densities of 0.036, 0.030 and 0.027 g/cm^2 (PWR) and 0.027, 0.0225 and 0.020 g/cm^2 (BWR). Dividing by either 75% or 90% effectiveness yields the minimum absorber levels required for the sheet manufacture.
- Fuel assembly and basket will retain their structure and will not show any significant permanent deformation during normal conditions, off-normal or accident events. Per Section 3.7.1.2 and Section 3.7.2.2, hypothetical tip-over analysis, the maximum permanent set across the diagonal of the fuel tube is less than 0.01 inch. This represents less than one-half the tolerance evaluated on the fuel tube interface width in Section 6.7.3 and Section 6.7.6 and shown to be statistically insignificant (i.e., no statistically significant conclusion can be drawn from the analysis). The tube deformation, therefore, has no resolvable effect on system reactivity or allowed payload configurations.
- Regardless of the specific type of stainless or carbon steel employed in the system construction, the default SS-304 and carbon steel compositions in the SCALE 4.4 standard composition library [5] are employed. Minor alloying differences between the steel types will not affect system reactivity significantly.
- The basket tubes are modeled at their drawing specified dimensions, i.e., no potential deformations associated with the beyond design basis cask tip-over accident event are applied to the analysis model. As demonstrated in Chapter 12 there is no design basis condition that will result in the cask tip-over. Therefore there is no permanent deformation in the basket tube structure during any design basis event. The minor permanent set in the tubes discussed for the hypothetical cask tip-over in Section 3.7.2 is limited to the top regions of the basket where neutron leakage effects will reduce any reactivity affects. As discussed in Section 3.7.2, permanent set in the center regions of the basket is not significant.

6.3.3 Cask Regional Densities

The densities used in the criticality analyses are primarily SCALE 4.4 default densities. NS-4-FR is a proprietary material and the listed information reflects values defined by the material information data sheet. Fuel assembly materials are listed in Table 6.3.3-1. Basket, TSC, and cask material definitions are shown in Table 6.3.3-2.

Figure 6.3.3-1 Generic Tube Cross-Section and Developed Cell Model Sketches

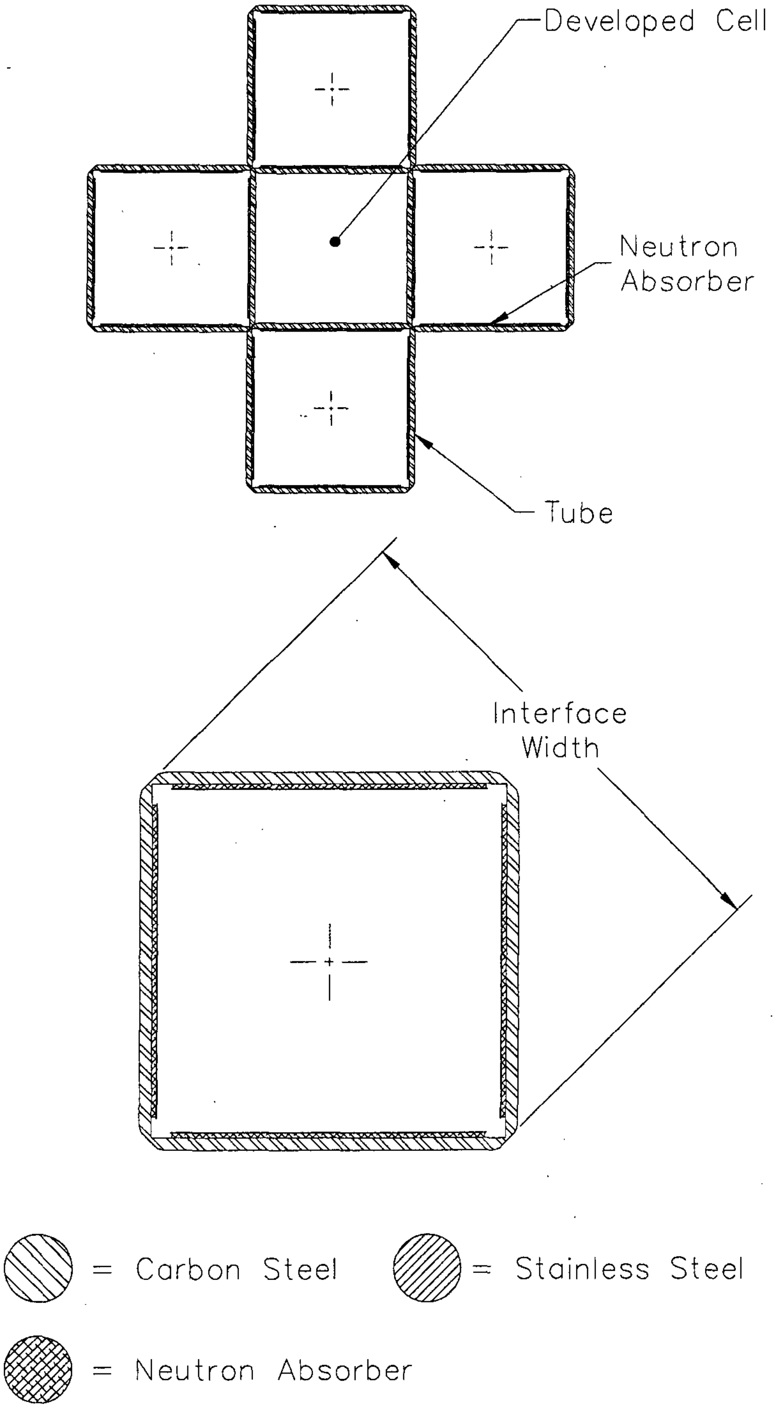

Figure 6.3.3-2 TSC Model Sketch

Figure Withheld Under 10 CFR 2.390

Note: Dimensions in inches

Figure 6.3.3-3 Transfer Cask Model Sketch

Figure Withheld Under 10 CFR 2.390

Note: Dimensions in inches

Figure 6.3.3-4 Storage Cask Model Sketch

Figure Withheld Under 10 CFR 2.390

Note: Dimensions in inches

Table 6.3.3-1 Fuel Assembly Material Densities and Compositions

Material	Density g/cm^3	Element/ Isotope	Density atom/barn-cm
UO_2 (5 wt % ^{235}U)[a] 96% theoretical density	10.522	^{235}U	1.19E-03
		^{238}U	2.23E-02
		O	4.70E-02
Zirconium-based Alloy	6.56	Fe	8.84E-05
		Cr	7.60E-05
		N	1.41E-04
		Zr	4.25E-02
		Sn	4.99E-04
Water Full Density – No Boron	0.9982	H	6.67E-02
		O	3.34E-02
Water[b] Full Density – 2500 ppm Boron	1.0025	H	6.65E-02
		O	3.35E-02
		^{10}B	2.66E-05
		^{11}B	1.13E-04
Stainless Steel	7.94	Cr	1.75E-02
		Fe	5.95E-02
		Ni	7.74E-03
		Mn	1.74E-03

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[a] System is evaluated at varying enrichment levels. Sample data is provided.

[b] Various soluble boron levels are evaluated. Listed value represents the upper end of the soluble boron range. Value was calculated based on the soluble boron source being boric acid.

Table 6.3.3-2 Basket, TSC, and Cask Material Densities and Compositions

Material	Density g/cm³	Element/ Isotope	Density atom/barn-cm
Carbon Steel	7.821	Fe	8.35E-02
		C	3.92E-03
Stainless Steel	7.94	Cr	1.75E-02
		Fe	5.95E-02
		Ni	7.74E-03
		Mn	1.74E-03
Aluminum	2.702	Al	6.03E-02
Lead	11.344	Pb	3.30E-02
NS-4-FR	1.632	H	5.8508E-02
		^{10}B	9.1385E-05
		^{11}B	3.3665E-04
		C	2.2600E-02
		N	1.3904E-03
		O	2.6107E-02
		Al	7.8003E-03
Concrete (145 lb/ft³)	2.322	H	1.3879E-02
		O	4.6522E-02
		Na	1.7643E-03
		Al	1.7625E-03
		Si	1.6783E-02
		Ca	1.5356E-03
		Fe	3.5063E-04
Neutron Absorber[a]	2.358	^{10}B	8.53E-03
		^{11}B	3.61E-02
		C	1.11E-02
		Al	2.98E-02

---

[a] Represents the as-modeled core density for BORAL based PWR (0.036 ^{10}B g/cm^2 effective) neutron absorber sheets. As-built neutron absorber density will vary depending on effective areal density and material choice (e.g., metal matrix composite, BORAL, borated aluminum), boron enrichment, and percent absorber credit taken (i.e., 75% or 90%).

6.4 Criticality Calculation

6.4.1 Calculation Method

System reactivity evaluations are performed with the MCNP5 three-dimensional Monte Carlo code and continuous neutron energy cross-sections [3,4]. The Monte Carlo code and neutron cross-section libraries are validated for use in fuel transport and storage cask applications through a series of calculations based on critical experiments. Validation detail is presented in Section 0.

The criticality analysis of the system is performed in several steps.

- Establish initial reactivities effects of gap conditions, partial flooding, and inserts (PWR) for each fuel type under the assumption that the assemblies are undermoderated (typical for PWR and BWR assemblies in storage and transport configuration).
- Determine bounding fuel assembly geometric definitions in terms of maximum or minimum rod pitch, rod diameter, and clad thickness, and guide/instrument/water rod diameter and thickness.
- For the BWR systems, justify the use of planar average versus heterogeneous enrichments is justified.
- Evaluate basket mechanical perturbations and basket geometric tolerances for sample fuel assembly types.
- Construct optimum moderator density curves for sample fuel types.
- Based on the maximum reactivity configuration, determine allowable enrichments for each fuel type. System reactivity must be below the USL. For the PWR system, minimum allowable soluble boron levels are set in conjunction with the maximum allowable enrichment.

6.4.2 Fuel Loading Optimization

The fuel loading is optimized in the criticality models using the following.

- Fresh fuel at 96% theoretical density
- Bounding fuel assembly geometry
- The most reactive cask configuration

Based on the fuel characteristics documented in Section 6.2, bounding fuel assembly nominal characteristics are established in terms of the following.

- Fuel rod outer diameter
- Fuel rod clad thickness
- Fuel rod pitch

- Guide tube/water rod outer diameter and thickness
- Channel thickness (BWR)
- Homogenous versus heterogeneous enrichment patterns (BWR)
- Presence of nonfuel hardware insert (PWR)

Refer to Section 6.7 for the fuel type-specific details of the fuel characteristics evaluation.

The maximum reactivity cask configuration considers basket fabrication tolerances, component shifting, and moderator density evaluations. Each of these effects is evaluated individually and in combination to assure that the highest reactivity configuration is documented. Fabrication tolerances and shift effect are evaluated using representative fuel types from the major core configurations. Basket-specific evaluations determining the maximum reactivity configurations are included in Section 6.7.

Casks are evaluated at various interior and exterior flood conditions with reflective boundary conditions. Reflective boundary conditions are applied to an independently generated cylindrical body surrounding the cask body. This allows the modeling of infinite cask arrays at various cask spacings. Space between the cask surface and the reflecting body may be flooded at various moderator densities. Given the low neutron fluxes on either concrete or transfer cask bodies, no significant effect is observed from conditions outside the cask body.

6.4.2.1 Fabrication Tolerances

The basket is composed of a set of fuel tubes located in the TSC cavity with side and corner weldments. The fuel tubes are pinned together in the tube corners. Tube location in the basket is controlled by the diagonal dimension across the exterior face of the fuel tube corners as shown in Figure 6.3.3-1. This value is a key dimension for tube array and developed cell size. The tube diagonal is referred to as tube "interface width" in the analysis discussion. Tube and neutron absorber width and thickness have the potential to significantly affect the size of the tube opening and developed cell locations. Tube wall thickness is conservatively evaluated for a tolerance of ±0.03 inch (versus a tolerance of -0.01, +0.03 inch from the ASTM standard for the specified plate material), while the neutron absorber is evaluated at a thickness tolerance of 0.006, +0.016 inch for the PWR system and ± 0.006 inch for the BWR system. The side and corner weldments provide structural support to the basket during normal and accident conditions, but do not generally dictate cell size. Tolerance effects are evaluated on the fuel tube and neutron absorber. Retainer thickness tolerance was not considered relevant to the analysis since the retainer strips are only 0.015-in thick (nominal). Off-nominal material thickness for this component would not involve a significant amount of material and would, therefore, not affect system reactivities significantly.

6.4.2.2 Component Shift

In addition to the component tolerances, a reactivity study on component shifts is required. Based on the pinned tube arrangement, the only radial shift to be evaluated is the shift of the fuel assembly within the tubes. The tubes are restrained in the corner by pins, eliminating a tube movement study.

6.4.2.3 Moderator Density Study

To verify that for the borated water cases maximum reactivity occurs at the highest mixture density in the TSC cavity, a sequence of cavity water densities ranging from void (0.0001 g/cm^3) to full density (0.9998 g/cm^3) are evaluated with a void (0.0001 g/cm^3) exterior. Similar evaluations are performed with a void interior and various exterior water densities, and simultaneous variations in interior and exterior water densities. Exterior moderator is conservatively modeled as unborated water regardless of TSC interior boron content. The moderator density variation studies one fuel assembly type per basket configuration.

6.4.3 Criticality Results

6.4.3.1 PWR 37-Assembly Reactivity Result Summary And Enrichment Limits

Results of the fuel characterization evaluation in Section 6.1.1 indicate that for each fuel assembly subset, the maximum fuel reactivity is achieved by the following.

- Maximum Pitch
- Maximum Fuel Pellet OD
- Minimum Fuel Rod OD and Clad Thickness

Insertion of nonfuel assembly hardware components into the active fuel regions affects system reactivity in the majority of cases. The level and direction of the reactivity effect depends on the level of soluble boron in the moderator and the fuel type. The effect is low for fuel rod-sized absorbers typical of Westinghouse and B&W cores, but becomes large for the guide tubes in CE cores, which typically displace four assembly lattice locations each. In the CE System 80 model, all five guide tubes are evaluated as containing nonfuel hardware. Only four of the five guide tubes are designed for control rod access from the top.

Maximum system reactivity was achieved for assemblies with an unborated water flooded pellet-to-clad gap. Flooding the gap with the minimum soluble boron content specified for the system results in no significant reactivity change from the dry gap condition.

Detailed studies in Section 6.7.3 demonstrate that no single component fabrication tolerance has a statistically significant effect on system reactivity. A radial shift of assemblies to the center of the TSC significantly increases system reactivity.

A combination of basket fabrication tolerances minimizing the tube internal free volume showed a minor positive reactivity effect. Minimum free volume removes soluble boron from the system and reduces water volume that may serve as moderator between the fuel assembly and the neutron absorber sheets. Reduced interface width also minimizes distance between assemblies.

The following set of dimensions/perturbations maximizes system reactivity.

- Minimum tube interface width
- Maximum tube thickness
- Minimum absorber width and maximum thickness
- Fuel assemblies shifted to basket center

While minimum absorber width increases the tube free volume, it also reduces total system absorber content. Even at maximum soluble boron content, the neutron absorber sheets contain significantly higher absorber concentration.

As demonstrated in Section 6.7, partial flooding and exterior moderator density variations do not significantly affect the flooded TSC's reactivity. In storage conditions, flooding the TSC-to-concrete cask gap has a minor effect on system reactivity due to differences in neutron reflection between the water in the gap and the steel liner.

In the void to full density moderator range, increasing the TSC interior moderator density raises system reactivity for the cases containing soluble boron at less than 1,800 ppm. At higher soluble boron concentration, reactivity levels off between 0.9 g/cm^3 and full density (0.9982 g/cm^3). No significant variations in reactivity occur in this area. For consistency in presentation, full moderation is listed as maximum reactivity TSC interior moderator.

For each of the fuel types, with and without nonfuel inserts in the active fuel region, several combinations of minimum soluble boron and maximum initial enrichments are determined. The allowable loadings are documented in Table 6.4.3-1 and Table 6.4.3-2 and represent the bounding values for assemblies with, and without, nonfuel hardware in the assembly guide tubes.

Maximum reactivities for normal and accident conditions for PWR fuel are listed in the following table. As there are no off-normal or accident events affecting the transfer cask reactivities, all transfer conditions are listed as normal. The USL applied is 0.9372 for all conditions.

Cask Body	Gap Condition	Operating Condition	Soluble Boron (ppm)	Enrichment (wt % ^{235}U)	Water Density (g/cc) Interior	Water Density (g/cc) Exterior	$k_{eff} + 2\sigma$
Transfer	Dry	Normal	2000	4.5	0.9982	0.0001	0.93183
Transfer	Wet	Normal	2000	4.5	0.9982	0.0001	0.93712
Transfer	Dry	Normal	2000	4.5	0.9982	0.9982	0.92975
Transfer	Wet	Normal	2000	4.5	0.9982	0.9982	0.93615
Storage	Dry	Normal	0	5.0	0.0001	0.0001	0.48145
Storage	Dry	Accident	0	5.0	0.0001	0.9982	0.47104

Note: Maximum PWR enrichment is 5.0 wt %. Transfer cask cases represent maximum reactivity cases from allowed enrichment/soluble boron content/fuel type matrix. Storage cask cases employ fuel type with maximum fissile material mass.

6.4.3.2 BWR 87-Assembly and 82-Assembly Basket Reactivity Result Summary And Enrichment Limits

Results of the fuel characterization evaluation in Section 6.7.5 indicate that for each fuel assembly subset, the maximum fuel reactivity is achieved by the following.

- Maximum Pitch
- Maximum Fuel Pellet OD
- Minimum Fuel Rod OD and Clad Thickness
- Maximum Planar Average Enrichment
- Flooded Pellet to Clad Gap

Detailed studies in Section 6.7.6 demonstrate that no single component fabrication tolerance has a statistically significant effect on system reactivity. A radial shift of assemblies to the center of the TSC significantly increases system reactivity.

A combination of basket fabrication tolerances minimizing the tube internal free volume showed a minor positive reactivity effect. Minimum free volume reduces water volume that serves as moderator between the fuel assembly and the borated aluminum neutron absorber sheets. Reduced interface width also minimizes distance between assemblies.

The following set of dimensions/perturbations maximizes system reactivity.

- Minimum tube interface width
- Maximum tube thickness
- Minimum absorber width and maximum thickness
- Fuel assemblies shifted to basket center

Minimum absorber width reduces total system absorber content.

As demonstrated in Section 6.7, partial flooding and exterior moderator density variations do not significantly affect the flooded TSCs reactivity. In the dry TSC flooding, the TSC-to-concrete cask gap has a minor effect on system reactivity. Increases in the TSC interior moderator density raise system reactivity.

For each of the fuel types, a maximum initial enrichment is defined. The allowable loadings are documented in Table 6.4.3-3 and Table 6.4.3-4.

Maximum reactivities for normal and accident conditions for BWR fuel are listed in the following table. As there are no off-normal or accident events affecting the transfer cask reactivities, all transfer conditions are listed as normal. The USL applied is 0.9372 for all conditions.

Cask Body	Gap Condition	Operating Condition	Enrichment (wt % ^{235}U)	Water Density (g/cc) Interior	Water Density (g/cc) Exterior	$k_{eff} + 2\sigma$
Transfer	Dry	Normal	3.8	0.9982	0.0001	0.92900
Transfer	Wet	Normal	3.8	0.9982	0.0001	0.93679
Transfer	Dry	Normal	3.8	0.9982	0.9982	0.92839
Transfer	Wet	Normal	3.8	0.9982	0.9982	0.93674
Storage	Dry	Normal	4.5	0.0001	0.0001	0.43685
Storage	Dry	Accident	4.5	0.0001	0.9982	0.42991

Note: Maximum BWR enrichment is 4.5 wt %. Transfer cask cases represent maximum reactivity cases from allowed enrichment/fuel type matrix. Storage cask cases employ fuel type with maximum fissile material mass.

Table 6.4.3-1 PWR Fuel Basket Allowable Loading (Assembly Description)

Assembly Type	No. of Fuel Rods	No. of Guide Tubes[a]	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

Notes:

- Assembly characteristics represent cold, unirradiated, nominal configurations.

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[a] Combined number of guide and instrument tubes.

Table 6.4.3-2 PWR Fuel Assembly Allowable Loading (Enrichment/Soluble Boron Limits)

	Max. Initial Enrichment (wt % ^{235}U)														
	Absorber[a] 0.036 ^{10}B g/cm^2					Absorber 0.030 ^{10}B g/cm^2					Absorber 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%	4.0%	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%	4.0%	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%	4.0%	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%	4.0%	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%	4.0%	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%

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

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

Table 6.4.3-3 BWR Fuel Basket Allowable Loading (Assembly Description)

Assembly Type	Number of Fuel Rods	Number of Partial Length Rods	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	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[a]	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[a]	8	0.5100	0.3957	0.02385	0.3420	150.0	0.1906
B10_92A	92[a]	14	0.5100	0.4040	0.02600	0.3455	150.0	0.1966
B10_96A	96[a]	12	0.4880	0.3780	0.02430	0.3224	150.0	0.1787
B10_100A	100	N/A	0.4880	0.3780	0.02430	0.3224	150.0	0.1861

Note: Assembly characteristics represent cold, unirradiated, nominal configurations.

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[a] Assemblies may contain partial length fuel rods. Partial length rod assemblies are evaluated by removing partial length rods from the lattice. This configuration bounds an assembly with full length rods and combinations of full and partial length rods.

Table 6.4.3-4 BWR Fuel Basket Allowable Loading (Enrichment Limits)

	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%	3.6%	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%	4.3%	3.4%	4.1%	3.4%	4.0%
B9_76A	3.5%	4.2%	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%	3.6%	4.3%	3.5%	4.1%
B10_92A	3.8%	4.5%	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%

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[a] Maximum planar average.

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

6.7.3 PWR Undamaged Fuel Criticality Evaluation

6.7.3.1 Optimum System Configuration

Enrichment and soluble boron limits are based on a maximum reactivity configuration system. To determine the maximum reactivity system, the following system perturbations are evaluated.

TSC interior moderator elevation variations (partial flooding)
Moderator density changes from void to full density (inside and outside the TSC)
Basket fabrication tolerance
Component shift scenarios

All system perturbation analyses are based on fuel assemblies at the maximum lattice moderator (H/U) ratio. Justification for this fuel assembly configuration is provided in Section 6.1.1. Only transfer cask cases are used in these evaluations since the transfer cask is the only cask body in which TSC flooding occurs. In the dry concrete cask, the TSC has a low reactivity, $k_{eff} < 0.5$.

Initial reactivity analysis is based on a basket and neutron absorber configuration with the following characteristics:

a.) Neutron absorbers on all four sides of each tube.

b.) A single column of weld posts connecting neutron absorber to tube, with 18 weld posts per tube.

c.) A neutron absorber thickness tolerance of ±0.005 inch.

d.) Fuel tube size and tube stack-up controlled by tube outer width and "interface width."

e.) Neutron absorber sheet effective areal density of 0.036 ^{10}B g/cm^2.

Differences in reactivity due to system configuration and tolerance changes from these characteristics are evaluated in the subsection titled "Neutron Absorber and Tube Modifications."

Changes in neutron absorber areal density are addressed in Section 6.7.3.2.

Partial Flooding

Partial flood cases drain the TSC to the top of the active fuel region. The partial flood reactivity cases investigate reactivity difference between a water reflector over the active fuel region and reflection from the steel lid. The results of the partial flooding study, documented in Table 6.7.3-1, demonstrate that there is no effect of partially flooding the TSC.

Moderator Density Variations

Moderator density variation cases are based on a cask array model generated by surrounding a single cask body with a cylindrical reflecting enclosure. The reflecting body is spaced 20 cm from the cask body to allow exterior moderator density conditions to affect the results. Reactivities calculated from the WE17H1 moderator density study are graphically illustrated in Figure 6.7.3-1 for an unborated wet pellet-to-clad gap, moderator containing 2,500 ppm boron, and an enrichment of 5 wt % ^{235}U. Reactivities for dry, unborated wet, and borated wet pellet-to-clad gap conditions under various canister cavity moderator densities are plotted in Figure 6.7.3-2. Reactivity increases in the system as TSC interior moderator density rises. Exterior moderator conditions have no significant effect on system reactivity for a flooded TSC. The k_{eff} of the dry TSC is less than 0.5 under all exterior conditions. For the flooded TSC, k_{eff} levels off at moderator density levels above 0.9 g/cm^3 (actual moderator density 0.903 g/cm^3 considering 2,500 ppm soluble boron), with no significant changes to full density 0.9982 g/cm^3 (1.0025 g/cm^3 at 2,500 ppm B). The reactivity curve levels off as increased thermalization from the moderator is offset by soluble boron neutron absorption. At a lower soluble boron level, the curve continues to rise to full moderator density.

Fabrication Tolerances and Component Shift

Fabrication tolerances and shift effect are evaluated using representative fuel types from the major core configurations (WE, CE, and B&W cores). Nominal fuel assembly characteristics are employed in the tolerance and shifting evaluations. Moderator soluble boron content is set to 2,500 ppm boron for the fabrication tolerance and component shift study.

Fabrication Tolerance

The basket is composed of a set of fuel tubes, pinned together in the tube corners, and located in the TSC cavity with side and corner weldments. Tube location in the basket is controlled by the diagonal dimension across the exterior face of the fuel tube corners. This value is a key dimension for tube array and developed cell size. The tube diagonal is referred to as tube "interface width" in the analysis discussions. Tube and neutron absorber dimensions have the potential to significantly affect the size of the tube opening and developed cell locations and are, therefore, evaluated for tolerance effects. Neutron absorber thickness studies are based on the minimum ^{10}B areal density allowed for the design. As such, variations in neutron absorber thickness require adjustments in the sheet composition. The results of the tolerance evaluation for centered fuel assemblies and basket components are included in Table 6.7.3-2. Little statistically significant information (>3σ) is available from this study. None of the fabrication-related tolerances, with the exception of maximum tube wall thickness, produce significant reactivity increases when taken independently.

Further evaluations of the component tolerances, including combinations of tolerances, are performed in conjunction with the shifted component configuration.

Component Shift

In addition to the component tolerances, a reactivity study on component shifts is required. Based on the pinned tube arrangement, the only radial shift to be evaluated is the shift of the fuel assembly within the tubes. The tubes are restrained in the corner by pins, eliminating a tube movement study. The results of shift evaluations are shown in Table 6.7.3-2, indicating that shifting the fuel assembly towards the basket center clearly increases system reactivity.

Combined Shift and Tolerance Study

This section evaluates the effect of combining various basket tolerances with the maximum reactivity shift configuration (radial in). The results for this evaluation are shown in Table 6.7.3-3. Similar to the results of the independent basket tolerance evaluation, only fuel tube thickness affects system reactivity to a statistically significant level.

While no statistically significant reactivity difference is found between the cases with and without tolerances applied, the maximum reactivity configuration chosen for the evaluations of all fuel hybrids is shown below.

Minimum tube width and interface width
Maximum tube thickness
Minimum absorber width and maximum thickness
Fuel assemblies shifted to basket center

This configuration produced reactivities within a 3σ uncertainty band of the maximum reported value for all fuel types evaluated, and provides for the minimum separation between adjacent assemblies. The minimum separation reduces the amount of moderation and the corresponding effectiveness of both the borated water and absorber sheet, which depend on the ^{10}B neutron capture cross-section in the thermal energy range.

Neutron Absorber and Tube Modifications

Phase 1 Design Modifications

Design options permit the replacement or removal of up to 16 neutron absorber sheets in basket peripheral fuel tubes. Locations for the optional absorber sheets are shown in Figure 6.7.3-3. Replacement sheets for the neutron absorber in the peripheral basket locations are composed of unborated aluminum. Using the most reactive basket and fuel assembly shifting specified in Section 6.7.3.1, three enrichment and soluble boron concentration combinations were evaluated for each PWR fuel type specified in Section 6.7.2 for neutron absorber removal or replacement. As shown in Table 6.7.3-4 and Table 6.7.3-5, no statistically significant reactivity changes are associated with the peripheral neutron absorber sheet removal or replacement by an aluminum sheet. Results were calculated using unborated water in the pellet-to-clad gap.

Design enhancements introduced after completion of the primary criticality evaluations replaced the single column of weld posts down the tube face centerline with a two-column weld post configuration. The weld post columns are located 2 inches from the tube centerline. This design change reduced the number of rows of weld posts in the Class 1 (short) tube to 17 from 18. As demonstrated in Table 6.7.3-6, the increased number of weld posts does not significantly change system reactivity. Results were calculated using unborated water in the pellet-to-clad gap.

As the combined reactivity effect of a reduced number of absorber sheets and an increased number of weld posts may exceed the statistically significant threshold (> 3σ) or potentially result in a $k_{eff} + 2\sigma >$ USL if added as a Δk, the maximum allowed enrichments are calculated in Section 6.7.3.2 with a model containing the reduced number of absorber sheets and the increased number of weld posts.

Phase 2 Design Modifications

Neutron absorbers may be manufactured at an increased tolerance band. Rather than the ±0.005-inch thickness tolerance evaluated in the previous calculations, a thickness tolerance of -0.006, +0.016 inch may be applied. Changes in the absorber thickness tolerance do not result in changes in the areal density of the ^{10}B absorber material as it is defined at its minimum value regardless of absorber thickness. The sheet thickness change within the above tolerance does affect the quantity of borated moderator between the assembly and neutron absorber sheet. Changes in this region influence system reactivity by offsetting effects. One effect is that the moderator quantity in this region thermalizes neutrons, i.e., affects the efficiency of the neutron absorber sheet. The second effect is on the quantity of soluble boron neutron absorber in the system. The focus of the revised analysis is the maximum tolerance sheet thickness effect, as the change in the minimum tolerance is 0.001 inch and is not statistically resolvable (the 0.005-inch tolerance evaluated on the base design did not show a statistically significant change in system reactivity).

In addition to the neutron absorber tolerance change, the weld post configuration on the Class 1 (short) tube was revised to 36 weld post locations (18 rows, 2 columns) from 34 weld posts (17 rows, 2 columns) per tube face. The additional posts remove a small amount of the fixed neutron absorber panels and are, therefore, applied in the revised absorber tolerance models evaluated in Section 6.7.3.2.

To evaluate the design changes, each maximum reactivity fuel type/enrichment/soluble boron combination in Section 6.7.3.2 is evaluated at the increased sheet thickness tolerance band and modified weld post geometry. Results for this analysis are shown in Table 6.7.3-7 and Table 6.7.3-8. The average change in reactivity of updated cases was 0.86σ ($\Delta k = 0.0004$). All cases with updated absorber tolerances had resulting reactivities under the USL (0.9372).

Phase 3 Design Modifications

PWR tube drawing dimensions were modified to list the outer width as a reference dimension with the tube corner chamfer specifying a minimum and maximum quantity of material to be removed. This specification limits tube minimum and maximum outer width when applied to the fixed tube interface width. The tube interface width is retained as a toleranced dimension (± 0.02 inch). The drawing changes provide additional flexibility on the tube outer width, while ensuring tube center-to-center spacing (key to both criticality and structural analysis) is retained. To demonstrate that this design modification does not result in significant reactivity changes, criticality evaluations are performed with the revised tolerance set for tube interface width at either nominal or minimum dimensions (minimum having been determined to be bounding in previous analysis). The tube outer width is derived to be the minimum or maximum based on allowed material removal at the tube corner.

Figure 6.7.3-4 through Figure 6.7.3-7 depict the four cases modeled in this study. For the nominal tube interface width, Figure 6.7.3-4 shows the nominal tube dimensions (no change from the baseline, "tube outer width" controlled, model). Figure 6.7.3-5 shows the tube with the same nominal interface width, but applying the minimum chamfer at the corners (resulting in minimum tube width). The minimum tube outer width is reduced from 9.74 inches (9.76 minus a tolerance of 0.02) to 9.714 inches based on the minimum chamfer. For the minimum tube interface width, Figure 6.7.3-6 and Figure 6.7.3-7 display the chamfer controlled minimum and maximum tube outer width. Minimum tube outer width at minimum interface width is 9.70 inches.

To evaluate the tube tolerance design modification a limited set of baseline cases is generated with the Phase 1 and Phase 2 design modifications incorporated, while retaining the original tube outer width constraints. These cases are compared in Table 6.7.3-9 to the updated tube tolerance models. The average change in reactivity of updated cases was 0.77σ. The reactivity change to the maximum reactivity case is less than 1σ for all three fuel assemblies and signifies an overall insignificant effect due to tube width tolerances. This study confirms the results of the initial tube width study that showed no statistically significant change in system reactivity as a function of tube width. Interface width controls tube spacing and, therefore, assembly spacing and system reactivity.

6.7.3.2 Allowable Loading Definitions and Maximum System Reactivities

Based on the most reactive basket configuration, each of the fuel assembly types is evaluated at various enrichment levels to determine the minimum soluble boron level required with and without insert. The pellet-to-clad gap is flooded with unborated water in all cases. The goal of this evaluation is for $k_{eff} + 2\sigma$ to remain below the USL of 0.9372. Limiting physical assembly characteristics for each of the evaluated fuel types is summarized in Table 6.7.3-12. The number of guide tubes in both tables refers to the number of instrument and guide tubes combined. All fuel geometry information is based on nominal, unirradiated dimensions. Enrichment and minimum soluble boron load limits for the 0.036 ^{10}B g/cm^2 neutron absorber sheet configuration without insert in the active fuel region are listed in Table 6.7.3-10. Table 6.7.3-11 contains similar data for fuel with nonfuel insert in the active fuel region. A generic definition taking the bounding values from the insert and no-insert evaluation is listed in Table 6.7.3-12 in conjunction with the assembly physical characteristics. Table 6.7.3-13 lists the corresponding enrichment/soluble boron limitations for each of the assembly types at two reduced neutron absorber sheet specifications. Reduced absorber contents evaluated are effective areal densities of 0.030 and 0.027 ^{10}B g/cm^2.

Summarized as follows are maximum system reactivities. Analysis results represent maximum reactivity basket and fuel geometry. There are no design basis off-normal or accident transfer cask conditions affecting system reactivity. Therefore, only normal condition results are presented. An accident condition for the concrete cask represents a flooding of the concrete cask to canister annulus. Concrete cask results are based on the maximum fuel mass assembly at the highest allowed enrichment (5.0 wt % ^{235}U).

Condition	Pellet to Clad Gap Condition	Maximum Multiplication Factors ($k_{eff} + 2\sigma$)	
		Transfer Cask	Concrete Cask
Normal	Dry	0.93183	0.48145
Normal	Wet	0.93712	N/A
Accident / Off-Normal	Dry	N/A	0.47104

No analysis has been performed on PWR radial enrichment patterns. Therefore, the enrichment limits specified in this analysis are applied as peak rod enrichments.

Figure 6.7.3-1 PWR Water Density Variations (2500 ppm B, Unborated Wet Gap)

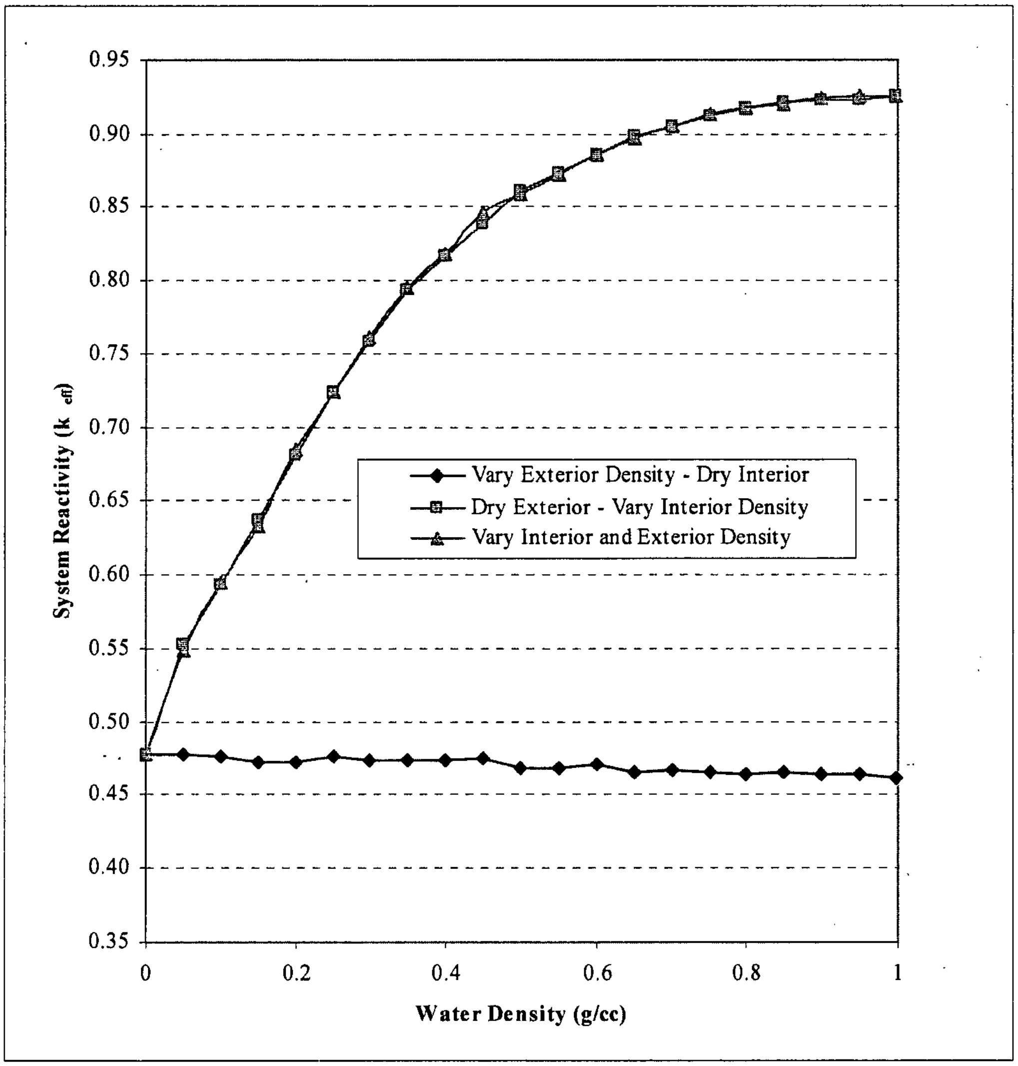


Figure 6.7.3-2 PWR Water Density Variations for Varying Gap Conditions (2500 ppm B)

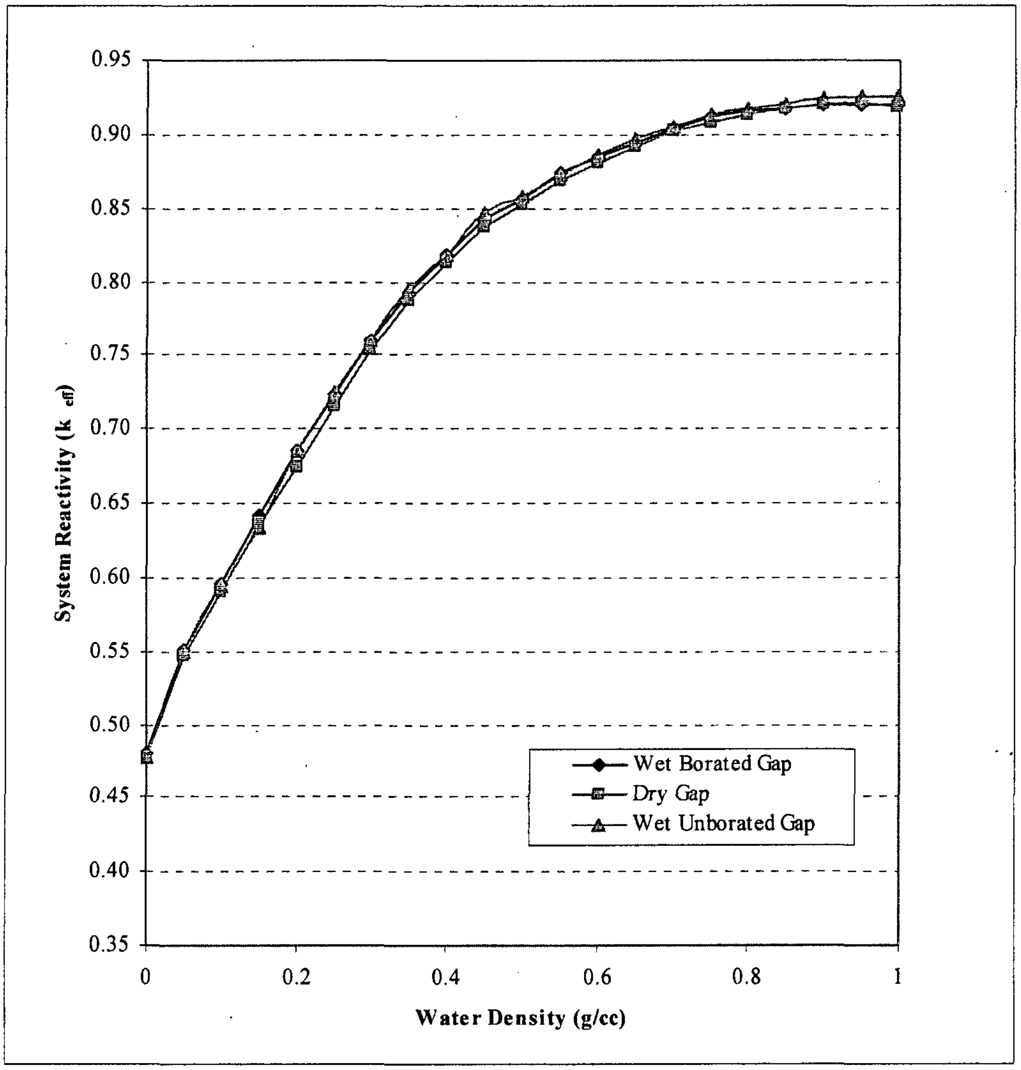
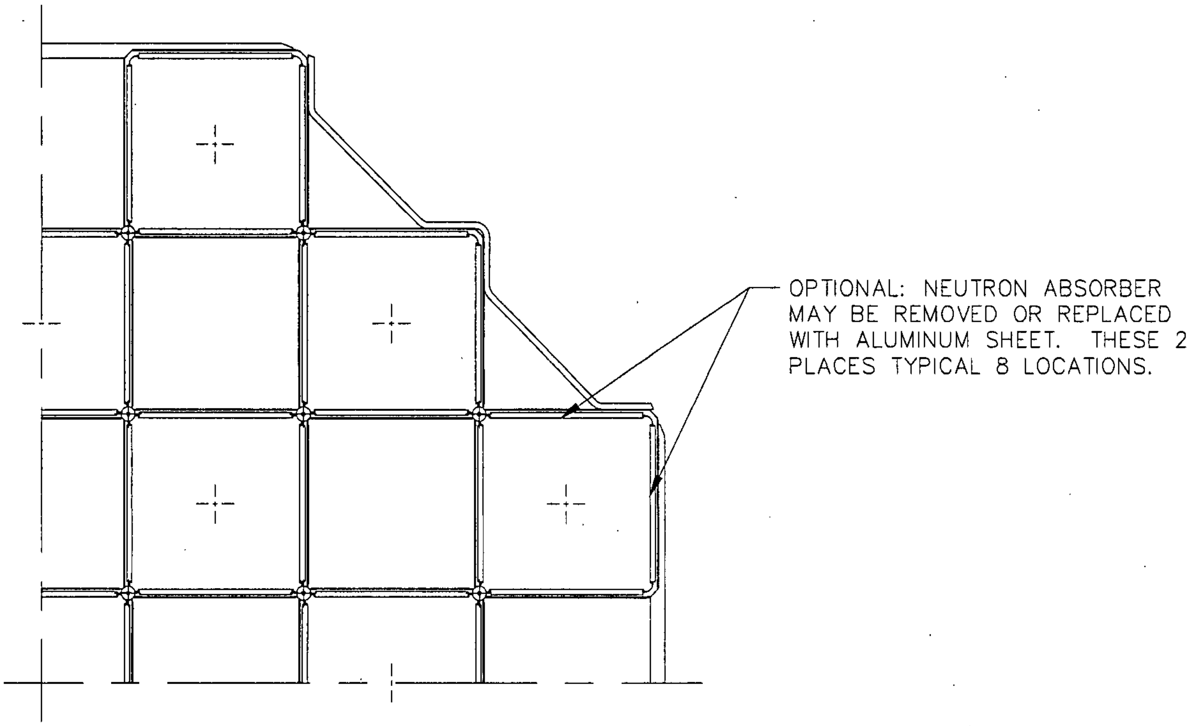


Figure 6.7.3-3 PWR Basket Optional Neutron Absorber Sheet Locations[a]



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[a] Quarter basket model is shown for clarity. Symmetric locations are affected in all four basket quadrants.

Figure 6.7.3-4 Nominal Tube Interface Width and Nominal Tube Outer Width

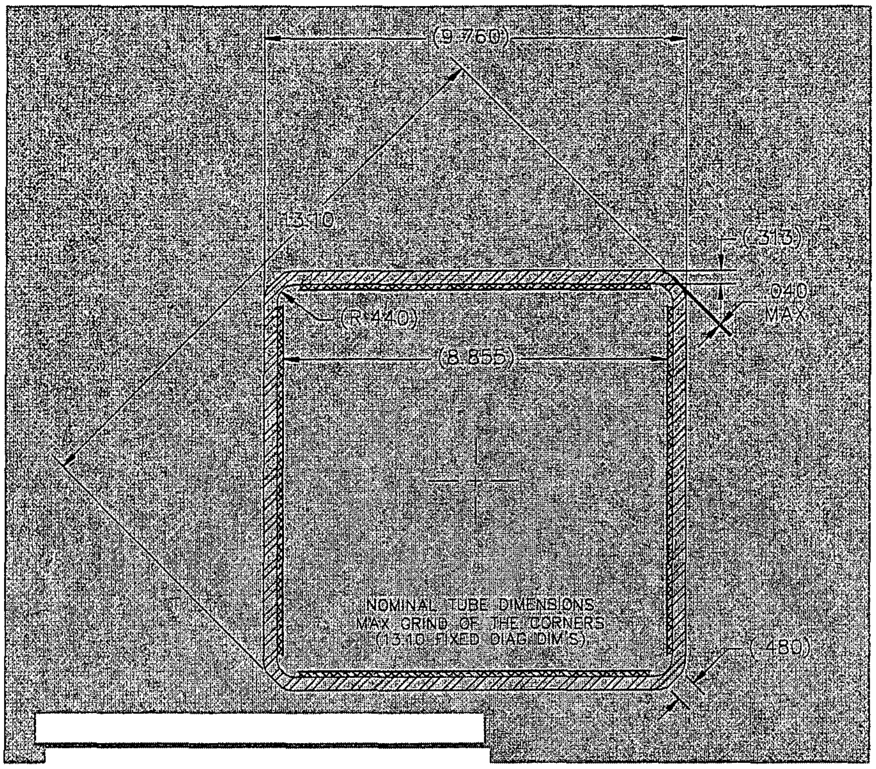

Figure 6.7.3-5 Nominal Tube Interface Width and Minimum Tube Outer Width

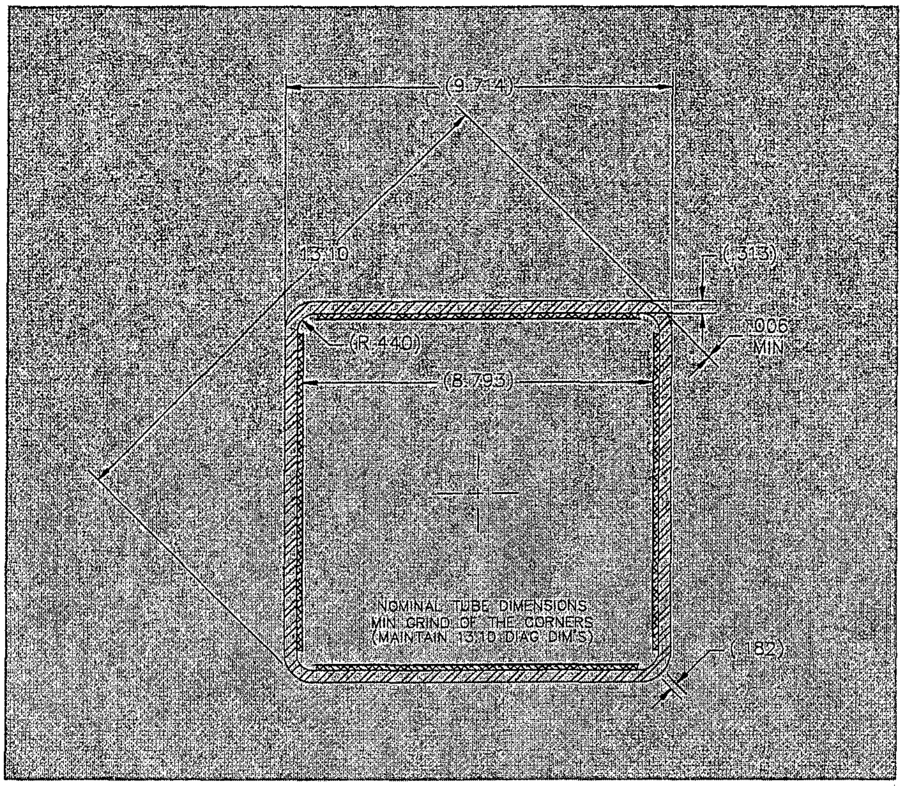

Figure 6.7.3-6 Minimum Tube Interface Width and Maximum Tube Outer Width

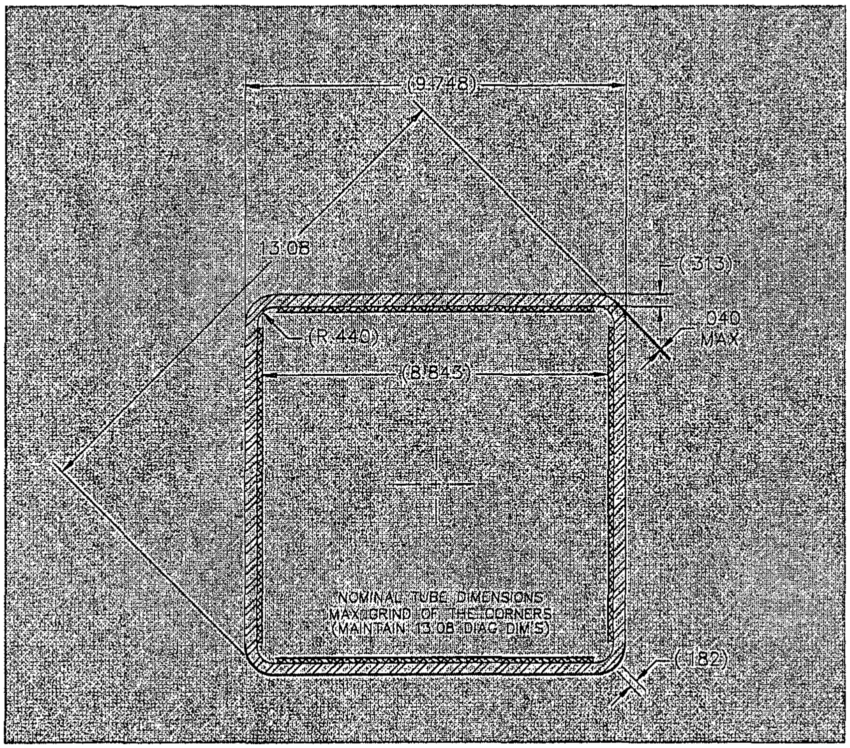

Figure 6.7.3-7 Minimum Tube Interface Width and Minimum Tube Outer Width

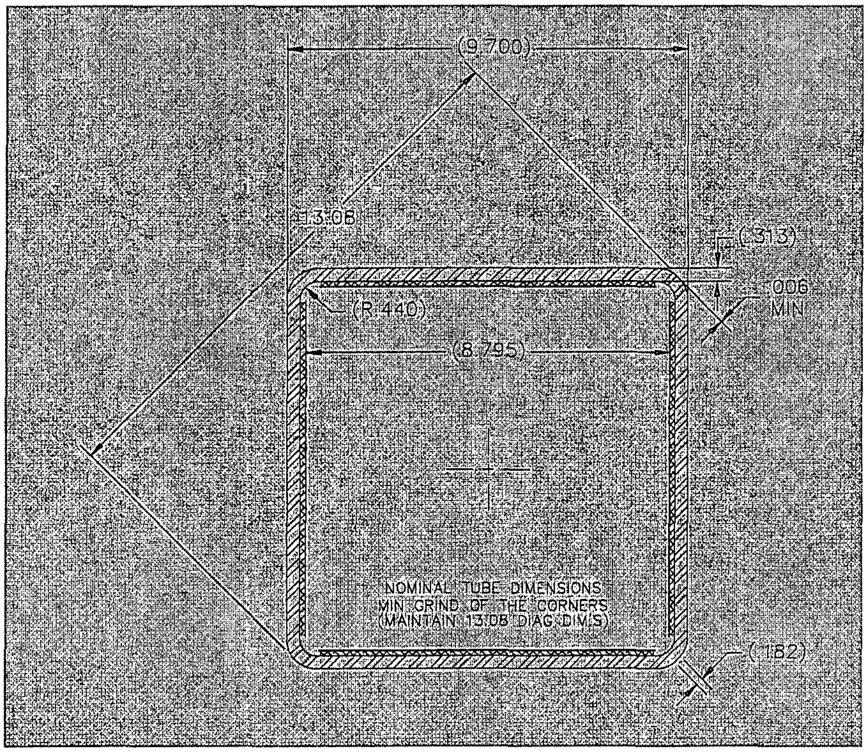

Table 6.7.3-1 PWR System Partial TSC Flood Evaluation

Assembly Type	2,500 ppm B 5.0 wt % Dry Gap No Insert k_{eff}	2,500 ppm B 5.0 wt % Dry Partial Flood k_{eff}	$\Delta k_{eff}/\sigma$
CE14H1	0.86225	0.86130	-0.9
CE16H1	0.86700	0.86614	-0.8
BW15H1	0.92089	0.92000	-0.8
BW15H2	0.92674	0.92454	-2.2
BW15H3	0.92727	0.92743	0.1
BW15H4	0.91301	0.91130	-1.6
BW17H1	0.92595	0.92743	1.3
WE14H1	0.84955	0.84950	0.0
WE15H1	0.91177	0.91244	0.6
WE15H2	0.90023	0.89936	-0.8
WE17H1	0.91897	0.91826	-0.7
WE17H2	0.89962	0.89887	-0.7

Table 6.7.3-2 PWR Basket Component Tolerance and Shift Study Results (Independent Variations)

Tube			Absorber		Shift	WE17H1		BW15H3		CE16H1	
Outer Width	Thick.	Interface Width	Width	Thick.	Rad Fuel	k_{eff}	$\Delta k_{eff}/\sigma$	k_{eff}	$\Delta k_{eff}/\sigma$	k_{eff}	$\Delta k_{eff}/\sigma$
Nom	Nom	Nom	Nom	Nom	Centered	0.91897	--	0.92727	--	0.86700	--
Nom	Nom	Nom	Min	Nom	Centered	0.91820	-0.7	0.92779	0.7	0.86990	2.6
Nom	Nom	Nom	Max	Nom	Centered	0.91988	0.9	0.92717	-0.1	0.86969	2.5
Nom	Nom	Nom	Nom	Min	Centered	0.91935	0.4	0.92862	1.8	0.86862	1.5
Nom	Nom	Nom	Nom	Max	Centered	0.91969	0.7	0.92723	-0.1	0.86928	2.2
Min	Nom	Nom	Nom	Nom	Centered	0.91940	0.4	0.92777	0.7	0.86734	0.3
Max	Nom	Nom	Nom	Nom	Centered	0.91865	-0.3	0.92650	-1.0	0.86667	-0.3
Nom	Min	Nom	Nom	Nom	Centered	0.91637	-2.5	0.92603	-1.6	0.86569	-1.2
Nom	Max	Nom	Nom	Nom	Centered	0.91976	0.8	0.93003	3.8	0.87116	4.0
Nom	Nom	Min	Nom	Nom	Centered	0.91912	0.1	0.92839	1.5	0.86837	1.3
Nom	Nom	Max	Nom	Nom	Centered	0.91801	-0.9	0.92873	2.0	0.86646	-0.5
Nom	Nom	Nom	Nom	Nom	In	0.92342	4.3	0.93137	5.5	0.87494	7.4
Nom	Nom	Nom	Nom	Nom	Out	0.90671	-11.6	0.91903	-11.1	0.83718	-27.9

Table 6.7.3-3 PWR Basket Component Tolerance and Shift Study Results (Combined Variations; Radial In Shift)

Tube			Absorber		Shift	WE17H1		BW15H3		CE16H1	
Outer Width	Thick.	Interface Width	Width	Thick.	Rad Fuel	k_{eff}	$\Delta k_{eff}/\sigma$	k_{eff}	$\Delta k_{eff}/\sigma$	k_{eff}	$\Delta k_{eff}/\sigma$
Nom	Nom	Nom	Nom	Nom	In	0.92342	--	0.93137	--	0.87494	--
Nom	Nom	Nom	Min	Nom	In	0.92421	0.8	0.93253	1.6	0.87493	0.0
Nom	Nom	Nom	Max	Nom	In	0.92451	1.1	0.93073	-0.9	0.87539	0.4
Nom	Nom	Nom	Nom	Min	In	0.92540	1.8	0.93350	2.9	0.87616	1.1
Nom	Nom	Nom	Nom	Max	In	0.92490	1.5	0.93292	2.1	0.87717	2.1
Min	Nom	Nom	Nom	Nom	In	0.92445	1.0	0.93111	-0.4	0.87498	0.0
Max	Nom	Nom	Nom	Nom	In	0.92504	1.6	0.93270	1.8	0.87563	0.6
Nom	Min	Nom	Nom	Nom	In	0.92209	-1.3	0.93102	-0.5	0.87505	0.1
Nom	Max	Nom	Nom	Nom	In	0.92668	3.1	0.93368	3.2	0.87864	3.5
Nom	Nom	Min	Nom	Nom	In	0.92510	1.6	0.93035	-1.4	0.87658	1.6
Nom	Nom	Max	Nom	Nom	In	0.92401	0.5	0.93214	1.0	0.87625	1.2
Min	Min	Min	Min	Min	In	0.92268	-0.7	0.93279	1.9	0.87464	-0.3
Min	Nom	Min	Min	Nom	In	0.92391	0.5	0.93335	2.6	0.87735	2.3
Max	Nom	Min	Min	Nom	In	0.92497	1.5	0.93348	2.9	0.87700	1.9
Nom	Nom	Min	Min	Nom	In	0.92531	1.8	0.93243	1.4	0.87823	3.1
Nom	Max	Nom	Nom	Max	In	0.92698	3.5	0.93303	2.3	0.87770	2.5
Min	Max	Min	Min	Max	In	0.92832	4.6	0.93373	3.1	0.88005	4.7

Table 6.7.3-4 PWR Neutron Absorber Removal Study Results

Assembly	Enrichment (wt % ^{235}U)	PPM	Nominal Absorber k_{eff}	Absorber Removal k_{eff}	Δk_{eff}	$\Delta k_{eff}/\sigma$
BW15H1	4.1	1500	0.95628	0.95700	0.00072	1.0
BW15H2	4.1	1500	0.96131	0.96122	-0.00009	-0.1
BW15H3	4.1	1500	0.96306	0.96262	-0.00044	-0.6
BW15H4	4.1	1500	0.95204	0.95077	-0.00127	-1.7
BW17H1	4.1	1500	0.95934	0.95953	0.00019	0.3
CE14H1	4.1	1500	0.90677	0.90511	-0.00166	-2.2
CE16H1	4.1	1500	0.91264	0.91224	-0.00040	-0.5
WE14H1	4.1	1500	0.89824	0.89709	-0.00115	-1.6
WE15H1	4.1	1500	0.95057	0.95214	0.00157	2.1
WE15H2	4.1	1500	0.93889	0.93913	0.00024	0.3
WE17H1	4.1	1500	0.95524	0.95621	0.00097	1.3
WE17H2	4.1	1500	0.93827	0.93869	0.00042	0.6
BW15H1	4.7	2000	0.95283	0.95367	0.00084	1.1
BW15H2	4.7	2000	0.95579	0.95655	0.00076	1.0
BW15H3	4.7	2000	0.95764	0.95937	0.00173	2.4
BW15H4	4.7	2000	0.94416	0.94346	-0.00070	-0.9
BW17H1	4.7	2000	0.95540	0.95632	0.00092	1.3
CE14H1	4.7	2000	0.89746	0.89772	0.00026	0.3
CE16H1	4.7	2000	0.90516	0.90405	-0.00111	-1.5
WE14H1	4.7	2000	0.88709	0.88928	0.00219	2.9
WE15H1	4.7	2000	0.94472	0.94687	0.00215	2.9
WE15H2	4.7	2000	0.93172	0.93213	0.00041	0.6
WE17H1	4.7	2000	0.95205	0.95331	0.00126	1.7
WE17H2	4.7	2000	0.93229	0.93178	-0.00051	-0.7
BW15H1	5.0	2500	0.92987	0.93071	0.00084	1.2
BW15H2	5.0	2500	0.93574	0.93677	0.00103	1.4
BW15H3	5.0	2500	0.93761	0.93746	-0.00015	-0.2
BW15H4	5.0	2500	0.92108	0.92159	0.00051	0.7
BW17H1	5.0	2500	0.93495	0.93465	-0.00030	-0.4
CE14H1	5.0	2500	0.87406	0.87402	-0.00004	-0.1
CE16H1	5.0	2500	0.88307	0.88259	-0.00048	-0.6
WE14H1	5.0	2500	0.86436	0.86481	0.00045	0.6
WE15H1	5.0	2500	0.92197	0.92214	0.00017	0.2
WE15H2	5.0	2500	0.90838	0.90962	0.00124	1.7
WE17H1	5.0	2500	0.93090	0.93071	-0.00019	-0.3
WE17H2	5.0	2500	0.90755	0.90832	0.00077	1.0

Table 6.7.3-5 PWR Neutron Absorber Replacement Study Results

Assembly	Enrichment (wt % ^{235}U)	PPM	Nominal Absorber k_{eff}	Absorber Replacement k_{eff}	Δk_{eff}	$\Delta k_{eff}/\sigma$
BW15H1	4.1	1500	0.95628	0.95638	0.00010	0.1
BW15H2	4.1	1500	0.96131	0.96210	0.00079	1.1
BW15H3	4.1	1500	0.96306	0.96353	0.00047	0.6
BW15H4	4.1	1500	0.95204	0.95242	0.00038	0.5
BW17H1	4.1	1500	0.95934	0.96135	0.00201	2.9
CE14H1	4.1	1500	0.90677	0.90498	-0.00179	-2.4
CE16H1	4.1	1500	0.91264	0.91071	-0.00193	-2.5
WE14H1	4.1	1500	0.89824	0.89911	0.00087	1.2
WE15H1	4.1	1500	0.95057	0.95153	0.00096	1.3
WE15H2	4.1	1500	0.93889	0.93999	0.00110	1.5
WE17H1	4.1	1500	0.95524	0.95710	0.00186	2.5
WE17H2	4.1	1500	0.93827	0.93999	0.00172	2.4
BW15H1	4.7	2000	0.95283	0.95152	-0.00131	-1.8
BW15H2	4.7	2000	0.95579	0.95610	0.00031	0.4
BW15H3	4.7	2000	0.95764	0.95910	0.00146	1.9
BW15H4	4.7	2000	0.94416	0.94404	-0.00012	-0.2
BW17H1	4.7	2000	0.95540	0.95596	0.00056	0.8
CE14H1	4.7	2000	0.89746	0.89731	-0.00015	-0.2
CE16H1	4.7	2000	0.90516	0.90482	-0.00034	-0.5
WE14H1	4.7	2000	0.88709	0.88604	-0.00105	-1.4
WE15H1	4.7	2000	0.94472	0.94447	-0.00025	-0.3
WE15H2	4.7	2000	0.93172	0.93154	-0.00018	-0.2
WE17H1	4.7	2000	0.95205	0.95160	-0.00045	-0.6
WE17H2	4.7	2000	0.93229	0.93157	-0.00072	-1.0
BW15H1	5.0	2500	0.92987	0.93182	0.00195	2.7
BW15H2	5.0	2500	0.93574	0.93579	0.00005	0.1
BW15H3	5.0	2500	0.93761	0.93805	0.00044	0.6
BW15H4	5.0	2500	0.92108	0.92183	0.00075	1.0
BW17H1	5.0	2500	0.93495	0.93666	0.00171	2.3
CE14H1	5.0	2500	0.87406	0.87526	0.00120	1.6
CE16H1	5.0	2500	0.88307	0.88408	0.00101	1.4
WE14H1	5.0	2500	0.86436	0.86399	-0.00037	-0.5
WE15H1	5.0	2500	0.92197	0.92273	0.00076	1.0
WE15H2	5.0	2500	0.90838	0.90955	0.00117	1.5
WE17H1	5.0	2500	0.93090	0.93241	0.00151	1.9
WE17H2	5.0	2500	0.90755	0.90782	0.00027	0.4

Table 6.7.3-6 PWR Neutron Absorber Attachment Study Results for Two Columns of Weld Posts

			Single Column Base Evaluation		Two Column Modified Attachment			
Assembly	Enrichment (wt % ^{235}U)	PPM	Weld Posts	k_{eff}	Weld Posts	k_{eff}	Δk	Δk/σ
BW15H1	5.0	2500	18	0.92987	34	0.93143	0.00156	2.1
BW15H2	5.0	2500	18	0.93574	34	0.93648	0.00074	1.0
BW15H3	4.9	2500	18	0.93244	34	0.93326	0.00082	1.1
BW15H4	5.0	2500	18	0.92108	34	0.92053	-0.00055	-0.7
BW17H1	5.0	2500	18	0.93495	34	0.93611	0.00116	1.5
CE14H1	5.0	2500	18	0.87406	34	0.87521	0.00115	1.5
CE16H1	5.0	2500	18	0.88307	36	0.88357	0.00050	0.7
WE14H1	5.0	2500	18	0.86436	34	0.86574	0.00138	1.8
WE15H1	5.0	2500	18	0.92197	34	0.92241	0.00044	0.6
WE15H2	5.0	2500	18	0.90838	34	0.90816	-0.00022	-0.3
WE17H1	5.0	2500	18	0.93090	34	0.93294	0.00204	2.7
WE17H2	5.0	2500	18	0.90755	34	0.90832	0.00077	1.0

Table 6.7.3-7 Absorber Tolerance and Tube Reactivity Change of PWR Models with No Inserts

Assembly Type	Minimum 1500 ppm B Max. Initial Enrichment		Minimum 1750 ppm B Max. Initial Enrichment		Minimum 2000 ppm B Max. Initial Enrichment		Minimum 2250 ppm B Max. Initial Enrichment		Minimum 2500 ppm B Max. Initial Enrichment	
	Δk	Δk/σ	Δk	Δk/σ	Δk	Δk/σ	Δk	Δk/σ	Δk	Δk/σ
BW15H1	-0.00067	-0.66	0.00158	1.51	-0.00009	-0.09	0.00092	0.90	-0.00016	-0.15
BW15H2	0.00027	0.27	-0.00066	-0.63	0.00114	1.11	0.00026	0.24	0.00073	0.70
BW15H3	0.00162	1.61	-0.00195	-1.91	-0.00014	-0.13	-0.00105	-1.00	0.00001	0.01
BW15H4	-0.00043	-0.42	-0.00333	-3.10	0.00078	0.77	-0.00078	-0.75	-0.00093	-0.91
BW17H1	-0.00015	-0.15	0.00048	0.46	0.00141	1.41	0.00012	0.11	0.00027	0.26
CE14H1	0.00194	1.89	0.00171	1.57	0.00022	0.21	-0.00056	-0.52	0.00057	0.52
CE16H1	-0.00021	-0.20	0.00094	0.85	0.00052	0.48	0.00299	2.80	0.00024	0.22
WE14H1	0.00009	0.09	-0.00077	-0.71	-0.00132	-1.25	-0.00036	-0.33	-0.00159	-1.52
WE15H1	0.00207	2.02	-0.00153	-1.46	0.00199	1.86	0.00158	1.51	0.00030	0.29
WE15H2	0.00048	0.45	-0.00005	-0.05	-0.00010	-0.10	0.00007	0.07	0.00174	1.72
WE17H1	-0.00070	-0.68	0.00009	0.09	0.00122	1.14	0.00026	0.26	0.00094	0.94
WE17H2	-0.00013	-0.13	-0.00012	-0.12	0.00012	0.12	0.00164	1.55	0.00080	0.78

Table 6.7.3-8 Absorber Tolerance and Tube Reactivity Change of PWR Models with Inserts

Assembly Type	Minimum 1500 ppm B Max. Initial Enrichment		Minimum 1750 ppm B Max. Initial Enrichment		Minimum 2000 ppm B Max. Initial Enrichment		Minimum 2250 ppm B Max. Initial Enrichment		Minimum 2500 ppm B Max. Initial Enrichment	
	Δk	Δk/σ	Δk	Δk/σ	Δk	Δk/σ	Δk	Δk/σ	Δk	Δk/σ
BW15H1	0.00113	1.06	0.00030	0.29	0.00100	0.95	-0.00050	-0.49	0.00172	1.67
BW15H2	0.00235	2.26	0.00042	0.41	0.00238	2.27	0.00176	1.75	-0.00013	-0.12
BW15H3	0.00148	1.43	0.00111	1.06	0.00212	2.07	0.00242	2.37	0.00062	0.60
BW15H4	-0.00088	-0.83	0.00039	0.38	0.00191	1.79	-0.00050	-0.49	0.00148	1.43
BW17H1	0.00125	1.16	0.00023	0.22	-0.00001	-0.01	0.00163	1.65	-0.00020	-0.19
CE14H1	0.00126	1.14	0.00197	1.92	0.00036	0.33	-0.00048	-0.45	0.00053	0.50
CE16H1	-0.00086	-0.83	-0.00013	-0.12	-0.00078	-0.73	0.00142	1.33	0.00184	1.76
WE14H1	0.00017	0.15	0.00155	1.37	0.00067	0.62	-0.00144	-1.33	-0.00087	-0.83
WE15H1	-0.00025	-0.25	-0.00046	-0.46	0.00046	0.45	0.00216	2.02	0.00118	1.15
WE15H2	0.00038	0.36	0.00001	0.01	-0.00105	-1.06	-0.00012	-0.12	0.00211	2.03
WE17H1	0.00072	0.70	0.00133	1.30	-0.00145	-1.38	-0.00062	-0.60	-0.00017	-0.17
WE17H2	0.00148	1.48	-0.00005	-0.05	0.00001	0.01	0.00109	1.03	-0.00012	-0.12

Table 6.7.3-9 PWR Tube Tolerance Study Results

	Tube			Shift	WE17H1		BW15H4		CE16H1	
Toleranced Component	Outer Width [in]	Thickness [in]	Interface Width [in]	Rad Fuel	k_{eff}	$\Delta k_{eff}/\sigma$	k_{eff}	$\Delta k_{eff}/\sigma$	k_{eff}	$\Delta k_{eff}/\sigma$
Tube Outer Width	9.760	0.313	13.080	Centered	0.92000	--	0.91644	--	0.87032	--
Corner Chamfer	9.700	0.313	13.080	Centered	0.92061	0.6	0.91362	-2.6	0.86946	-0.9
Corner Chamfer	9.748	0.313	13.080	Centered	0.92036	0.3	0.91529	-1.1	0.87106	0.6
Tube Outer Width	9.760	0.313	13.080	In	0.92707	--	0.91904	--	0.87768	--
Corner Chamfer	9.700	0.313	13.080	In	0.92627	-0.8	0.91893	-0.2	0.87748	-0.2
Corner Chamfer	9.748	0.313	13.080	In	0.92539	-1.6	0.91874	-0.2	0.87932	1.5
Tube Outer Width	9.740	0.313	13.100	Centered	0.91985	--	0.91414	--	0.86869	--
Corner Chamfer	9.714	0.313	13.100	Centered	0.92034	0.4	0.91457	0.4	0.86924	0.5
Tube Outer Width	9.740	0.313	13.100	In	0.92611	--	0.91748	--	0.87598	--
Corner Chamfer	9.714	0.313	13.100	In	0.92682	0.7	0.91929	1.8	0.87559	-0.3
Tube Outer Width	9.740	0.343	13.080	In	0.92806	--	0.92026	--	0.88113	--
Corner Chamfer	9.700	0.343	13.080	In	0.92740	-0.6	0.92103	0.7	0.88209	0.9

Table 6.7.3-10 PWR System Load Limits (without Nonfuel Insert in Active Fuel Region and 0.036 ^{10}B g/cm^2 Absorber)

	Minimum 1500 ppm B		Minimum 1750 ppm B		Minimum 2000 ppm B		Minimum 2250 ppm B		Minimum 2500 ppm B	
Assembly Type	Max Initial Enrich. (wt% ^{235}U)	Reactivity $k_{eff} + 2\sigma$	Max Initial Enrich. (wt% ^{235}U)	Reactivity $k_{eff} + 2\sigma$	Max Initial Enrich. (wt% ^{235}U)	Reactivity $k_{eff} + 2\sigma$	Max Initial Enrich. (wt% ^{235}U)	Reactivity $k_{eff} + 2\sigma$	Max Initial Enrich. (wt% ^{235}U)	Reactivity $k_{eff} + 2\sigma$
BW15H1	3.70%	0.93032	4.10%	0.93514	4.40%	0.93547	4.70%	0.93489	5.00%	0.93432
BW15H2	3.70%	0.93554	4.00%	0.93451	4.30%	0.93384	4.60%	0.93295	4.90%	0.93244
BW15H3	3.70%	0.93538	4.00%	0.93613	4.30%	0.93528	4.60%	0.93569	4.90%	0.93414
BW15H4	3.80%	0.93189	4.20%	0.93697	4.50%	0.93286	4.80%	0.93228	5.00%	0.92461
BW17H1	3.70%	0.93311	4.00%	0.93204	4.30%	0.93241	4.60%	0.93215	5.00%	0.93689
CE14H1	4.50%	0.93324	4.90%	0.93148	5.00%	0.91561	5.00%	0.89718	5.00%	0.87709
CE16H1	4.40%	0.93350	4.80%	0.93457	5.00%	0.92463	5.00%	0.90197	5.00%	0.88620
WE14H1	4.70%	0.93673	5.00%	0.92958	5.00%	0.90757	5.00%	0.88721	5.00%	0.86816
WE15H1	3.80%	0.93088	4.20%	0.93699	4.50%	0.93415	4.80%	0.93224	5.00%	0.92440
WE15H2	4.00%	0.93406	4.40%	0.93674	4.70%	0.93530	5.00%	0.93129	5.00%	0.91181
WE17H1	3.70%	0.92991	4.10%	0.93553	4.40%	0.93506	4.70%	0.93425	5.00%	0.93308
WE17H2	4.00%	0.93428	4.30%	0.92952	4.70%	0.93330	5.00%	0.93079	5.00%	0.91229

Table 6.7.3-11 PWR System Load Limits (with Nonfuel Insert in Active Fuel Region and 0.036 ^{10}B g/cm^2 Absorber)

Assembly Type	Minimum 1500 ppm B		Minimum 1750 ppm B		Minimum 2000 ppm B		Minimum 2250 ppm B		Minimum 2500 ppm B	
	Max Initial Enrich. (wt% ^{235}U)	Reactivity $k_{eff} + 2\sigma$	Max Initial Enrich. (wt% ^{235}U)	Reactivity $k_{eff} + 2\sigma$	Max Initial Enrich. (wt% ^{235}U)	Reactivity $k_{eff} + 2\sigma$	Max Initial Enrich. (wt% ^{235}U)	Reactivity $k_{eff} + 2\sigma$	Max Initial Enrich. (wt% ^{235}U)	Reactivity $k_{eff} + 2\sigma$
BW15H1	3.80%	0.93273	4.10%	0.93540	4.40%	0.93380	4.70%	0.93644	5.00%	0.93468
BW15H2	3.70%	0.92923	4.00%	0.93281	4.30%	0.93250	4.60%	0.93389	4.90%	0.93451
BW15H3	3.70%	0.93169	4.00%	0.93345	4.30%	0.93311	4.60%	0.93475	4.90%	0.93564
BW15H4	3.80%	0.92945	4.20%	0.93582	4.50%	0.93322	4.80%	0.93247	5.00%	0.92658
BW17H1	3.80%	0.93545	4.10%	0.93648	4.40%	0.93695	4.60%	0.93200	4.90%	0.93284
CE14H1	4.50%	0.93588	4.80%	0.93066	5.00%	0.92489	5.00%	0.90699	5.00%	0.89106
CE16H1	4.40%	0.93241	4.80%	0.93602	5.00%	0.92723	5.00%	0.90831	5.00%	0.89213
WE14H1	4.80%	0.93574	5.00%	0.92232	5.00%	0.90377	5.00%	0.88564	5.00%	0.86589
WE15H1	3.90%	0.93411	4.20%	0.93343	4.50%	0.93351	4.80%	0.93262	5.00%	0.92694
WE15H2	4.00%	0.93138	4.40%	0.93683	4.70%	0.93626	5.00%	0.93357	5.00%	0.91454
WE17H1	3.90%	0.93532	4.20%	0.93495	4.50%	0.93712	4.80%	0.93706	5.00%	0.93241
WE17H2	4.10%	0.93359	4.40%	0.93279	4.80%	0.93707	5.00%	0.92966	5.00%	0.91118

Table 6.7.3-12 PWR System Generic Load Limits (0.036 ^{10}B g/cm^2 Absorber)

									Max. Initial Enrichment (wt % ^{235}U)				
Assembly Type	# of Fuel Rods	# of Guide Tubes[a]	Max Pitch (inch)	Min Clad OD (inch)	Min Clad Thick. (inch)	Max Pellet OD (inch)	Max Active Length (inch)	Max Load (MTU)	Soluble Boron 1500 ppm	Soluble Boron 1750 ppm	Soluble Boron 2000 ppm	Soluble Boron 2250 pm	Soluble Boron 2500 ppm
BW15H1	208	17	0.568	0.43	0.0265	0.3686	144.0	0.4858	3.70%	4.10%	4.40%	4.70%	5.00%
BW15H2	208	17	0.568	0.43	0.025	0.3735	144.0	0.4988	3.70%	4.00%	4.30%	4.60%	4.90%
BW15H3	208	17	0.568	0.428	0.023	0.3742	144.0	0.5006	3.70%	4.00%	4.30%	4.60%	4.90%
BW15H4	208	17	0.568	0.414	0.022	0.3622	144.0	0.4690	3.80%	4.20%	4.50%	4.80%	5.00%
BW17H1	264	25	0.502	0.377	0.022	0.3252	144.0	0.4799	3.70%	4.00%	4.30%	4.60%	4.90%
CE14H1	176	5	0.58	0.44	0.026	0.3805	137.0	0.4167	4.50%	4.80%	5.00%	5.00%	5.00%
CE16H1	236	5	0.5063	0.382	0.025	0.325	150.0	0.4463	4.40%	4.80%	5.00%	5.00%	5.00%
WE14H1	179	17	0.556	0.40	0.0162	0.3674	145.2	0.4188	4.70%	5.00%	5.00%	5.00%	5.00%
WE15H1	204	21	0.563	0.422	0.0242	0.3669	144.0	0.4720	3.80%	4.20%	4.50%	4.80%	5.00%
WE15H2	204	21	0.563	0.417	0.0265	0.357	144.0	0.4469	4.00%	4.40%	4.70%	5.00%	5.00%
WE17H1	264	25	0.496	0.372	0.0205	0.3232	144.0	0.4740	3.70%	4.10%	4.40%	4.70%	5.00%
WE17H2	264	25	0.496	0.36	0.0225	0.3088	144.0	0.4327	4.00%	4.30%	4.70%	5.00%	5.00%

Note: Assembly characteristics represent cold, unirradiated, nominal configurations.

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[a] Combined number of guide and instrument tubes.

Table 6.7.3-13 PWR System Load Limits for Reduced Absorber

Max. Initial Enrichment (wt % ^{235}U)

	Absorber 0.030 ^{10}B g/cm^2					Absorber 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)
BW15H1	3.6%	4.0%	4.2%	4.5%	4.8%	3.6%	3.9%	4.2%	4.5%	4.8%
BW15H2	3.6%	3.9%	4.2%	4.5%	4.8%	3.6%	3.8%	4.1%	4.4%	4.7%
BW15H3	3.6%	3.9%	4.2%	4.4%	4.7%	3.5%	3.8%	4.1%	4.4%	4.7%
BW15H4	3.7%	4.1%	4.4%	4.7%	5.0%	3.7%	4.0%	4.3%	4.6%	5.0%
BW17H1	3.6%	3.9%	4.2%	4.5%	4.8%	3.6%	3.9%	4.1%	4.5%	4.7%
CE14H1	4.3%	4.7%	5.0%	5.0%	5.0%	4.3%	4.6%	5.0%	5.0%	5.0%
CE16H1	4.3%	4.6%	5.0%	5.0%	5.0%	4.2%	4.6%	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%
WE15H1	3.7%	4.1%	4.4%	4.7%	5.0%	3.7%	4.0%	4.3%	4.6%	4.9%
WE15H2	3.9%	4.2%	4.6%	4.9%	5.0%	3.8%	4.2%	4.5%	4.8%	5.0%
WE17H1	3.7%	4.0%	4.3%	4.6%	4.9%	3.6%	3.9%	4.2%	4.5%	4.9%
WE17H2	3.9%	4.3%	4.6%	4.9%	5.0%	3.8%	4.2%	4.5%	4.9%	5.0%

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

6.7.6 BWR Undamaged Fuel Criticality Evaluation

6.7.6.1 Optimum System Configuration

Enrichment limits are based on a maximum reactivity configuration system. To determine the maximum reactivity system, the following system perturbations are evaluated:

TSC interior moderator elevation variations (partial flooding)
Moderator density changes from void to full density (inside and outside the TSC)
Basket fabrication tolerance
Component shift scenarios

All system perturbation analyses are based on fuel assemblies at the maximum lattice moderator (H/U) ratio. Justification for this fuel assembly configuration is provided in Section 6.7.5. Only transfer cask cases are used in these evaluations since the transfer cask is the only cask body in which TSC flooding occurs. In the dry concrete cask, the TSC has a low reactivity, $k_{eff} < 0.5$.

All elevations in this section are based on full-length rods in all assemblies. Partial length rods are addressed in the loading tables. Optimum system configuration studies are based on the 87-assembly basket configuration and a 4.0 wt % ^{235}U initial enrichment, unless otherwise stated. Certain assembly types and configurations exceed the USL at the 4.0 wt % ^{235}U in the 87-assembly basket configuration. These assemblies require the use of either the 82-assembly basket configuration or reduced maximum enrichments.

Initial reactivity analysis is based on a basket and neutron absorber configuration with the following characteristics:

a.) Neutron absorbers on all four sides of each tube.

b.) A single column of weld posts connecting neutron absorber to tube.

c.) A neutron absorber thickness tolerance of ±0.005 inch.

d.) A neutron absorber width tolerance of ±0.02 inch.

e.) Neutron absorber sheet effective areal density of 0.027 ^{10}B g/cm^2.

Differences in reactivity due to system configuration and tolerance changes from these characteristics are evaluated in the subsection titled "Neutron Absorber Modifications."

Changes in neutron absorber areal density are addressed in Section 6.7.6.2.

Partial Flooding

Partial flood cases drain the TSC to the top of the active fuel region. The partial flood reactivity cases investigate reactivity difference between a water reflector over the active fuel region and reflection from the steel lid. The results of the partial flooding study, documented in Table 6.7.6-1, demonstrate that BWR system reactivity is independent of TSC moderator elevations.

Moderator Density Variations

Moderator density variation cases are based on a cask array model generated by surrounding a single cask body with a cylindrical reflecting enclosure. The reflecting body is spaced 20 cm from the cask body to allow exterior moderator density conditions to affect the results. Reactivities calculated for various moderator densities are graphically illustrated in Figure 6.7.6-1 and Figure 6.7.6-2 for the 87-assembly and 82-assembly basket configurations, respectively. Moderator density curves are based on the B9_79A assembly hybrid at an initial enrichment of 4.0 wt % ^{235}U and a flooded pellet-to-clad gap. Reactivity increases in the system as TSC interior moderator density rises. Exterior moderator conditions have no significant effect on system reactivity for a flooded TSC. The k_{eff} of the dry TSC is less than 0.5 under all exterior conditions.

Fabrication Tolerances and Component Shift

Fabrication tolerances and shift effects are evaluated using representative fuel types from the major core configurations. Nominal fuel assembly characteristics are employed in the tolerance and shifting evaluations.

Fabrication Tolerance

The basket is composed of a set of fuel tubes, pinned together in the tube corners, and located in the TSC cavity with side and corner weldments. Tube location in the basket is controlled by the diagonal dimension across the exterior face of the fuel tube corners. This value is a key dimension for tube array and developed cell size. The tube diagonal is referred to as tube "interface width" in the analysis discussions. Similar to the PWR model, neutron absorber and tube tolerances are evaluated. Neutron absorber thickness studies are based on the minimum ^{10}B areal density allowed for the design. As such, variations in absorber thickness require adjustments in the sheet composition. The results of the tolerance evaluation for centered fuel assemblies and basket components are included in Table 6.7.6-2. As indicated in the table, little statistically significant information ($>3\sigma$) is available from this study. None of the fabrication-related tolerances, with the exception of maximum tube wall thickness, produce significant reactivity increases when taken independently.

Further evaluations of the component tolerances, including combinations of tolerances, are performed in conjunction with the shifted component configuration.

Component Shift

In addition to the component tolerances, a reactivity study on component shifts is required. Based on the pinned tube arrangement, the only radial shift to be evaluated is the shift of the fuel assembly within the tubes. The tubes are restrained in the corner by pins, eliminating a tube movement study. The results of shift evaluations are shown in Table 6.7.6-2, indicating that shifting the fuel assembly towards the basket center clearly increases system reactivity.

Combined Shift and Tolerance Study

This section evaluates the effect of combining various basket tolerances with the maximum reactivity shift configuration (radial in). The results for this evaluation are shown in Table 6.7.6-3. Similar to the results of the independent basket tolerance evaluation, only fuel tube thickness affects system reactivity to a statistically significant level.

While no statistically significant reactivity difference is found between the cases with and without tolerances applied, the maximum reactivity configuration chosen for the evaluations of all fuel hybrids is as follows.

Minimum tube width and interface width
Maximum tube thickness
Minimum absorber width and maximum thickness
Fuel assemblies shifted to basket center

This configuration produced reactivities within a 3σ uncertainty band of the maximum reported value for all fuel types evaluated, and provides for the minimum separation between adjacent assemblies. The minimum separation reduces the amount of moderation and the corresponding effectiveness of the absorber sheet, which depend on the ^{10}B neutron capture cross-section in the thermal energy range.

Shift and tolerance evaluations were based on a full, 87-assembly, basket loading. While fabrication tolerance impacts relate to tube and developed cell unit behavior, a limited set of evaluations is performed to verify that the radial shifting in a fuel assembly pattern remains bounding for the 82-assembly basket configuration. The results of this evaluation are shown in Table 6.7.6-4 and demonstrate that the radial shifting in a fuel assembly pattern is limiting.

Neutron Absorber Modifications

Phase 1 Design Modifications

Design options permit the replacement or removal of up to 24 neutron absorber sheets in the 87-assembly basket peripheral fuel tubes or up to 16 neutron absorber sheets in the 82-assembly basket. Locations for the optional absorber sheets are shown in Figure 6.7.6-3 and Figure 6.7.6-4, respectively. Replacement sheets for the neutron absorber in the peripheral basket locations are composed of unborated aluminum. Using the most reactive basket and fuel assembly shifting specified in Section 6.7.6.1, each BWR fuel type specified in Section 6.7.5 was analyzed at 4.0 wt % ^{235}U for the 87-assembly basket and 4.5 wt % ^{235}U for the 82-assembly basket. As shown in Table 6.7.6-5 and Table 6.7.6-6, no statistically significant reactivity changes are associated with the absorber sheet removal or replacement in the model. Results were calculated using unborated water in the pellet-to-clad gap. Results for the 87-assembly basket may exceed the USL at 4.0 wt% ^{235}U. For assemblies exceeding the USL, a lower enrichment or the use of the 82-assembly basket configuration is required.

Design enhancements introduced after completion of the primary criticality evaluations replaced the single column of weld posts down the tube face centerline with a two-column weld post configuration. The weld post columns are located 1.8 in from the tube centerline. As demonstrated in Table 6.7.6-7, the increased number of weld posts does not significantly change system reactivity. Results were calculated using unborated water in the pellet-to-clad gap.

As the combined reactivity effect of a reduced number of absorber sheets and an increased number of weld posts may exceed the statistically significant threshold ($> 3\sigma$) or potentially result in a $k_{eff} + 2\sigma > USL$ if added as `a Δk, the maximum allowed enrichments are calculated with a model containing the reduced number of absorber sheets and the increased number of weld posts.

Phase 2 Design Modifications

Neutron absorbers may be manufactured at an increased tolerance band. Rather than the ±0.005-inch thickness and ±0.02-inch width tolerance evaluated in the previous calculations, a thickness tolerance of ±0.006 inch and a width tolerance of ±0.08 inch may be applied. Changes in the absorber thickness tolerance do not result in changes in the areal density of the ^{10}B absorber material as it is defined at its minimum value regardless of absorber thickness. The focus of the revised analysis is maximum tolerance sheet thickness and minimum width, as the maximum thickness change displaces moderator between fuel and absorber (i.e., potentially decreases absorber efficiency) and the minimum width removes absorber from the system.

To evaluate the design change, each maximum reactivity fuel type/enrichment combination in Section 6.7.6.2 is evaluated at the increased tolerance band. Results for this analysis at the updated maximum tolerance thickness and minimum width cases are shown in Table 6.7.6-8.

The maximum change in reactivity due to the updated absorber tolerances for the BWR cases was 1.81σ. The overall average change in reactivity was 0.58σ. No case exceeded the USL. The change in the absorber tolerance had an insignificant effect on the reactivity of the BWR system.

6.7.6.2 Allowable Loading Definitions and Maximum System Reactivities

Based on the most reactive basket configuration, each of the fuel assembly types is evaluated at various enrichment levels to determine the maximum enrichment at which $k_{eff} + 2\sigma$ remains below the USL. Physical limitation on the assemblies allowed for loading are listed in Table 6.7.6-9. The maximum allowed planar average initial enrichments are listed in Table 6.7.6-10 for assemblies with and without partial length rods, where applicable, for a 0.027 ^{10}B g/cm^2 absorber basket configuration. Table 6.7.6-11 summarizes the enrichment limits for both 87-assembly and 82-assembly basket configurations at neutron absorber sheet effective areal densities of 0.027, 0.0225, and 0.020 ^{10}B g/cm^2. In all evaluations, the pellet-to-clad gap is flooded.

Maximum system reactivities are summarized as follows. Analysis results represent maximum reactivity basket and fuel geometry. There are no design basis off-normal or accident transfer cask conditions affecting system reactivity. Therefore, only normal condition results are presented. An accident condition for the concrete cask represents a flooding of the concrete cask to canister annulus. Concrete cask results are based on the maximum fuel mass assembly at the highest allowed enrichment (4.5 wt % ^{235}U).

Condition	Pellet to Clad Gap Condition	Maximum Multiplication Factors ($k_{eff} + 2\sigma$)	
		Transfer Cask	Concrete Cask
Normal	Dry	0.92900	0.43685
Normal	Wet	0.93679	N/A
Accident / Off-Normal	Dry	N/A	0.42991

Note that there is no statistical difference between normal and accident condition cases, which differ only by the flooding of the pellet-to-clad gap under the "accident condition."

Figure 6.7.6-1 87-Assembly Basket BWR Water Density Variations

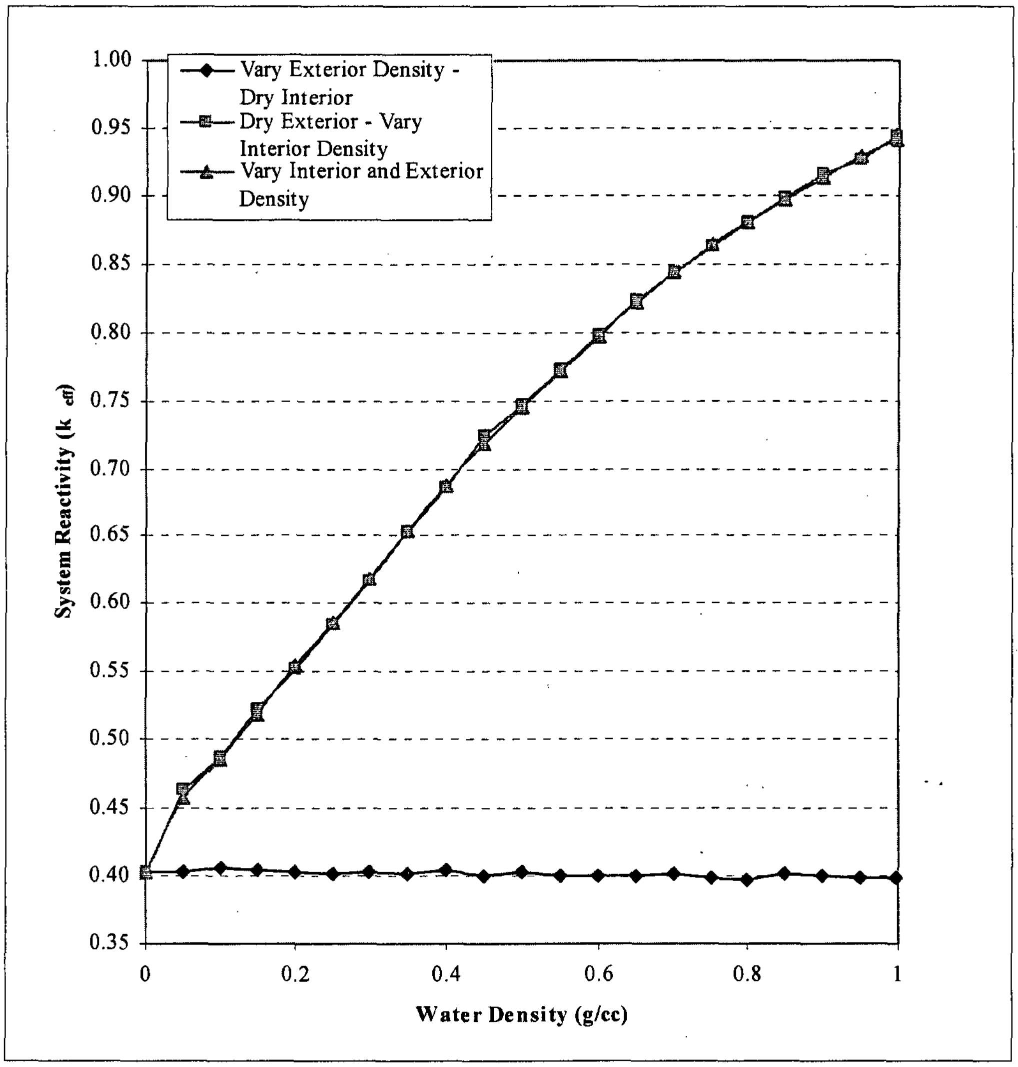


Figure 6.7.6-2 82-Assembly Basket BWR Water Density Variations

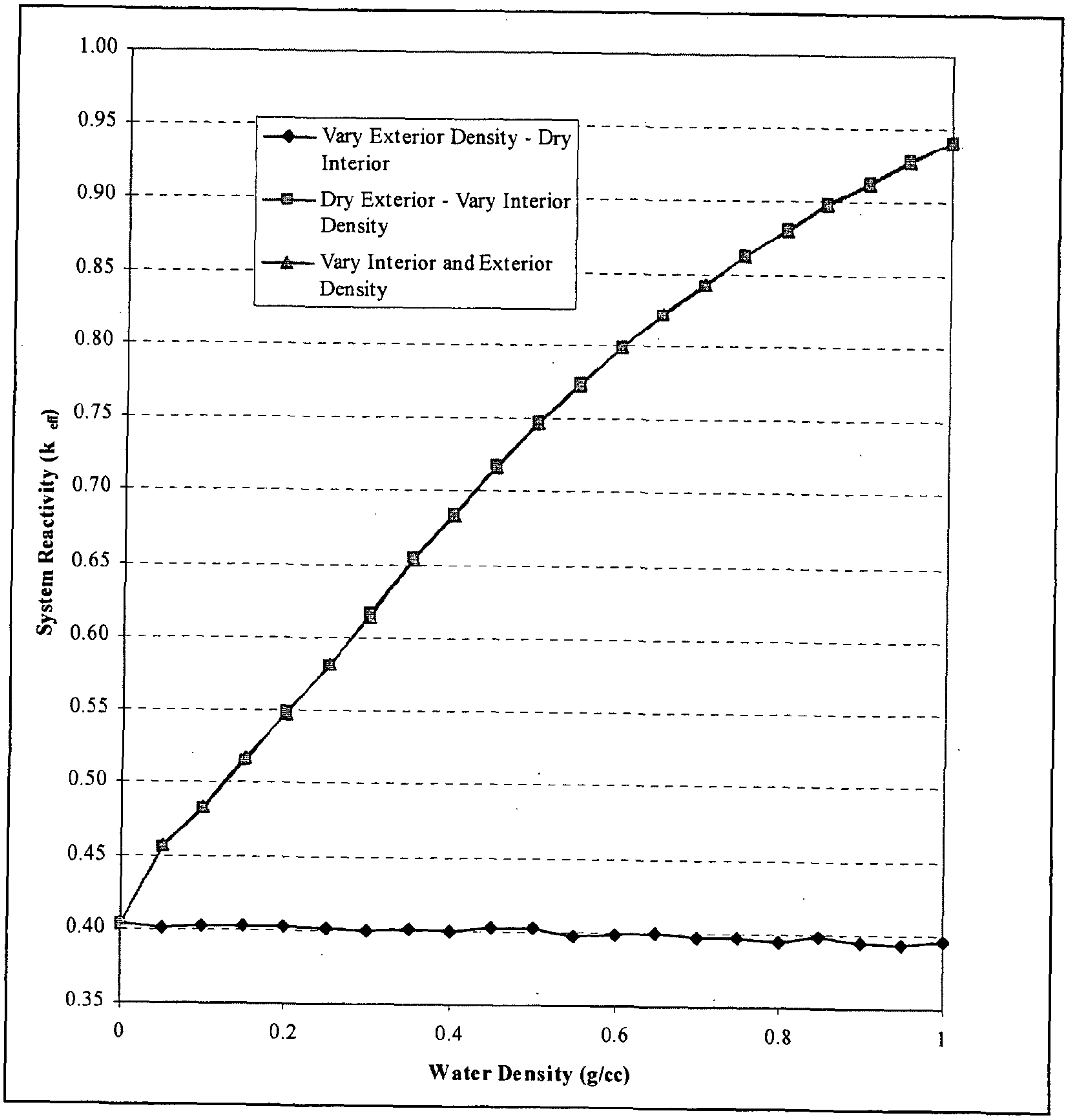
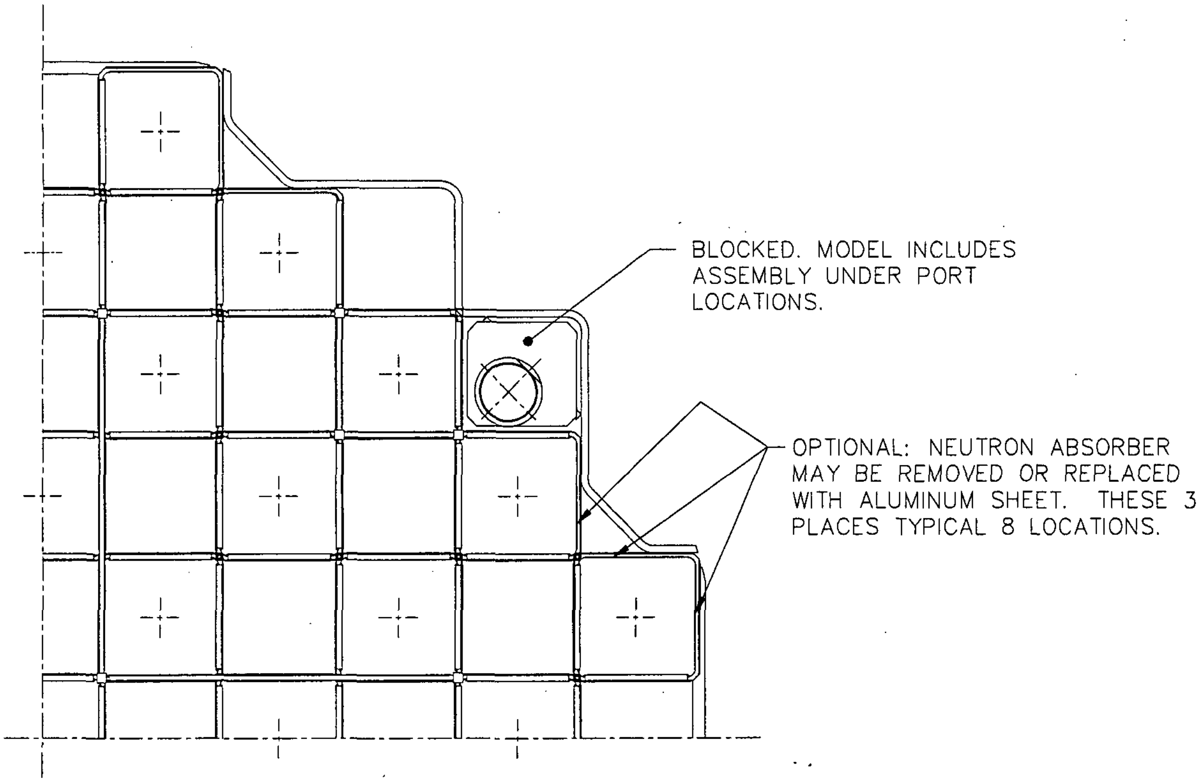


Figure 6.7.6-3 BWR 87-Assembly Basket Optional Neutron Absorber Sheet Locations[a]



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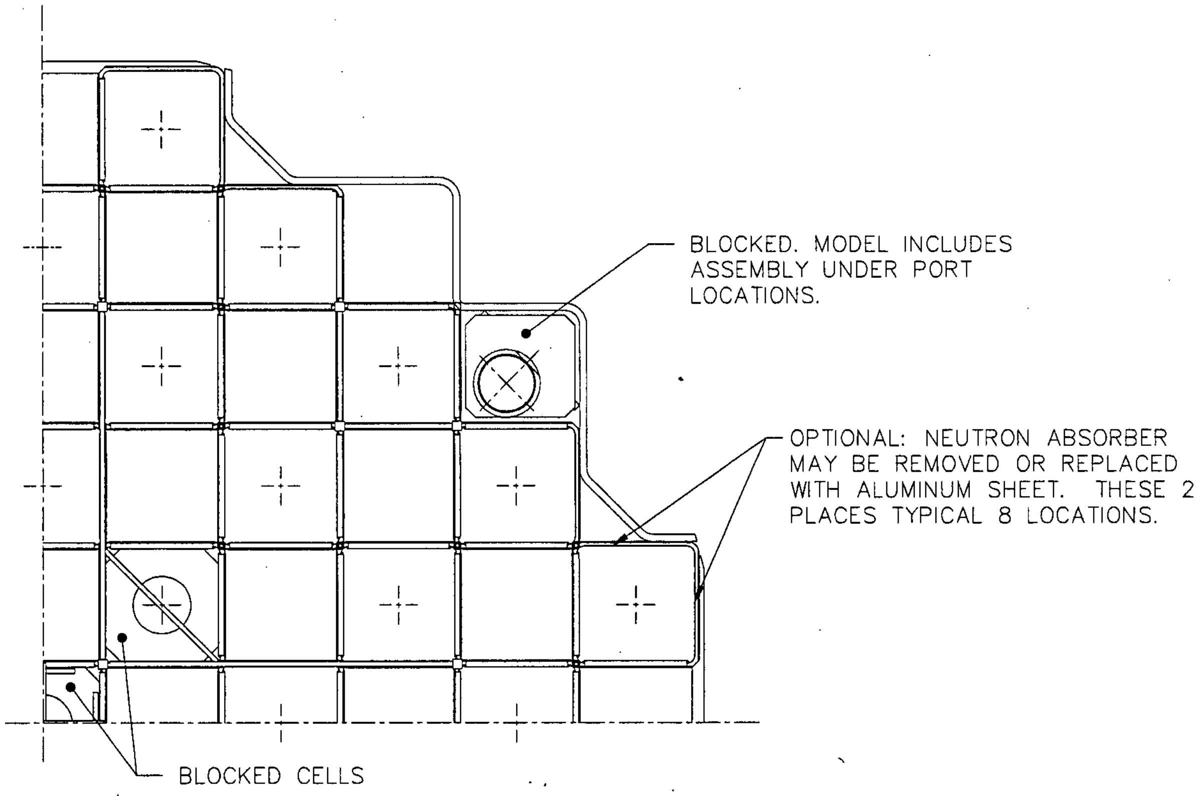
[a] Quarter basket model is shown for clarity. Symmetric locations are affected in all four basket quadrants.

Figure 6.7.6-4 BWR 82-Assembly Basket Optional Neutron Absorber Sheet Locations[a]



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[a] Quarter basket model is shown for clarity. Symmetric locations are affected in all four basket quadrants.

Table 6.7.6-1 BWR System Partial TSC Flood Evaluation

Assembly Type	Dry Gap Full Flood k_{eff}	Dry Gap Partial Flood k_{eff}	$\Delta k_{eff}/\sigma$
B7_48A	0.91765	0.91775	0.1
B7_49A	0.92470	0.92290	-1.7
B7_49B	0.92610	0.92573	-0.3
B8_59A	0.91930	0.92071	1.3
B8_60A	0.92497	0.92501	0.0
B8_60B	0.92589	0.92556	-0.3
B8_61B	0.92650	0.92508	-1.3
B8_62A	0.93055	0.93021	-0.3
B8_63A	0.92687	0.92707	0.2
B8_64A	0.92594	0.92381	-2.0
B8_64B	0.94157	0.94100	-0.5
B9_72A	0.93299	0.93281	-0.2
B9_74A	0.94392	0.94389	0.0
B9_76A	0.95063	0.94907	-1.5
B9_79A	0.94155	0.94044	-1.1
B9_80A	0.92757	0.92671	-0.8
B10_91A	0.92961	0.92853	-1.0
B10_92A	0.92366	0.92532	1.5
B10_96A	0.93807	0.93749	-0.6
B10_100A	0.93827	0.93829	0.0

Table 6.7.6-2 BWR 87-Assembly Basket Component Tolerance and Shift Study Results (Independent Variations)

Tube			Absorber		Shift	B7_49A		B8_62A		B9_76A		B9_79A		B10_92A	
Outer Width	Thick.	Interface Width	Width	Thick.	Rad Fuel	k_{eff}	$\Delta k_{eff}/\sigma$	k_{eff}	$\Delta k_{eff}/\sigma$	k_{eff}	$\Delta k_{eff}/\sigma$	k_{eff}	$\Delta k_{eff}/\sigma$	k_{eff}	$\Delta k_{eff}/\sigma$
Nom	Nom	Nom	Nom	Nom	Centered	0.92470	--	0.93055	--	0.95063	--	0.94155	--	0.92366	--
Nom	Nom	Nom	Min	Nom	Centered	0.92478	0.1	0.92946	-1.0	0.94894	-2.3	0.94026	-1.2	0.92559	1.8
Nom	Nom	Nom	Max	Nom	Centered	0.92400	-0.7	0.92923	-1.2	0.94751	-4.2	0.94124	-0.3	0.92542	1.7
Nom	Nom	Nom	Nom	Min	Centered	0.92329	-1.3	0.92996	-0.5	0.94914	-2.0	0.94168	0.1	0.92401	0.3
Nom	Nom	Nom	Nom	Max	Centered	0.92434	-0.3	0.92879	-1.6	0.94899	-2.2	0.94198	0.4	0.92519	1.4
Min	Nom	Nom	Nom	Nom	Centered	0.92485	0.1	0.93045	-0.1	0.94778	-3.8	0.94244	0.8	0.92430	0.6
Max	Nom	Nom	Nom	Nom	Centered	0.92329	-1.3	0.92768	-2.6	0.94892	-2.3	0.94192	0.3	0.92402	0.3
Nom	Min	Nom	Nom	Nom	Centered	0.92187	-2.8	0.92582	-4.2	0.94667	-5.2	0.93917	-2.2	0.92227	-1.3
Nom	Max	Nom	Nom	Nom	Centered	0.92660	1.8	0.93193	1.2	0.95095	0.4	0.94512	3.4	0.92850	4.5
Nom	Nom	Min	Nom	Nom	Centered	0.92481	0.1	0.92988	-0.6	0.94915	-2.0	0.94341	1.8	0.92487	1.1
Nom	Nom	Max	Nom	Nom	Centered	0.92248	-2.1	0.92926	-1.1	0.94718	-4.4	0.94155	--	0.92641	2.6
Nom	Nom	Nom	Nom	Nom	In	0.92890	3.9	0.93293	2.1	0.95324	3.5	0.94634	4.6	0.93168	7.5
Nom	Nom	Nom	Nom	Nom	Out	0.91191	-12.2	0.91606	-13.0	0.93809	-16.6	0.93148	-9.6	0.91466	-8.6

Table 6.7.6-3 BWR 87-Assembly Basket Component Tolerance and Shift Study Results (Combined Variations; Radial In Shift)

Tube			Absorber		Shift	B7_49A		B8_62A		B9_76A		B9_79A		B10_92A	
Outer Width	Thick.	Interface Width	Width	Thick.	Rad Fuel	k_{eff}	$\Delta k_{eff}/\sigma$	k_{eff}	$\Delta k_{eff}/\sigma$	k_{eff}	$\Delta k_{eff}/\sigma$	k_{eff}	$\Delta k_{eff}/\sigma$	k_{eff}	$\Delta k_{eff}/\sigma$
Nom	Nom	Nom	Nom	Nom	In	0.92890	--	0.93293	--	0.95324	--	0.94634	--	0.93168	--
Min	Nom	Nom	Nom	Nom	In	0.93004	1.0	0.93433	1.3	0.95538	2.8	0.94814	1.7	0.93194	0.2
Max	Nom	Nom	Nom	Nom	In	0.92936	0.4	0.93435	1.3	0.95432	1.4	0.94558	-0.7	0.92987	-1.7
Nom	Min	Nom	Nom	Nom	In	0.92927	0.3	0.93188	-1.0	0.95412	1.2	0.94467	-1.5	0.92868	-2.7
Nom	Max	Nom	Nom	Nom	In	0.93194	2.8	0.93775	4.4	0.95475	2.0	0.94882	2.3	0.93563	3.7
Nom	Nom	Min	Nom	Nom	In	0.92865	-0.2	0.93379	0.8	0.95386	0.8	0.94770	1.3	0.93227	0.6
Nom	Nom	Max	Nom	Nom	In	0.92957	0.6	0.93290	0.0	0.95358	0.5	0.94679	0.4	0.93059	-1.0
Nom	Nom	Nom	Min	Nom	In	0.92964	0.7	0.93441	1.3	0.95188	-1.8	0.94832	1.8	0.93072	-0.9
Nom	Nom	Nom	Max	Nom	In	0.92801	-0.8	0.93396	1.0	0.95660	4.5	0.94514	-1.1	0.93082	-0.8
Nom	Nom	Nom	Nom	Min	In	0.93042	1.4	0.93469	1.6	0.95418	1.3	0.94708	0.7	0.93190	0.2
Nom	Nom	Nom	Nom	Max	In	0.92931	0.4	0.93533	2.3	0.95344	0.3	0.94530	-1.0	0.93019	-1.4
Min	Min	Min	Min	Min	In	0.92717	-1.6	0.93238	-0.5	0.95125	-2.6	0.94416	-2.0	0.92825	-3.2
Min	Nom	Min	Min	Nom	In	0.93058	1.6	0.93526	2.1	0.95631	4.0	0.94802	1.6	0.93081	-0.8
Max	Nom	Min	Min	Nom	In	0.92953	0.6	0.93465	1.6	0.95320	-0.1	0.94916	2.7	0.93372	1.9
Nom	Nom	Min	Min	Nom	In	0.93044	1.4	0.93504	1.9	0.95433	1.5	0.94750	1.1	0.93135	-0.3
Nom	Max	Nom	Nom	Max	In	0.93320	3.8	0.93701	3.8	0.95615	3.9	0.94918	2.7	0.93378	2.0
Min	Max	Min	Min	Max	In	0.93284	3.6	0.93816	4.9	0.95791	6.2	0.95034	3.8	0.93442	2.6

Table 6.7.6-4 BWR 82-Assembly Basket Component Tolerance and Shift Study Results (Combined Variations; Radial In Shift)

Tube			Absorber		Shift	B7_49A		B8_62A		B9_76A		B9_79A		B10_92A	
Outer Width	Thick.	Interface Width	Width	Thick.	Rad Fuel	k_{eff}	$\Delta k_{eff}/\sigma$	k_{eff}	$\Delta k_{eff}/\sigma$	k_{eff}	$\Delta k_{eff}/\sigma$	k_{eff}	$\Delta k_{eff}/\sigma$	k_{eff}	$\Delta k_{eff}/\sigma$
Min	Max	Min	Min	Max	In	0.88693	--	0.89367	--	0.91528	--	0.90858	--	0.88953	--
Min	Max	Min	Min	Max	Centered	0.88706	0.1	0.89379	0.1	0.91574	0.7	0.90671	-1.7	0.89070	1.1
Min	Max	Min	Min	Max	Out	0.88251	-4.0	0.88855	-4.8	0.91035	-6.8	0.90190	-6.1	0.88389	-5.4

Table 6.7.6-5 BWR 87-Assembly Basket Neutron Absorber Removal & Replacement Study Results

			Absorber Removal			Absorber Replacement		
Assembly	Enrichment (wt % ^{235}U)	Nominal Absorber k_{eff}	k_{eff}	Δk	$\Delta k/\sigma$	k_{eff}	Δk	$\Delta k/\sigma$
B7_48A	4.0	0.93146	0.93023	-0.00123	-1.7	0.93170	0.00024	0.3
B7_49A	4.0	0.94139	0.93975	-0.00164	-2.2	0.94033	-0.00106	-1.4
B7_49B	4.0	0.93978	0.93960	-0.00018	-0.2	0.93971	-0.00007	-0.1
B8_59A	4.0	0.93354	0.93489	0.00135	1.8	0.93408	0.00054	0.7
B8_60A	4.0	0.93932	0.93854	-0.00078	-1.1	0.93844	-0.00088	-1.2
B8_60B	4.0	0.93981	0.93974	-0.00007	-0.1	0.93870	-0.00111	-1.4
B8_61B	4.0	0.94021	0.94108	0.00087	1.2	0.94021	0.00000	0.0
B8_62A	4.0	0.94468	0.94274	-0.00194	-2.5	0.94248	-0.00220	-2.8
B8_63A	4.0	0.94427	0.94310	-0.00117	-1.5	0.94277	-0.00150	-2.0
B8_64A	4.0	0.94133	0.94113	-0.00020	-0.3	0.93912	-0.00221	-3.0
B8_64B	4.0	0.95409	0.95256	-0.00153	-2.1	0.95382	-0.00027	-0.4
B9_72A	4.0	0.94508	0.94404	-0.00104	-1.5	0.94493	-0.00015	-0.2
B9_74A	4.0	0.95198	0.95062	-0.00136	-1.8	0.94971	-0.00227	-2.9
B9_76A	4.0	0.95816	0.95864	0.00048	0.6	0.95749	-0.00067	-0.9
B9_79A	4.0	0.95125	0.95033	-0.00092	-1.2	0.94961	-0.00164	-2.1
B9_80A	4.0	0.93990	0.93934	-0.00056	-0.7	0.93960	-0.00030	-0.4
B10_91A	4.0	0.94279	0.94220	-0.00059	-0.8	0.94135	-0.00144	-2.0
B10_92A	4.0	0.93784	0.93967	0.00183	2.4	0.93990	0.00206	2.8
B10_96A	4.0	0.95060	0.95001	-0.00059	-0.8	0.95152	0.00092	1.2
B10_100A	4.0	0.95219	0.95225	0.00006	0.1	0.95175	-0.00044	-0.6

Table 6.7.6-6 BWR 82-Assembly Basket Neutron Absorber Removal & Replacement Study Results

Assembly	Enrichment (wt % ^{235}U)	Nominal Absorber k_{eff}	Absorber Removal			Absorber Replacement		
			k_{eff}	Δk	Δk/σ	k_{eff}	Δk	Δk/σ
B7_48A	4.5	0.91329	0.91427	0.00098	1.3	0.91435	0.00106	1.3
B7_49A	4.5	0.92148	0.92211	0.00063	0.8	0.92311	0.00163	2.1
B7_49B	4.5	0.92249	0.92244	-0.00005	-0.1	0.92115	-0.00134	-1.7
B8_59A	4.5	0.91678	0.91828	0.00150	2.0	0.91841	0.00163	2.2
B8_60A	4.5	0.92379	0.92406	0.00027	0.4	0.92460	0.00081	1.0
B8_60B	4.5	0.92363	0.92505	0.00142	2.0	0.92319	-0.00044	-0.6
B8_61B	4.5	0.92485	0.92597	0.00112	1.5	0.92466	-0.00019	-0.2
B8_62A	4.5	0.92685	0.92669	-0.00016	-0.2	0.92737	0.00052	0.6
B8_63A	4.5	0.92725	0.92723	-0.00002	0.0	0.92680	-0.00045	-0.5
B8_64A	4.5	0.92408	0.92392	-0.00016	-0.2	0.92524	0.00116	1.5
B8_64B	4.5	0.93936	0.93977	0.00041	0.5	0.93877	-0.00059	-0.8
B9_72A	4.5	0.93060	0.92841	-0.00219	-2.9	0.92850	-0.00210	-2.8
B9_74A	4.5	0.93649	0.93629	-0.00020	-0.3	0.93681	0.00032	0.4
B9_76A	4.5	0.94314	0.94277	-0.00037	-0.5	0.94299	-0.00015	-0.2
B9_79A	4.5	0.93237	0.93400	0.00163	2.1	0.93292	0.00055	0.7
B9_80A	4.5	0.92417	0.92364	-0.00053	-0.7	0.92458	0.00041	0.5
B10_91A	4.5	0.92684	0.92476	-0.00208	-2.7	0.92630	-0.00054	-0.7
B10_92A	4.5	0.92191	0.92287	0.00096	1.2	0.92232	0.00041	0.5
B10_96A	4.5	0.93438	0.93508	0.00070	0.9	0.93597	0.00159	2.0
B10_100A	4.5	0.93701	0.93720	0.00019	0.3	0.93767	0.00066	0.9

Table 6.7.6-7 BWR 87-Assembly Basket Neutron Absorber Attachment Modification Study Results

		Base Evaluation		Modified Attachment			
Assembly	Enrichment (wt % ^{235}U)	Weld Posts	k_{eff}	Weld Posts	k_{eff}	Δk	Δk/σ
B7_48A	4.1	4	0.93806	28	0.93891	0.00085	1.1
B7_49A	3.9	4	0.93303	28	0.93474	0.00171	2.3
B7_49B	3.9	4	0.93311	28	0.93471	0.00160	2.1
B8_59A	4.0	4	0.93354	28	0.93469	0.00115	1.6
B8_60A	3.9	4	0.93370	28	0.93473	0.00103	1.4
B8_60B	3.9	4	0.93355	28	0.93450	0.00095	1.3
B8_61B	3.9	4	0.93582	28	0.93547	-0.00035	-0.5
B8_62A	3.9	4	0.93668	28	0.93831	0.00163	2.1
B8_63A	3.8	4	0.93264	28	0.93369	0.00105	1.5
B8_64A	3.9	4	0.93416	28	0.93579	0.00163	2.2
B8_64B	3.7	4	0.93588	28	0.93778	0.00190	2.6
B9_72A	3.8	4	0.93198	28	0.93369	0.00171	2.3
B9_74A	3.7	4	0.93331	28	0.93392	0.00061	0.8
B9_76A	3.6	4	0.93391	28	0.93491	0.00100	1.3
B9_79A	3.7	4	0.93261	28	0.93227	-0.00034	-0.5
B9_80A	3.9	4	0.93383	28	0.93479	0.00096	1.3
B10_91A	3.8	4	0.93081	28	0.93256	0.00175	2.3
B10_92A	3.8	4	0.92729	28	0.92907	0.00178	2.4
B10_96A	3.7	4	0.93175	28	0.93355	0.00180	2.4
B10_100A	3.7	4	0.93318	28	0.93395	0.00077	1.0

Table 6.7.6-8 Absorber Tolerance Reactivity Change of BWR Models

Assembly Type	Maximum Enrichment 87 Assy.		Maximum Enrichment 82 Assy.	
	Δk	Δk/σ	Δk	Δk/σ
B7_48A	-0.00017	-0.16	-0.00016	-0.15
B7_49A	0.00116	1.12	0.00158	1.43
B7_49B	-0.00021	-0.20	0.00014	0.13
B8_59A	0.00062	0.62	-0.00026	-0.23
B8_60A	0.00045	0.41	0.00025	0.23
B8_60B	0.00057	0.54	-0.00018	-0.16
B8_61B	0.00009	0.09	0.00140	1.28
B8_62A	0.00123	1.14	0.00115	1.05
B8_63A	-0.00018	-0.17	0.00122	1.12
B8_64A	-0.00013	-0.12	-0.00046	-0.42
B8_64B	0.00005	0.05	-0.00049	-0.46
B9_72A	0.00009	0.09	-0.00023	-0.22
B9_74A	0.00000	0.00	0.00121	1.11
B9_76A	0.00130	1.23	0.00114	1.03
B9_79A	-0.00023	-0.22	0.00035	0.33
B9_80A	0.00009	0.08	-0.00010	-0.09
B10_91A	0.00016	0.16	-0.00037	-0.33
B10_92A	0.00096	0.89	0.00010	0.09
B10_96A	0.00047	0.45	0.00094	0.89
B10_100A	-0.00096	-0.94	0.00193	1.77
Partial Length Rods				
B9_74A	0.00139	1.35	0.00192	1.81
B10_91A	0.00124	1.19	0.00058	0.54
B10_92A	0.00161	1.57	-0.00002	-0.02
B10_96A	0.00006	0.06	0.00017	0.16

Table 6.7.6-9 BWR System Generic Load Limits (Assembly Description)

Assembly Type	Number of Fuel Rods	Number of Partial Length Rods	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	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[a]	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[a]	8	0.5100	0.3957	0.02385	0.3420	150.0	0.1906
B10_92A	92[a]	14	0.5100	0.4040	0.02600	0.3455	150.0	0.1966
B10_96A	96[a]	12	0.4880	0.3780	0.02430	0.3224	150.0	0.1787
B10_100A	100	N/A	0.4880	0.3780	0.02430	0.3224	150.0	0.1861

Note: Assembly characteristics represent cold, unirradiated, nominal configurations.

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[a] Assemblies may contain partial length fuel rods. Partial length rod assemblies are evaluated by removing partial length rods from the lattice. This configuration bounds an assembly with full length rods and combinations of full and partial length rods.

Table 6.7.6-10 BWR System Maximum Reactivity Summary

Assembly Type	Number of Fuel Rods	87-Assembly Basket		82-Assembly Basket	
		Max Initial Enrich. (wt % ^{235}U)	Reactivity $k_{eff} + 2\sigma$	Max Initial Enrich. (wt % ^{235}U)	Reactivity $k_{eff} + 2\sigma$
B7_48A	48	4.00%	0.93601	4.50%	0.91816
B7_49A	49	3.80%	0.93206	4.50%	0.92623
B7_49B	49	3.80%	0.93335	4.50%	0.92750
B8_59A	59	3.90%	0.93132	4.50%	0.92395
B8_60A	60	3.80%	0.93167	4.50%	0.92748
B8_60B	60	3.80%	0.93143	4.50%	0.93014
B8_61B	61	3.80%	0.93322	4.50%	0.92787
B8_62A	62	3.80%	0.93469	4.50%	0.93102
B8_63A	63	3.80%	0.93679	4.50%	0.93126
B8_64A	64	3.80%	0.93298	4.50%	0.92949
B8_64B	64	3.60%	0.93222	4.30%	0.93539
B9_72A	72	3.80%	0.93632	4.50%	0.93408
B9_74A	74	3.70%	0.93578	4.40%	0.93440
B9_76A	76	3.50%	0.92937	4.20%	0.93158
B9_79A	79	3.70%	0.93665	4.40%	0.93406
B9_80A	80	3.80%	0.93143	4.50%	0.92882
B10_91A	91	3.80%	0.93566	4.50%	0.93093
B10_92A	92	3.90%	0.93620	4.50%	0.92773
B10_96A	96	3.70%	0.93534	4.40%	0.93498
B10_100A	100	3.60%	0.93295	4.40%	0.93505
B9_74A[a]	74	3.70%	0.93575	4.30%	0.93223
B10_91A[a]	91	3.70%	0.92844	4.50%	0.93477
B10_92A[a]	92	3.80%	0.93488	4.50%	0.93570
B10_96A[a]	96	3.70%	0.93368	4.30%	0.93310

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[a] Assemblies contain partial length fuel rods. Partial length rod assemblies are evaluated by removing partial length rods from the lattice. This configuration bounds an assembly with full length rods and combinations of full and partial length rods.

Table 6.7.6-11 BWR Fuel Assembly Loading Criteria (Enrichment Limits)

	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%	3.6%	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%	4.3%	3.4%	4.1%	3.4%	4.0%
B9_76A	3.5%	4.2%	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%	3.6%	4.3%	3.5%	4.1%
B10_92A	3.8%	4.5%	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%

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[a] Maximum planar average.

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

Chapter 10

10.1 Acceptance Criteria

This section provides the workmanship and acceptance tests to be performed on the MAGNASTOR components and systems during their fabrication, as well as prior to and during loading of the system. These tests and inspections provide assurance that the components and systems have been procured, fabricated, assembled, inspected, tested, and accepted for use under the conditions and controls specified in this document and the Certificate of Compliance.

10.1.1 Visual Inspection and Nondestructive Examination

Fabrication, inspection, and testing are performed in accordance with the applicable design criteria, codes and standards specified in Chapter 2 and on the license drawings.

The following fabrication controls and inspections shall be performed to assure compliance with this document and the license drawings:

a) Materials of construction for the MAGNASTOR are identified on the license drawings and shall be procured with certification and supporting documentation as required by the ASME Code, Section II [1], when applicable; and the requirements of ASME Code, Section III, Subsection NB [2], Subsection NF [4] and Subsection NG [3], when applicable.

b) Materials and components shall be receipt inspected for visual and dimensional acceptability, material conformance to the applicable Code specification and traceability markings, as applicable. Materials for the TSC confinement boundary (e.g., TSC shell plates, base plate, closure lid, and port covers) shall also be inspected per the requirements of ASME Code, Section III, Subsection NB-2500.

c) The confinement boundary shall be fabricated and inspected in accordance with ASME Code, Section III, Subsection NB, with the code alternatives as listed in Chapter 2, Table 2.1-2. The TSC fuel basket and basket supports shall be fabricated and inspected in accordance with the ASME Code, Section III, Subsection NG, with the alternatives listed in Table 2.1-2.

d) The steel components of the transfer cask shall be in accordance with ASTM specifications and fabricated in accordance with ANSI N14.6 [11]. Inspections and NDE of the transfer cask shall be in accordance with ASME Code, Section III, Subsection NF.

e) The steel components of the concrete cask shall be in accordance with ASTM specifications and fabricated in accordance with ASME Code, Section VIII [6] (or fabrication may be in accordance with ANSI/AWS D1.1). Inspections of the welded steel components of the concrete cask shall be in accordance with ASME Code, Section VIII or ANSI/AWS D1.1.

f) ASME Code welding shall be performed using welders and weld procedures qualified in accordance with ASME Code, Section IX [7] and the ASME Code, Section III subsection applicable to the component (e.g., NB, NG or NF). ANSI/AWS code welding may be performed using welders and procedures qualified in accordance with the applicable AWS requirements or in accordance with ASME Code, Section IX.

g) Construction and inspections of the concrete component of the concrete cask shall be performed in accordance with the applicable sections and requirements of ACI-318 [8].

h) Visual examinations of the welds of the confinement boundary shall be performed in accordance with ASME Code, Section V, Articles 1 and 9 [9], with acceptance per Section III, Subsection NF, Article NF-5360. The final surface of TSC shell welds shall be dye penetrant examined (PT) in accordance with ASME Code, Section V, Articles 1, 6 and 24, with acceptance per Section III, Subsection NB, Article NB-5350. The TSC shell longitudinal and circumferential welds shall be radiographic examined (RT) in accordance with ASME Code, Section V, Articles 1 and 2, with acceptance per Section III, Subsection NB, Article NB-5320. The weld of the TSC baseplate to the TSC shell shall be ultrasonic examined (UT) in accordance with ASME Code, Section V, Articles 1 and 5, with acceptance per Section III, Subsection NB, Article NB-5330. In accordance with ISG-15 [14], the TSC closure lid to shell weld, performed following fuel loading, shall be dye penetrant (PT) examined at the root, mid-plane and final surface in accordance with ASME Code, Section V, Articles 1, 6 and 24, with acceptance per Section III, Subsection NB, Article NB-5350. The closure ring to TSC shell and the closure ring to closure lid welds shall be PT examined in accordance with the same code and acceptance criteria as the closure lid to TSC shell weld, except that only the weld final surface will be examined. The inner and outer (redundant) port covers to closure lid welds shall be PT examined at the final surface in accordance with the same code and acceptance criteria as for the closure lid to shell weld. Repairs to TSC vessel welds shall be performed in accordance with ASME Code, Section III, Subsection NB, Article NB-4450, and the welds reinspected per the original acceptance criteria applicable to the examination method.

i) Visual examinations of the welds of the fuel basket and basket supports shall be performed in accordance with ASME Code, Section V, Articles 1 and 9, with acceptance per Section III, Subsection NG, Article NG-5360. The fuel tube welds shall be magnetic particle examined (MT) in accordance with ASME Code, Section V, Articles 1, 7 and 25, with acceptance criteria per Section III, Subsection NG, Article NG-5340. Repairs to fuel basket welds shall be performed in accordance with ASME Code, Section III, Subsection NG, Article NG-4450, and the welds reinspected per the original acceptance criteria applicable to the examination method.

j) Visual examinations of the concrete cask structural steel weldments shall be performed in accordance with the ASME Code, Section V, Articles 1 and 9, or ANS/AWS D1.1, Section 6.9, with acceptance per Section VIII, Division 1, Part UW, Articles UW-35 and UW-36, or Table 6.1 of ANSI/AWS D1.1, respectively. Repairs to concrete cask structural weldment welds shall be performed in accordance with ANSI/AWS D1.1, and the welds reinspected per the original acceptance criteria.

k) Visual examination of the welds of the transfer cask shall be performed in accordance with ASME Code, Section V, Articles 1 and 9, or ANSI/AWS D1.1, Section 6.9, with acceptance per Section III, Subsection NF, Article NF-5360. Following structural load testing of the transfer cask, the final surface of all critical load-bearing welds shall be either dye penetrant (PT) or magnetic particle (MT) examined in accordance with ASME Code, Section V, Articles 1, 6 and 24 for PT and Articles 1, 7 and 25 for MT. The acceptance criteria for the weld examinations shall be in accordance with Section III, Subsection NF, Article NF-5350 for PT and NF-5340 for MT. Repairs to the transfer cask vertical load-bearing welds shall be performed in accordance with ASME Code, Section III, Subsection NF, Article NF-4450 or ANSI/AWS D1.1. Repaired welds shall be reinspected per the original acceptance criteria applicable to the examination method.

l) Dimensional inspections of components shall be performed in accordance with written and approved procedures to verify compliance to the license drawings and fit-up of individual components. All dimensional inspections and functional fit-up tests shall be documented.

m) All components shall be inspected for cleanliness and proper packaging for shipping in accordance with written and approved procedures. All components will be free of any foreign material, oil, grease, and solvents.

n) Inspection and nondestructive examination personnel shall be qualified in accordance with the requirements of SNT-TC-1A [10].

10.1.2 Structural and Pressure Tests

10.1.2.1 Load Testing of Transfer Casks

The transfer cask is designed, fabricated, and tested to the requirements of ANSI N14.6 [11]. The transfer cask is provided with two lifting trunnions near the top of the cask for lifting and handling. The trunnion pair is designed for a maximum design lift load of 230,000 pounds for MTC1 and 228,000 pounds for MTC2. The MTC1 and MTC2 transfer cask shield doors and supporting door rails are designed to retain and support the maximum TSC loaded weight of 118,000 pounds.

Following completion of fabrication, the load-bearing components of the transfer cask, including the lifting trunnions, shield doors, and rails, are load tested to verify their structural integrity to lift and retain the applicable loads.

The lifting and handling of the transfer cask and loaded TSC are defined as critical lifting loads per NUREG-0612 [12] at a number of nuclear facilities. In accordance with ANSI N14.6, special lifting devices for critical loads shall be provided with redundant lifting paths, or be designed and tested to higher safety factors. The transfer cask lifting trunnions, shield doors, and rails are designed to higher safety factors and are load tested to 300% of the maximum service load for each type of component.

The lifting trunnion pair shall have a load equal to three times their maximum service load applied for a minimum of 10 minutes. Likewise, the transfer cask shield doors and rails shall have a load equal to three times their maximum service load applied for a minimum of 10 minutes. After release of the test loads, the accessible portions of the trunnions and the adjacent areas, and the shield doors and rails and adjacent areas shall be visually examined to verify no deformation, distortion, or cracking occurred. The critical load-bearing welds of the transfer cask shall be examined by the methods and acceptance criteria defined in Section 10.1.1, Item k).

Any evidence of deformation, distortion, or cracking of the loaded components, critical load-bearing welds or adjacent areas shall be cause for failure of the load test, and repair and/or replacement of the component. Following repair or replacement, the applicable portions of the load test shall be performed again and the components reexamined in accordance with the original procedure and acceptance criteria.

Load testing of the transfer cask shall be performed in accordance with written and approved procedures, and the test results shall be documented.

10.1.2.2 Load Testing of Concrete Cask Lifting Lugs and Anchors

The concrete cask is designed to be lifted and transported using two lifting anchors imbedded in the reinforced concrete of the shell. Lifting lugs are bolted to the anchors and provide a pin connection to a lifting system. The concrete lifting anchors, lifting lugs and attachment bolting are designed, fabricated, and tested in accordance with the requirements of ANSI N14.6 for lifts not made over safety-related equipment (noncritical lifts).

The concrete cask lifting lug load test shall be performed on the lugs independently of the concrete cask. The test will consist of applying a vertical load to the individual lugs at a value that is equal to one-half of 150% of the maximum concrete cask weight. The test load shall be applied for a minimum of 10 minutes. After the release of the test load, the accessible portions of the lifting anchors shall be visually examined to verify no deformation, distortion, or cracking occurred. Critical load-bearing welds of the lifting anchors shall be magnetic particle (MT) examined in accordance with ASME Code, Section V, Articles 1, 7 and 25, or liquid penetrant (PT) examined in accordance with ASME Code, Section V, Articles 1, 6 and 24, with acceptance criteria per Section III, Subsection NF, Article NF-5340 or NF-5350.

Any evidence of deformation, distortion, or cracking of the loaded components, critical load-bearing welds or adjacent areas shall be cause for failure of the load test, and repair and/or replacement of the affected component(s). Following repair or replacement, the applicable portions of the load test shall be reperformed and the components reexamined in accordance with the original procedure and acceptance criteria.

Load testing of the concrete cask lifting lugs shall be performed in accordance with written and approved procedures, and the test results shall be documented.

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 in accordance with ASME Code, Section III, Subsection NB, NB-6000 requirements as described in Section 9.1.1. The minimum test pressure of 130 psig shall be applied to the drain port connection for a minimum of 10 minutes. The minimum test pressure is 125% of the normal operating pressure of 104 psig. There shall be no loss in pressure or visible water leakage from the closure lid weld during the 10-minute test period. The normal operating pressure and minimum test pressure are identical for both PWR and BWR TSCs.

10.1.3 Leakage Tests

The confinement boundary is defined as the TSC shell weldment, closure lid, 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.

Following welding, the TSC shell weldment shall be leakage tested using the evacuated envelope method as described in ASME Code, Section V, Article 10, and ANSI N14.5 to confirm the total leakage rate is less than or equal to 1×10^{-7} ref. cm^3/s at an upstream pressure of 1 atmosphere absolute and a downstream pressure of 0.01 atmosphere absolute, or less. Under these test conditions, this corresponds to a test leakage rate of 2×10^{-7} cm^3/s, helium at standard conditions.

The TSC shell weldment will be closed using a test lid installed over the top of the shell and the cavity evacuated with a vacuum pump to a vacuum of two torr or less. A test envelope will be installed around the TSC enclosing all of the TSC shell confinement welds, evacuated and backfilled to approximately 1 atmosphere absolute with 99.995% (minimum) pure helium. The percentage of helium gas in the test envelope will be accounted for in the determination of the test sensitivity. A mass spectrometer leak detector (MSLD) is attached to the test lid and samples the evacuated volume for helium. The minimum sensitivity of the helium MSLD and test system shall be less than or equal to 1×10^{-7} cm^3/s, helium, which is one-half of the allowable leakage criteria for leaktight.

If helium leakage is detected, the area of leakage shall be identified and repaired in accordance with the ASME Code, Section III, Subsection NB, NB-4450. The complete helium leakage test shall be performed again 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, leakage testing of the closure lid is not required. In order to ensure the integrity of the vent and drain inner port cover welds, a helium leakage test of each weld is performed 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 $\leq 1 \times 10^{-7}$ ref. cm^3/s, which corresponds to a helium test leakage rate of $\leq 2 \times 10^{-7}$ ref. cm^3/s. 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 Mass Spectrometer Leak Detector (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 and repaired in accordance with ASME Code, Section III, Subsection NB, NB-4450. The helium leak test shall be reperformed 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 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 and 10.1.6.4.7 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 three 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. Neutron attenuation 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 properties 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.

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 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 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 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 at room temperature 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 (0.1-in thick boron composite core with 0.0125-in thick aluminum face plates - Boral) for the PWR fuel basket and a 0.10-in nominal thickness sheet (0.075-in thick boron composite core with 0.0125-in thick aluminum face plates - Boral) 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
PWR	4.565	4.191	4.870	4.754
BWR	4.687	4.335	5.054	5.017

Neutron absorber sheets of borated MMC material or borated aluminum will have higher effective coefficients of thermal conductivity than the Boral sheets evaluated due to their larger aluminum alloy content. 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.

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 the laminated absorber (i.e., Boral), yield strength credited in the structural analysis was limited to the outer aluminum cover sheets. Therefore, only the cover sheet material must be shown to meet the required strength.

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 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 composed of a homogeneous ^{10}B compound. Other calibrated standards may be used, but those standards must be shown to be equivalent to a homogeneous standard. 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.**
- **Alternative test methods for neutron attenuation may include chemical analysis or radiography, or a combination of these two methods, provided the alternate methods have been benchmarked (validated or calibrated) to neutron attenuation testing results and have adequate precision to confirm absorber efficacy.**
- **The ^{10}B areal density is measured using a collimated thermal neutron beam of up to 1.2 cm diameter. A beam size greater than 1.2 cm diameter, but no larger than 1.7 cm diameter, may be used if computations are performed to demonstrate that the calculated k_{eff} of the system is still below the calculated Upper Subcritical Limit (USL) of the system, assuming defect areas the same area as the beam. Following are the required computations for using a neutron beam size greater than 1.2 cm diameter.**

    1. **Defects of the same area as the proposed neutron beam or larger have an areal density significantly below the specified minimum areal density.**

2. **These defects are distributed randomly or systematically over the material, or in a manner that is conservative for the design analysis.**
3. **The total of such defective areas amounts to (100-x) percent of the neutron absorber material area, where x is the probability level used for determining the lower tolerance limit.**

Alternately, apply more rigorous statistical criteria for lot acceptance, i.e., increase the factor K in the following expression.

> **Lower tolerance limit = average of sample – K * standard deviation of sample ≥ Technical Specification areal density acceptance criterion,**
>
> > **where, K is the one-sided tolerance limit factor for a normal distribution with a specified sample size, probability and confidence.**

The value of K should be increased to compensate for the decreased standard deviation that results from using a larger neutron beam to examine a material that has defect areas with a characteristic dimension of 1.2 cm.

- **Based on the MAGNASTOR required minimum effective areal density of ^{10}B – 0.036 g/cm^2 for the PWR basket and 0.027 g/cm^2 for the BWR basket – and the credit taken for the ^{10}B for the criticality analyses, i.e., 75% for Boral and 90% 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 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 may 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 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.

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 weight and date of loading. Specific marking instructions are provided on the license drawings for these system components.

Chapter 13
(Appendix C – Technical Specification Bases for the MAGNASTOR® System)

Appendix C
Technical Specification Bases for the MAGNASTOR® SYSTEM

Table of Contents

1.0 INTRODUCTION

This Appendix presents the design or operational condition, or regulatory requirement, which establishes the bases for the Technical Specifications provided in Appendix A.

The section and paragraph numbering used in this Appendix is consistent with the numbering used in Appendix A, Technical Specifications for the MAGNASTOR SYSTEM, and Appendix B, Approved Contents for the MAGNASTOR SYSTEM.

2.0 APPROVED CONTENTS

2.1 Fuel Specifications and Loading Conditions

BASES

BACKGROUND

The MAGNASTOR SYSTEM design requires specifications for the spent fuel to be stored, such as the type of spent fuel, minimum and maximum allowable enrichment prior to irradiation, maximum burnup, minimum acceptable post-irradiation cooling time prior to storage, maximum decay heat, and condition of the spent fuel (i.e., UNDAMAGED FUEL). Other important limitations are the dimensions and weight of the fuel assemblies.

The approved contents, which can be loaded into the MAGNASTOR SYSTEM, are specified in Section 2.0 of Appendix B.

Specific limitations for the MAGNASTOR SYSTEM are specified in Tables 2-1 and 2-9 of Appendix B. These limitations support the assumptions and inputs used in the thermal, structural, shielding, and criticality evaluations performed for the MAGNASTOR SYSTEM.

APPLICABLE SAFETY ANALYSES

To ensure that the closure lid is not placed on a TSC containing an unauthorized fuel assembly, facility procedures require verification of the loaded fuel assemblies to ensure that the correct fuel assemblies have been loaded in the TSC.

APPROVED CONTENTS

Tables 2-1 and 2-9 in Appendix B define the specific fuel assembly characteristics for the PWR and BWR fuel assemblies authorized for loading into the MAGNASTOR SYSTEM. These fuel assembly characteristics include parameters such as cladding material, minimum and maximum enrichment, decay heat generation, post-irradiation cooling time, burnup, and fuel assembly length, width, and weight. The fuel assembly and nonfuel assembly hardware characteristic limits of Tables 2-2 through 2-8 and Tables 2-10 through 2-14 in Appendix B must be met to ensure that the thermal, structural, shielding, and criticality analyses supporting the MAGNASTOR SYSTEM Safety Analysis Report are bounding.

(continued)

APPROVED CONTENT LIMITS AND VIOLATIONS	If any Approved Contents limits of Section 2.0 in Appendix B are violated, the limitations on fuel assemblies to be loaded are not met. Action must be taken to place the affected fuel assembly(s) in a safe condition. This safe condition may be established by returning the affected fuel assembly(s) to the spent fuel pool. However, it is acceptable for the affected fuel assemblies to temporarily remain in the MAGNASTOR SYSTEM, in a wet or dry condition, if that is determined to be a safe condition. NRC notification of the Approved Contents limit violation is required within 24 hours. A written report on the violation must be submitted to the NRC within 60 days. This notification and written report are independent of any reports and notification that may be required by 10 CFR 72.216.
REFERENCES	FSAR, Sections 2.1 and Chapter 6.

3.0 LIMITING CONDITION FOR OPERATION (LCO) APPLICABILITY

BASES

LCOs

LCO 3.0.1, 3.0.2 and 3.0.4 establish the general requirements applicable to all Specifications and apply at all times, unless otherwise stated.

LCO 3.0.1

LCO 3.0.1 establishes the Applicability statement within each individual Specification as the requirement for when the LCO is required to be met (i.e., when the system is in the specific conditions of the Applicability statement of each Specification).

LCO 3.0.2

LCO 3.0.2 establishes that upon discovery of a failure to meet an LCO, the associated ACTIONS shall be met. The Completion Time of each Required Action for an ACTIONS condition is applicable from the point in time that an ACTIONS condition is entered. The Required Actions establish those remedial measures that must be taken within specified Completion Times when the requirements of an LCO are not met. This Specification establishes that:

a. Completion of the Required Actions within the specified Completion Times constitutes compliance with a Specification; and,

b. Completion of the Required Actions is not required when an LCO is met within the specified Completion Time, unless otherwise specified.

There are two basic types of Required Actions. The first type of Required Action specifies a time limit in which the LCO must be met. This time limit is the Completion Time to restore a system or component or to restore variables to within specified limits. Whether stated as a Required Action or not, correction of the entered condition is an action that may always be considered upon entering ACTIONS. The second type of Required Action specifies the remedial measures that permit continued operation that is not further restricted by the Completion Time. In this case, compliance with the Required Actions provides an acceptable level of safety for continued operation.

Completing the Required Actions is not required when an LCO is met or is no longer applicable, unless otherwise stated in the individual Specifications.

The Completion Times of the Required Actions are also applicable when a system or component is removed from service intentionally. The reasons for intentionally relying on the ACTIONS include, but are not limited to, performance of Surveillances, preventive maintenance, corrective maintenance, or investigation of operational problems. Entering ACTIONS for these reasons must be done in a manner that does not compromise safety. Intentional entry into ACTIONS should not be made for operational convenience.

(continued)

LCO 3.0.3	This specification is not applicable to the MAGNASTOR SYSTEM.

LCO 3.0.4

LCO 3.0.4 establishes limitations on changes in specified conditions in the Applicability when an LCO is not met. It precludes placing the facility in a specified condition stated in that Applicability (e.g., Applicability desired to be entered) when the following conditions exist:

a. Facility conditions are such that the requirements of the LCO would not be met in the Applicability desired to be entered; and,

b. Continued noncompliance with the LCO requirements, if the Applicability were entered, would result in being required to exit the Applicability desired to be entered to comply with the Required Actions.

Compliance with Required Actions that permit continued operation of the system for an unlimited period of time in a specified condition provides an acceptable level of safety for continued operation. That is without regard to the status of the system. Therefore, in such cases, entry into a specified condition in the Applicability may be made in accordance with the provisions of the Required Actions.

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

The provisions of LCO 3.0.4 shall not prevent changes in specified conditions in the Applicability that are required to comply with ACTIONS, or that are related to the unloading of a TSC.

Exceptions to LCO 3.0.4 are stated in the individual Specifications. Exceptions may apply to all the ACTIONS or to a specific Required Action of a Specification.

LCO 3.0.5

This specification is not applicable to the MAGNASTOR SYSTEM, as there is no provision for a return to service under administrative control for testing.

3.0 SURVEILLANCE REQUIREMENT (SR) APPLICABILITY

BASES

SRs

SR 3.0.1 through SR 3.0.4 establish the general requirements applicable to all Specifications and apply at all times, unless otherwise stated.

SR 3.0.1

SR 3.0.1 establishes the requirement that SRs must be met during the specified conditions in the Applicability for which the requirements of the LCO apply, unless otherwise specified in the individual SRs. This Specification is to ensure that Surveillances are performed to verify that systems and components meet the LCO and variables are within specified limits. Failure to complete Surveillance within the specified Frequency, in accordance with SR 3.0.2, constitutes a failure to meet an LCO.

Systems and components are assumed to meet the LCO when the associated SRs have been met. Nothing in this Specification, however, is to be construed as implying that systems or components meet the associated LCO when:

a. The systems or components are known to not meet the LCO, although still meeting the SRs; and,

b. The requirements of the Surveillance(s) are known to be not met between required Surveillance performances.

Surveillances do not have to be performed when the system is in a specified condition for which the requirements of the associated LCO are not applicable, unless otherwise specified.

Surveillances, including Surveillances invoked by Required Actions, do not have to be performed on equipment determined to not meet the LCO because the ACTIONS define the remedial measures that apply. Surveillances have to be met and performed in accordance with SR 3.0.2, prior to returning the equipment to service. Upon completion of maintenance, appropriate post-maintenance testing is required. This includes ensuring applicable Surveillances are not failed and their most recent performance is in accordance with SR 3.0.2.

Post-maintenance testing may not be possible in the current specified conditions in the Applicability due to the necessary system parameters not having been established. In these situations, the equipment may be considered to meet the LCO, provided testing has been satisfactorily completed to the extent possible and the equipment is not otherwise believed to be incapable of performing its function. This will allow operations to proceed to a specified condition where other necessary post-maintenance tests can be completed.

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SR 3.0.2

SR 3.0.2 establishes the requirements for meeting the specified Frequency for Surveillances and any Required Action with a Completion Time that requires the periodic performance of the Required Action on a “once per …” interval.

SR 3.0.2 permits a 25% extension of the interval specified in the Frequency. This extension facilitates Surveillance scheduling and considers system conditions that may be suitable for conducting the Surveillance (e.g., transient conditions or other ongoing Surveillance or maintenance activities).

The 25% extension does not significantly degrade the reliability that results from performing the Surveillance at its specified Frequency. This is based on the recognition that the most probable result of any particular Surveillance being performed is the verification of conformance with the SRs. The exceptions to SR 3.0.2 are those Surveillances for which the 25% extension of the interval specified in the Frequency does not apply. These exceptions are stated in the individual Specifications as a Note in the Frequency stating, “SR 3.0.2 is not applicable.”

As stated in SR 3.0.2, the 25% extension also does not apply to the initial portion of a periodic Completion Time that requires performance on a “once per …” basis. The 25% extension applies to each performance after the initial performance. The initial performance of the Required Action, whether it is a particular Surveillance or some other remedial action, is considered a single action with a single Completion Time. One reason for not allowing the 25% extension to this Completion Time is that such an action usually verifies that no loss of function has occurred by checking the status of redundant or diverse components or accomplishes the function of the affected equipment in an alternative manner.

The provisions of SR 3.0.2 are not intended to be used repeatedly merely as an operational convenience to extend Surveillance intervals or periodic Completion Time intervals beyond those specified.

SR 3.0.3

SR 3.0.3 establishes the flexibility to defer declaring affected equipment as not meeting the LCO or an affected variable outside the specified limits when Surveillance has not been completed within the specified Frequency. A delay period of up to 24 hours or up to the limit of the specified Frequency, whichever is less, applies from the point in time that it is discovered that the Surveillance has not been performed in accordance with SR 3.0.2, and not at the time that the specified Frequency was not met.

(continued)

SR 3.0.3 (continued)

This delay period provides adequate time to complete Surveillances that have been missed. This delay period permits the completion of Surveillance before complying with Required Actions or other remedial measures that might preclude completion of the Surveillance.

The basis for this delay period includes consideration of system conditions, adequate planning, availability of personnel, the time required to perform the Surveillance, the safety significance of the delay in completing the required Surveillance, and the recognition that the most probable result of any particular Surveillance being performed is the verification of conformance with the requirements. When Surveillance with a Frequency based not on time intervals, but upon specified system conditions, is discovered not to have been performed when specified, SR 3.0.3 allows the full delay period of 24 hours to perform the Surveillance.

SR 3.0.3 also provides a time limit for completion of Surveillances that become applicable as a consequence of changes in the specified conditions in the Applicability imposed by the Required Actions.

Failure to comply with specified Frequencies for SRs is expected to be an infrequent occurrence. Use of the delay period established by SR 3.0.3 is a flexibility, which is not intended to be used as an operational convenience to extend Surveillance intervals.

If Surveillance is not complete within the allowed delay period, then the equipment is considered to not meet the LCO, or the variable is considered outside the specified limits, and the Completion Times of the Required Actions for the applicable LCO Conditions begin immediately upon expiration of the delay period. If Surveillance is failed within the delay period, then the equipment does not meet the LCO, or the variable is outside the specified limits, and the Completion Times of the Required Actions for the applicable LCO Conditions begin immediately upon the failure of the Surveillance.

Completion of the Surveillance within the delay period allowed by this Specification, or within the Completion Time of the ACTIONS, restores compliance with SR 3.0.1.

SR 3.0.4

SR 3.0.4 establishes the requirement that all applicable SRs must be met before entry into a specified condition in the Applicability.

This Specification ensures that system and component requirements and variable limits are met before entry into specified conditions in the Applicability for which these systems and components ensure safe operation of the system.

(continued)

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

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

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

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

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

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

3.1 MAGNASTOR SYSTEM Integrity

3.1.1 Transportable Storage Canister (TSC)

BASES

BACKGROUND

A TRANSFER CASK with an empty TSC is placed into the spent fuel pool and loaded with fuel assemblies meeting the requirements of Appendix B, Approved Contents. A closure lid is then placed on the TSC and the TRANSFER CASK containing the TSC is removed from the pool and placed in the cask preparation area or prepared in a partially submerged condition. Water flow to the TRANSFER CASK annulus may be provided to assist in limiting the MAGNASTOR SYSTEM component temperatures during TSC preparation and closure activities. The closure lid is welded to the TSC shell and the weld is examined by dye penetrant examination methods (i.e., root, mid-plane and final surface). A hydrostatic pressure test of the weld is performed to 125% of maximum normal operating pressure. A closure ring is installed in the closure lid-to-TSC shell weld groove, welded to the shell and to the closure lid and examined by dye penetrant methods. The TSC cavity water is removed by pumping and/or blow down while backfilling the cavity with helium, and the free volume of the TSC is determined by measuring the volume of water removed. The final residual moisture removal is completed by vacuum drying, and the cavity is backfilled to a specified mass or pressure of high purity helium. The redundant port covers at the vent port and at the drain port are installed and welded to the closure lid, and the welds are dye penetrant examined to complete the confinement boundary. The TRANSFER CASK is then used to complete the transfer of the TSC to the CONCRETE CASK, and the loaded and closed CONCRETE CASK is moved to the ISFSI pad for long-term storage.

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

Upon verification of the dryness of the TSC cavity following vacuum drying operations, the TSC is backfilled with high purity helium until the required density is established. Drying and backfilling the TSC cavity with helium provides the capability to remove the contents decay heat and minimizes any oxidizing gases. Establishment of the inert helium atmosphere protects the fuel cladding from degradation. The backfilling

(continued)

BACKGROUND (cont.)	and resulting pressurization of the cavity with helium to an established density will provide the required helium mass and pressure to ensure the operation of the heat transfer design of the MAGNASTOR SYSTEM, and will eliminate the possibility of air in-leakage over the storage period. The TSC is designed, analyzed, and tested to meet the leaktight criteria of ANSI N14.5, and the closure lid-to-TSC shell weld is hydrostatically pressure tested following fuel loading. The closure lid, closure ring and port covers provide redundant closures to assure confinement boundary integrity. Therefore, loss of helium and possible in-leakage of air are precluded.
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 assured 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 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 helium backfill mass ensures that the TSC internal pressure does not exceed the vessel's design pressure under storage design 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.
APPLICABILITY	The sealed TSC with a dry inert 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 these operating phases.

(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.

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.

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.

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.

(continued)

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.

3.1 MAGNASTOR SYSTEM Integrity

3.1.2 CONCRETE CASK Heat Removal System

BASES

BACKGROUND

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

APPLICABLE SAFETY ANALYSIS

The thermal analyses of the MAGNASTOR SYSTEM take credit for the decay heat from the TSC contents being transferred to the ambient environment surrounding the CONCRETE CASK. Transfer of heat from the TSC contents ensures that the fuel cladding and TSC component temperatures do not exceed established limits. During normal STORAGE OPERATIONS, the four air inlets and four air outlets are unobstructed and full natural convection heat transfer occurs (i.e., maximum heat transfer for a given ambient temperature and decay heat load).

Analyses have been performed for the complete obstruction of two and four air inlets. Blockage of two air inlets reduces the convective air flow through the CONCRETE CASK/TSC annulus and decreases the heat transfer from the TSC surfaces to the ambient environment. Under this off-normal event of blockage of two air inlets, no CONCRETE CASK or TSC components or fuel cladding exceed established short-term temperature limits, and the TSC internal pressure does not exceed the analyzed maximum pressure.

The complete blockage of all four air inlets effectively stops the transfer of the decay heat from the TSC due to the elimination of the convective air flow. The TSC will continue to radiate heat to the liner of the CONCRETE CASK. Upon loss of air cooling, the MAGNASTOR SYSTEM component temperatures will increase toward their respective established accident temperature limits. The spent fuel cladding and fuel basket and CONCRETE CASK structural component temperatures do not reach their accident limits for a time period of approximately 72 hours. The internal pressure in the TSC cavity will not reach the analyzed maximum pressure condition for approximately 58 hours after a complete blockage condition occurs.

(continued)

APPLICABLE SAFETY ANALYSIS (cont.)

Therefore, following the identification of a reduction in the heat dissipation capabilities of the CONCRETE CASK by the temperature-monitoring program or the visual inspection of the air inlet and outlet screens, actions are to be taken immediately to restore at least partial convective airflow (i.e., a minimum of 2 air inlet screens and 2 air outlets screens are unobstructed). Once partial airflow is established, the fuel cladding and the TSC and component temperatures will not exceed normal STORAGE OPERATIONS limits. Efforts to reestablish full OPERABLE status for the CONCRETE CASK can then be undertaken in a controlled manner. If necessary, the TSC may be transferred into the TRANSFER CASK to permit full access to the base of the CONCRETE CASK for repairs with minimal radiological effects.

LCO

The CONCRETE CASK heat removal system is to be verified to be OPERABLE to preserve the applicability of the design bases thermal analyses. The continued operability of the heat removal system ensures that the decay heat generated by the TSC contents is transferred to the ambient environment to maintain the fuel cladding and CONCRETE CASK and TSC temperatures within established limits.

APPLICABILITY

The LCO is applicable during TRANSPORT OPERATIONS and STORAGE OPERATIONS. Once the CONCRETE CASK lid is installed following transfer of a loaded TSC, the heat removal system is required to be OPERABLE to ensure adequate heat transfer.

ACTIONS

A Note has been added to the Actions that states for this LCO, separate condition entry is allowed for each CONCRETE CASK. This is acceptable, as the Required Actions for each Condition provide appropriate compensatory measures for each CONCRETE CASK not meeting the LCO. Other CONCRETE CASKs that do not meet the LCO are addressed by independent Condition entry and application of the associated Required Actions.

A.1

If the CONCRETE CASK heat removal system has been determined to be inoperable, full operability is to be restored, or at a minimum, adequate heat removal must be restored or verified to prevent exceeding fuel cladding and critical component temperatures for accident events. Adequate heat removal capability is defined as no more than two obstructed CONCRETE CASK air inlets and air outlets and constitutes the analyzed off-normal event. This verification must be completed immediately.

(continued)

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.

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. 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.

3.2 MAGNASTOR SYSTEM Criticality Control for PWR Fuel

3.2.1 Dissolved Boron Concentration

BASES

BACKGROUND

A TRANSFER CASK with an empty TSC is placed into a spent fuel pool and loaded with fuel assemblies and associated nonfuel hardware meeting the requirements of Appendix B, Approved Contents for the MAGNASTOR SYSTEM.

After loading the TSC, a closure lid is installed on the TSC, the closure lid is welded to the TSC shell, and the water in the cavity is drained.

For those TSCs to be loaded with PWR fuel assemblies, credit is taken in the criticality analyses for boron dissolved in the water within the TSC cavity during the loading and TSC preparation up through the draining of the cavity water. To preserve the analyses bases, the dissolved boron concentration of the TSC cavity water must be verified to meet specified limits when there are fuel assemblies and water in the TSC. This may occur during LOADING OPERATIONS and UNLOADING OPERATIONS.

APPLICABLE SAFETY ANALYSIS

The spent fuel stored in the MAGNASTOR SYSTEM is required to remain subcritical ($k_{eff} < 0.95$) under all conditions of storage. The MAGNASTOR SYSTEM is analyzed to safely store a wide variety of spent fuel assembly types with differing initial enrichments and associated nonfuel hardware. For PWR fuel assemblies to be loaded in the TSCs, credit has been taken in the criticality analyses for neutron poison in the form of soluble boron in the water in the TSC cavity. Compliance with this LCO preserves the assumptions made in the criticality analyses and ensures that the stored PWR fuel assemblies will remain subcritical with a $k_{eff} < 0.95$ while water is in the TSC.

LCO

Compliance with this LCO ensures that the stored PWR fuel will remain subcritical with a $k_{eff} < 0.95$ while water is in the TSC. The LCO provides the minimum concentration of soluble boron required to be in the TSC cavity water based on the type, initial enrichment, and contained nonfuel hardware of the PWR fuel assembly.

All UNDAMAGED FUEL ASSEMBLIES loaded into the TSC are limited by analysis to maximum enrichments of 5.0 wt% ^{235}U.

(continued)

APPLICABILITY

The dissolved boron concentration LCO is applicable whenever a TSC has at least one PWR fuel assembly in a storage location and water in the TSC.

ACTIONS

A Note has been added to the Actions that states for this LCO, separate condition entry is allowed for each TSC. This is acceptable since the Required Actions for each condition provide appropriate compensatory measures for each TSC not meeting the LCO. Subsequent TSCs being loaded or unloaded will be controlled by subsequent condition entry and application of associated Required Actions.

A.1 and A.2

Continuation of LOADING OPERATIONS, UNLOADING OPERATIONS or positive reactivity additions (including actions to reduce dissolved boron concentration) is contingent upon maintaining the TSC in compliance with the LCO. Determination of a measurement of soluble boron below the required concentration for the limiting fuel assembly parameters, LOADING OPERATIONS, UNLOADING OPERATIONS, and any positive reactivity additions are to be immediately suspended and placed in a safe condition.

A.3

Immediate actions are to be taken to restore the dissolved boron concentration in the TSC cavity water to within the established limits. One method of complying with the action is to initiate direct boration of the TSC water immediately in a controlled manner. Alternatively, the direct boration of the spent fuel pool water can be performed.

Once initiated, the addition of boron to the TSC or spent fuel pool are to continue until the required soluble boron concentration is restored. The time to complete restoration will depend on the amount of boron required to be added and the capacity of the available boron addition equipment.

SURVEILLANCE REQUIREMENTS

SR 3.2.1.1

When the TSC is placed in the spent fuel pool for loading of PWR fuel assemblies requiring boron credit, the dissolved boron concentration in the TSC water must be verified by two independent measurements to be within the applicable limit within four hours prior to entering the applicability of the LCO. For LOADING OPERATIONS, this means within four hours prior to loading any approved content into the TSC.

(continued)

BASES (continued)

SURVEILLANCE REQUIREMENTS (cont.)

The use of two independent measurements provides assurance that the dissolved boron concentration limit is met and maintained. The period of four hours prior to fuel loading for the surveillance frequency is reasonable based on the potential for boron dilution to occur prior to the start of loading without limiting operational flexibility. Following the verification of the boron concentration, there is no credible unplanned event that would change the concentration. During the period between the completion of boron concentration verification and commencement of loading operations, possible methods to change the boron concentration will be administratively controlled. If actions are taken that could result in a reduction in the boron concentration within the four-hour period, the surveillance will be performed again.

While the TSC is in the spent fuel pool or while water is in the TSC, the boron concentration will be verified every 24 hours. Facility procedures will specifically ensure that any water to be added to, or recirculated through, the TSC will have a boron concentration greater than or equal to the minimum boron concentration specified by the LCO.

For UNLOADING OPERATIONS, the dissolved boron concentration in water to be used to reflood a TSC containing PWR fuel, requiring a minimum boron concentration in accordance with this LCO, will be verified within four hours of initiating TSC reflooding operations. This ensures that when the LCO is applicable the LCO will be met. The boron concentration shall be verified every 24 hours until all PWR fuel assemblies are removed from the TSC during wet unloading operations.

REFERENCES

FSAR Chapter 6

3.3 MAGNASTOR SYSTEM Radiation Protection

3.3.1 CONCRETE CASK Maximum Surface Dose Rates

BASES

BACKGROUND	The regulations governing the operation of an ISFSI set limits on the control of occupational radiation exposure and radiation doses to the general public (Ref. 1). Radiation doses to the public are limited for both normal and accident conditions in accordance with 10 CFR 72 and 10 CFR 20. Occupational radiation exposure should be kept as low as reasonably achievable (ALARA) and within the limits of 10 CFR 20. Unexpected high dose rates may also lead to the identification of a fuel misload exceeding CoC Fuel Content limitations.
APPLICABLE SAFETY ANALYSIS	The CONCRETE CASK maximum surface dose rates are not an assumption in any accident analysis, but are used to ensure compliance with regulatory limits on dose to the public and occupational dose, and to potentially identify a misloaded spent fuel assembly.
LCO	The limits on CONCRETE CASK maximum neutron and gamma surface dose rates are based on the Safety Analysis Report shielding analysis of the MAGNASTOR System (Ref. 2). The limits are selected to minimize radiation exposure to the public, as determined in accordance with 10 CFR 72 and 10 CFR 20, and to maintain occupational dose ALARA to personnel working in the vicinity of the MAGNASTOR SYSTEM. The LCO specifies sufficient locations for taking dose rate measurements to ensure the dose rates measured are indicative of the effectiveness of the shielding materials.
APPLICABILITY	The CONCRETE CASK maximum neutron and gamma surface dose rates apply immediately prior to the start of STORAGE OPERATIONS. The selected limits ensure that the CONCRETE CASK surface dose rates during STORAGE OPERATIONS are bounded by the shielding safety analyses. Radiation doses during STORAGE OPERATIONS are monitored by the MAGNASTOR SYSTEM user in accordance with the plant-specific radiation protection program as required by 10 CFR 72.212(b)(6) and 10 CFR 20 (Ref. 1).
ACTIONS	A note has been added to the ACTIONS, which states that for this LCO, separate Condition entry is allowed for each loaded CONCRETE CASK. This is acceptable since the Required Actions for each Condition provide appropriate compensatory measures for each CONCRETE CASK not meeting the LCO. Subsequent MAGNASTOR SYSTEMs that do not meet the LCO are governed by subsequent Condition entry and application of associated Required Actions.

(continued)

ACTIONS (continued)

A.1

If the CONCRETE CASK maximum surface dose rates are not within limits, it could be an indication that a fuel assembly that did not meet the Approved Contents Limits in Section B2.0 of Appendix B was inadvertently loaded into the TSC. Administrative verification of the TSC fuel loading, by means such as review of video recordings and records of the loaded fuel assembly serial numbers, can establish whether a misloaded fuel assembly is the cause of the out-of-limit condition. The Completion time is based on the time required to perform verification.

A.2

If the CONCRETE CASK maximum surface dose rates are not within limits and it is determined that the CONCRETE CASK was loaded with the correct fuel assemblies, an analysis may be performed. This analysis will determine if the CONCRETE CASK would result in the ISFSI offsite or occupational calculated doses exceeding regulatory limits in 10 CFR 72 or 10 CFR 20, respectively. If it is determined that the measured maximum surface dose rates do not result in the regulatory limits being exceeded, STORAGE OPERATIONS may proceed.

B.1

If it is verified that the fuel was misloaded, or that the ISFSI offsite radiation protection requirements of 10 CFR 20 or 10 CFR 72 will not be met with the CONCRETE CASK maximum surface dose rates above the LCO limit, the performance of the CONCRETE CASK shall be assessed and a safe configuration established. The Completion Time is reasonable, based on the time required to perform an engineering evaluation and safety assessment of the CONCRETE CASK, to implement corrective actions such as augmented shielding applied to the CONCRETE CASK, repositioning the CONCRETE CASK in the cask array at the ISFSI to reduce the offsite dose impact of the CONCRETE CASK, or to off-load the affected TSC.

(continued)

BASES (continued)

SURVEILLANCE REQUIREMENTS

SR 3.3.1.1

This SR ensures that the CONCRETE CASK maximum neutron and gamma surface dose rates are within the LCO limits after transfer of the TSC into the CONCRETE CASK and prior to the beginning of STORAGE OPERATIONS. This Frequency is acceptable, as corrective actions can be taken before offsite dose limits are compromised. The surface dose rates are measured approximately at the locations indicated on Figure 3-1 of Appendix A of the Technical Specifications.

REFERENCES

1. 10 CFR Parts 20 and 72
2. SAR Section 5.1

3.3	MAGNASTOR SYSTEM Radiation Protection
3.3.2	TSC Surface Contamination
BASES	
BACKGROUND	A TRANSFER CASK containing an empty TSC is immersed in the spent fuel pool in order to load the spent fuel assemblies. The external surfaces of the TSC are maintained clean by the application of clean water to the annulus of the TRANSFER CASK. However, there is potential for the surface of the TSC to become contaminated with the radioactive material in the spent fuel pool water. Contamination exceeding LCO limits is removed prior to moving the CONCRETE CASK containing the TSC to the ISFSI in order to minimize the radioactive contamination to personnel or the environment. This allows the ISFSI to be entered without additional radiological controls to prevent the spread of contamination and reduces personnel dose due to the spread of loose contamination or airborne contamination. This is consistent with ALARA practices.
APPLICABLE SAFETY ANALYSIS	The radiation protection measures implemented at the ISFSI are based on the assumption that the exterior surfaces of the TSC are not significantly contaminated. Failure to decontaminate the surfaces of the TSC to below the LCO limits could lead to higher-than-projected occupational dose and potential site contamination.
LCO	Removable surface contamination on the exterior surfaces of the TSC is limited to 10,000 dpm/100 cm^2 from beta and gamma sources and 100 dpm/100 cm^2 from alpha sources. Only loose contamination is controlled, as fixed contamination will not result from the TSC loading process. Experience has shown that these limits are low enough to prevent the spread of contamination to clean areas and are significantly less than the levels that could cause significant personnel skin dose.

(continued)

LCO (continued)

LCO 3.3.2 requires removable contamination to be within the specified limits for the exterior surfaces of the TSC. Compliance with this LCO may be verified by direct and/or indirect methods. The location and number of TSC and TRANSFER CASK surface swipes used to determine compliance with this LCO are determined based on standard industry practice and the user's plant-specific contamination measurement program for objects of this size. The objective is to determine a removable contamination value representative of the entire TSC surface area while implementing sound ALARA practices.

Swipes and measurements of removable surface contamination levels on the interior surfaces of the TRANSFER CASK may be performed to verify the TSC LCO limits following transfer of the TSC to the CONCRETE CASK. These measurements will provide indirect indications regarding the removable contamination on the exterior surfaces of the TSC.

APPLICABILITY

Verification that the exterior surface contamination of the TSC is less than the LCO limits is performed during LOADING OPERATIONS. This occurs before TRANSPORT OPERATIONS and STORAGE OPERATIONS. Measurement of the TSC surface contamination is unnecessary during UNLOADING OPERATIONS, as surface contamination would have been measured prior to moving the subject TSC to the ISFSI.

(continued)

ACTIONS

A note has been added to the ACTIONS, which states that, for this LCO, separate Condition entry is allowed for each TSC LOADING OPERATION. This is acceptable, since 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 removable surface contamination of the TSC that has been loaded with spent fuel is not within the LCO limits, action must be initiated to decontaminate the TSC and bring the removable surface contamination to within limits. The Completion Time of prior TRANSPORT OPERATIONS is appropriate, given that the time needed to complete the decontamination is indeterminate and surface contamination does not affect the safe storage of the spent fuel assemblies.

SURVEILLANCE REQUIREMENTS

SR 3.3.2.1

This SR verifies (either directly or indirectly) that the removable surface contamination on the exterior surfaces of the TSC is less than the limits in the LCO. The Surveillance is performed using smear surveys to detect removable surface contamination. The Frequency requires performing the verification prior to initiating TRANSPORT OPERATIONS in order to confirm that the TSC can be moved to the ISFSI without spreading loose contamination.

REFERENCES

1. FSAR Section 9.1.
2. NRC IE Circular 81-07.